Mock-ups for the Forest Information System Europe

Content and design

Anouk Cormont, Peter Verweij, Robert Jan van Oosten, Silke Jacobs, Kees Hendriks, Mariana Hassegawa, Hans Verkerk, Jenny Lazebnik, Jeanne Nel, Laura Nikinmaa, Blasius Schmid, Yasmin Maximo, Jaclyn Bolt, Eric Arets, Mart-Jan Schelhaas, Gert-Jan Nabuurs, Annemarie Bastrup-Birk, Daniela Docan, Nils Hettich

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Approved for publication:
Sander Janssen, teamleader Earth Informatics

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EUROPEAN FOREST INSTITUTE

ROBERT JAN VAN OOSTEN GRAFISCH ONTWERP

European Environment Agency

Anouk Cormont, Peter Verweij, Robert Jan van Oosten, Silke Jacobs, Kees Hendriks, Mariana Hassegawa, Hans Verkerk, Jenny Lazebnik, Jeanne Nel, Laura Nikinmaa, Blasius Schmid, Yasmin Maximo, Jaclyn Bolt, Eric Arets, Mart-Jan Schelhaas, Gert-Jan Nabuurs, Annemarie Bastrup-Birk, Daniela Docan, Nils Hettich, 2021. *Mock-ups for the Forest Information System Europe; Content and design.* Wageningen, Wageningen Environmental Research, Report 3141. 136 pp.

Een toenemend aantal beleidsstukken op EU- en nationaal niveau heeft - direct of indirect – effect op de bossen in Europa. Daarom is er een groeiende behoefte aan een overzicht van de actuele toestand van de Europese bossen. Het Forest Information System for Europe (FISE) is opgezet om in deze behoefte te voorzien. In dit rapport wordt de voor het FISE-platform ontwikkelde inhoud in de vorm van mock-ups getoond.

A large and growing number of EU and national policies draw on, or affect directly and indirectly, Europe's forests, including their ecosystems. Hence, there is a need for improved efforts to provide up-to-date assessments of the condition of European forests. The Forest Information System for Europe (FISE) is launched to respond to this need. This report shows the content developed for the FISE platform in the form of mock-ups.

Keywords: FISE, platform, forest policy, European Commission, European Union, European Environment Agency

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Contents

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Wageningen Environmental Research (WENR) values the quality of our end products greatly. A review of the reports on scientific quality by a reviewer is a standard part of our quality policy.

Approved reviewer who stated the appraisal,

position: Researcher

name: Allard de Wit

date: 1 December 2021

Approved team leader responsible for the contents,

name: Sander Janssen

date: 22 December 2021

1 Introduction

A large and growing number of EU and national policies draw on, or affect directly and indirectly, Europe's forests, including their ecosystems. The European Green Deal and the EU Biodiversity Strategy for 2030 refer to the important role that forests play for biodiversity, climate and water regulation, the provision of food, medicines, materials and woody biomass, carbon sequestration and storage, soil stabilisation and the purification of air and water. In addition, fires, pests, and extreme weather including droughts and storms are damaging forests more frequently; a trend that is expected to further increase with climate change. Forests also suffer from continued habitat and biodiversity loss, while high nitrogen depositions are a concern, along with urban sprawl, and invasive alien species.

Hence, there is a need for improved efforts to provide up-to-date assessments of the condition of European forests. This requires more accurate, frequent data and assessment tools on the status and management of Europe's forest ecosystems. Moreover there is a need to link to all EU forest-data web-platforms. The Forest Information System for Europe (FISE) is launched to respond to this need. FISE is a harmonized forest information system for the 27 EU Member States and the non-EU EEA member countries in the form of a web portal.

Between 2018 and 2021, Wageningen Environmental Research and its partners provided services for the European Environment Agency and Directorate-General for Environment of the European Commission as part of the framework contract called '*framework service contract for providing services in the area of natural capital and ecosystem assessment. Lot 1: Spatial analysis and mapping, informing ecosystem-based management*'. Within this framework contract, specific contract '*Content update and development of the Forest Information System for Europe (FISE)*' focussed on providing content for the FISE platform in the form of mock-ups.

2 Approach

Prior to the start of the contract, the donors DG Environment and the European Environment Agency (EEA) provided a list of priority topics to be addressed and updated. With an interdisciplinary team of topical experts, editors, data analysts and designers new content has been developed for these topics. Topical experts include forest management scientists, climate experts and nature conservation specialists.

Content was produced in the form of mock-ups. Mock-ups combine content, data and map visualisation to explain the state and development of the respective topic. A mock-up includes the causes for development on the state of the topic, the impacts, the responses and solutions for mitigating any negative impacts, and the implications thereof. For each mock-up, first a draft outline was produced, to indicate the logical flow of information, draft visualisations, the location on FISE and possible crosslinks.

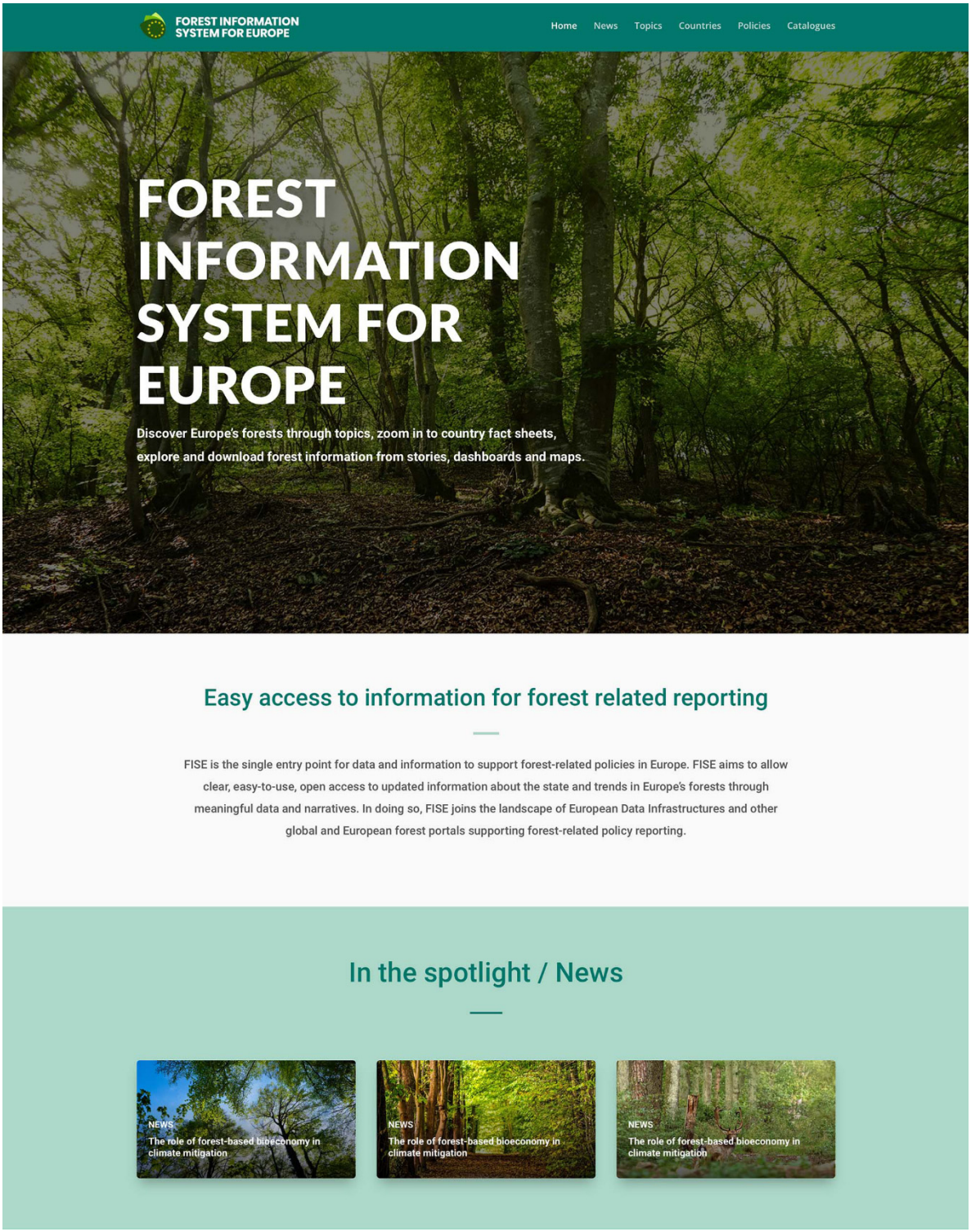
After feedback from the donors, the content was adapted to incorporate the feedback and reformulated by a professional editor. A graphical designer developed artwork, such as info-graphics and photographs, and applied a consistent layout.

The following mock-ups were produced:
- Homepage, that serves as a visual summary of what is on FISE. It providers clarity to users and stimulates exploration of the website's content;
- Banners and spotlight items, the branding of the FISE website with important topics
- Forest area
- Nature
- Climate change
- Bioeconomy
- Biodiversity
- Vitality
- Management
- Country factsheets

The above mock-ups are displayed in the section below.

3 Mock-ups

3.1 Homepage



FISE Topics

Various topics help explain the value of forests in Europe.

Factsheet
Nature

Factsheet
Forest area

Factsheet
Biodiversity

Factsheet
Climate change mitigation

Factsheet
Natural disturbances

Factsheet
Restoration potential

Factsheet
Health and resilience

Factsheet
Bioeconomy and harvest

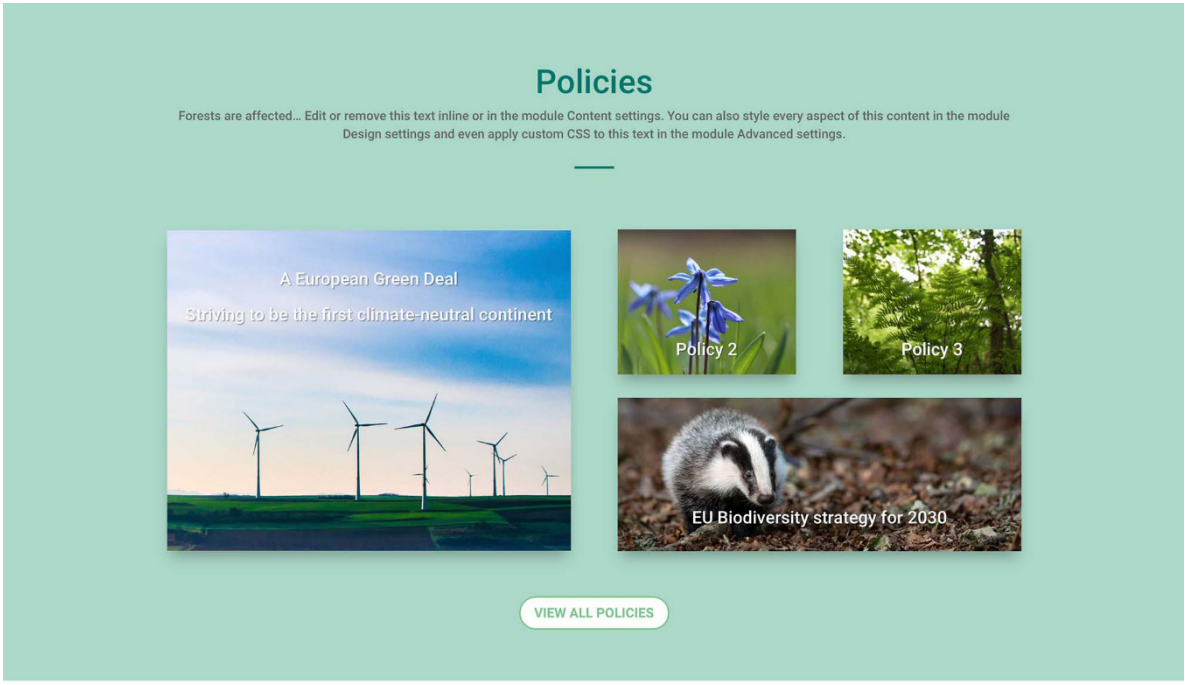
Factsheet
Circularity in the forest sector

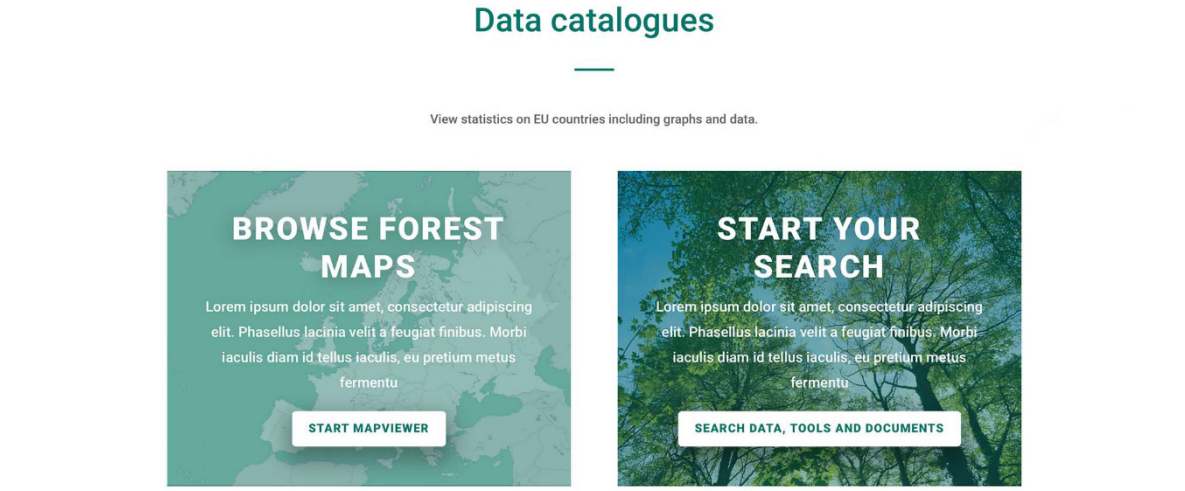
Factsheet
Forest management

Country and region profiles

View statistics on EU countries including graphs and data.

View the European Union region


Policies
Forests are affected... Edit or remove this text inline or in the module Content settings. You can also style every aspect of this content in the module Design settings and even apply custom CSS to this text in the module Advanced settings.
A European Green Deal
Striving to be the first climate-neutral continent
Policy 2
Policy 3
EU Biodiversity strategy for 2030
VIEW ALL POLICIES


Data catalogues
View statistics on EU countries including graphs and data.
BROWSE FOREST MAPS
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START MAPVIEWER
START YOUR SEARCH
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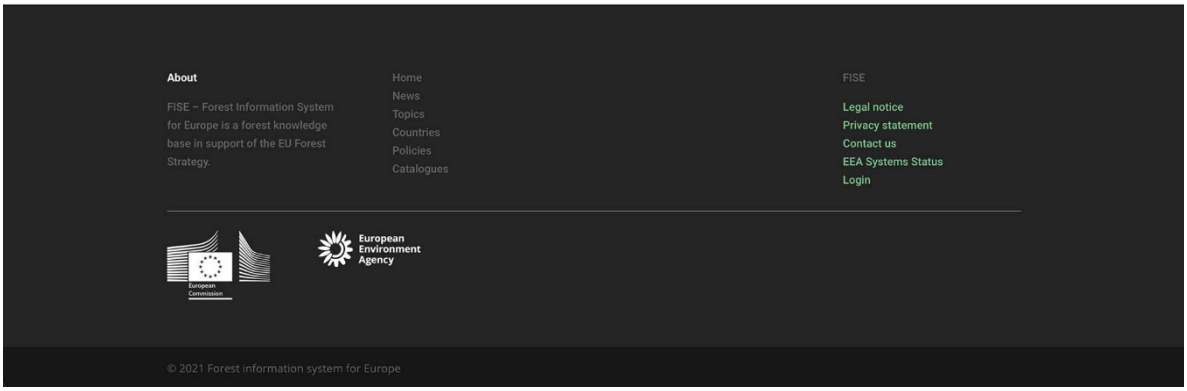
SEARCH DATA, TOOLS AND DOCUMENTS


About
FISE – Forest Information System for Europe is a forest knowledge base in support of the EU Forest Strategy.
Home
News
Topics
Countries
Policies
Catalogues
FISE
Legal notice
Privacy statement
Contact us
EEA Systems Status
Login
European Commission
European Environment Agency
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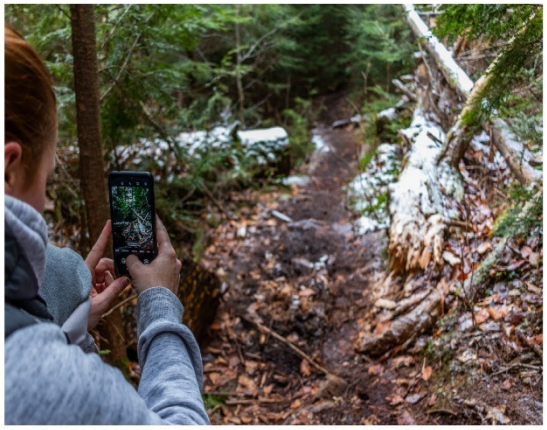
3.2 Banners and spotlight items



FOREST MONITORING

Report the state of our forests

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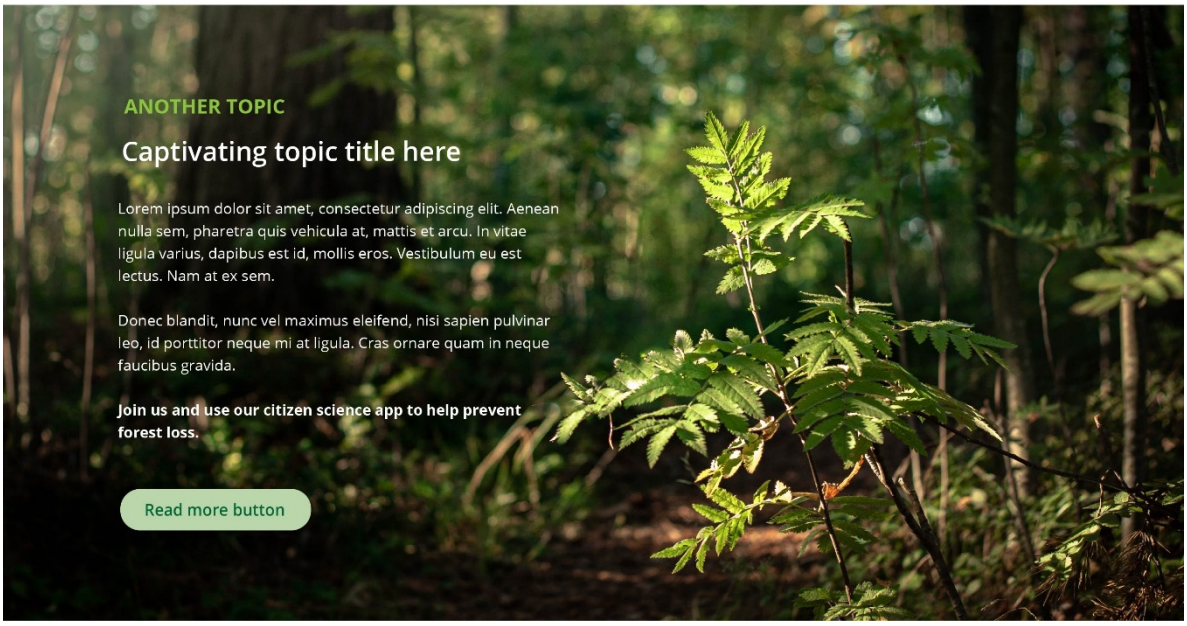
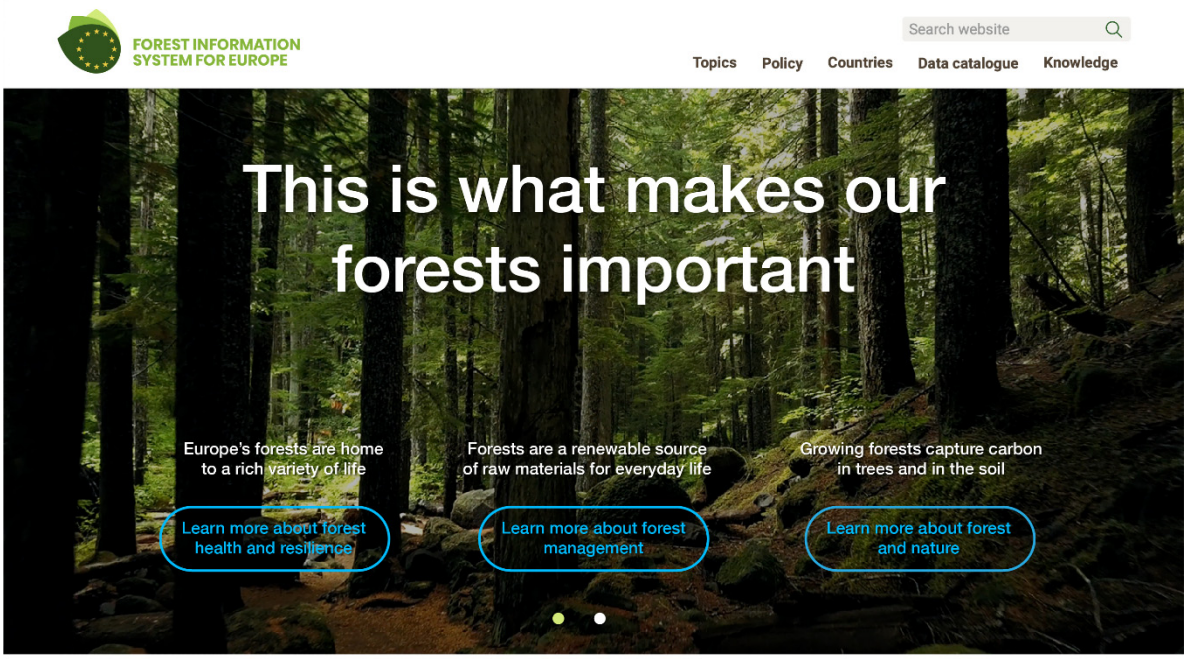
Donec blandit, nunc vel maximus eleifend, nisi sapien pulvinar leo, id porttitor neque mi at ligula. Cras ornare quam in neque faucibus gravida.

Join us and use our citizen science app to help prevent forest loss.

Get our app and join





Welcome to FISE

FISE is the entry point for sharing information with the forest community on Europe's forest environment, its state and development.

FISE brings together data, information and knowledge gathered or derived through key forest-related policy drivers.

MAP MY TREE

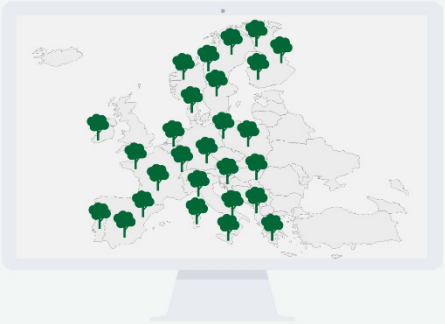
Join Europe's biggest tree planting project

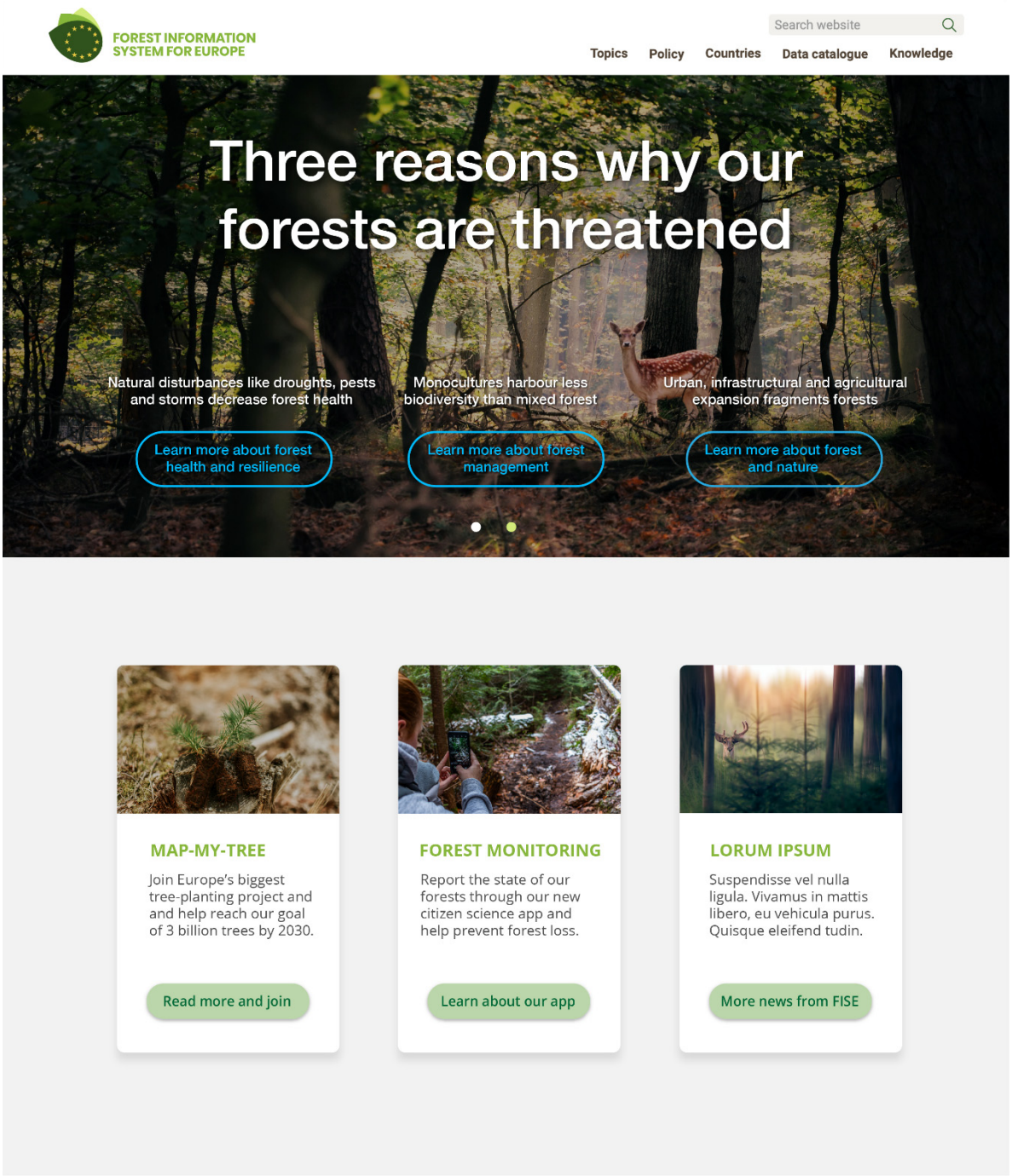
Anyone can plant a tree! And by 2030 we want 3 billion more trees in Europe. To achieve this ambitious target, we need motivated Europeans to plant trees and make sure that they grow over time.

Tree planting requires everyone involved to work together and the success of the pledge depends heavily on grassroots initiatives. Individuals, landowners, associations, companies, and public bodies such as cities and regions are all encouraged to participate in the initiative.

Join Europe's biggest tree-planting project and and help reach our goal of three billion trees by 2030.

Read more and join





Welcome to FISE, the entry point for sharing information with the forest community on Europe's forest environment, its state and development.

FISE brings together data, information and knowledge gathered or derived through key forest-related policy drivers.

3.3 Forest area

Legal notice

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This fact sheet is produced as a part of a project for developing the Forest Information System for Europe (FISE). It contains information obtained or derived from various publicly available sources described within the fact sheet in more detail. It does not intend to be a comprehensive analysis of forest area, but a collection of the main elements for a better insight on the different ways of defining forest area in Europe and the consequences of the various definitions. Our goal is to keep this information timely and accurate. If errors are brought to our attention, please get in touch with charlotte.colliander@eea.europa.eu. We will try to correct them.

WHAT IS A FOREST

a view of Europe's forest coverage

What is considered a forest?

When looking into forest area and cover it is important to consider that the term 'forest' may have very different meanings depending on the context. As a result, different data sources may use different forest definitions or even concepts, typically linked to the assessment methods and criteria agreed in various international frameworks. Great care should thus be taken when using, comparing, or combining, forest area and forest cover estimates.

So, attention should be paid when using different data sources because they may use different forest definitions depending on the assessment method and criteria as agreed in various international frameworks.

A fundamental distinction needs to be made between forest as land cover and forest as land use. Land cover describes the state of the land, often closely linked to the instant or short period an observation is made, e.g. using a sensor aboard a satellite or other forms of Earth Observation. Land use focuses on the function of a piece of land, recorded in cadastral information or land use or management plans, which may disregard the momentary state of the land. This has important implications for managed forest land that undergoes cycles of planting, growth, and harvest. When such land is recently harvested the area seizes to be forest in terms of land cover, until the trees regrow. In terms of land use, however, this land is considered forest throughout the management cycle, including when no trees are present.

Many forest land cover maps follow the Food and Agricultural Organization (FAO) modular-hierarchical Land Cover Classification System. At the regional scale, Forest Europe makes use of the FAO results under the Forest Resources Assessment (FRA), following a land use definition for reporting on the European forest area. Countries validate collected information before publishing and aligning forest definitions on forest cover and land use. At the European scale, data on forest is gathered by the CORINE Land Cover monitoring (CLC) combining land cover information from satellite with land use information from other sources.

Forest definitions

The FAO-FRA definition of forest is "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use." EUROSTAT and Forest Europe make use of the same definition[1]. The FAO-FRA definition provides further explanations such as that forests are designated landholdings used as forests, regardless of their current vegetation. Regeneration sites after harvesting, understocked sites due to clear-cut and (natural) disasters, nurseries, forest roads and firebreaks, rubber-wood, cork oak and Christmas tree plantations, areas with bamboo and palms (if height and canopy cover criteria are met) etc. are included in the forest area. It excludes tree stands in agricultural production systems such as in fruit plantations and agro-forestry systems, and trees in urban parks and gardens[2].

[1] Eurostat collects information on the area of wooded land, including forest and other wooded land as defined in FAO FRA, through the European Forest Accounts (EFA). The methodology states that data on land reported through that questionnaire "must be coherent with other data provided at European and international level (national accounts, Forest Europe, FAO, and OECD)". 14 Member States report data on forest area to Eurostat under the EFA, and in addition Eurostat gapfills EFA tables with FAO-FRA data on forest area. Data reported for the same variable are in general well aligned among EFA, FRA and Forest Europe.

[2] National definition of forests however, could differ from the FAO definition.

The FAO's Forest definition is the internationally recognised reference definition and is being used by Forest Europe, FISE, and the Joint Forest Sector Questionnaire (JFSQ)/Forest Accounts of Eurostat.

The CORINE Land Cover (CLC) definition is: "Areas occupied by forests and woodlands with a vegetation pattern composed of native or exotic coniferous and/or broad-leaved trees and which can be used for the production of timber or other forest products. The forest trees are under normal climatic conditions higher than 5 m with a canopy closure of 30% at least. In case of young plantation, the minimum cut-off-point is 500 subjects by ha." This definition uses Forest cover to refer to areas where trees dominate a veg-

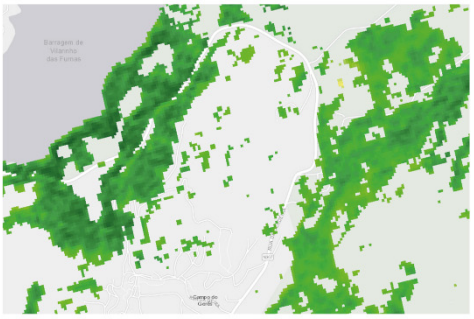


Figure 1. Image of forest cover example Copernicus HRL forest cover 2018, screenshot Peneda-Gerês National Park, Portugal (copernicus.eu).

etation type. 'Forest cover' is used primarily when assessments are based on remote sensing, and legal designation of the land or forest or other is unknown. This definition also uses criteria for minimum tree cover, minimum tree height and a minimum area below which the area it is not considered a forest.

Besides the FAO and CLC assessments, which both have their own definition of forest, the EUROSTAT LUCAS and the UN-FCC-LULUCF assessments are noteworthy. They both use the FAO forest definition in their own process to collect and process data of the forest area but have their own specific criteria and thresholds set in their specific policy context..

The EUROSTAT LUCAS survey is a European-scale field survey. It generates harmonised forest land cover and land use data for European statistics through direct field observations every three years since 2006 (EUROSTAT-LUCAS). The LUCAS 'Woodland' land cover class equals the FAO Forest class and the 'Shrubland' cover' class is equal to the FAO class 'Other Wooded Land'. The share of forest area based on the LUCAS data is used as indicator for the Sustainable Development Goal Life on land (SDG 15).

Under the UN Framework Convention on Climate Change (UNFCCC), parties annually report on land use, land use change and forestry (LULUCF) to provide information on carbon greenhouse gas emissions and removals from land use including forests. The forest definition follows the 2006 IPCC Guidelines on national greenhouse gas inventories (vol. 4) which allows to set minimum thresholds for area, tree height and tree crown cover density according to national circumstances. Specific Member States implementations are reported in National Inventory Reports and listed in Annex II of the LULUCF Regulation. In few cases there are differences between definitions in National inventory reports and the LULUCF Regulation which will require reconciliation for compliance.

As the UNFCCC focus on anthropogenic emissions and removals and this is distinguished by whether land is managed (anthropogenic) or unmanaged (non-anthropogenic) Parties also report on whether areas are managed or unmanaged. Using the land-based approach means including all the national territory in one of the six land use categories and all emissions and removals from managed land will then be included in the national greenhouse gas inventory. Countries provide information on the base of guidelines on the forest area following their own criteria for crown cover, tree height, minimum area (for land spanning elements) and minimum width (for linear elements) (Annex 2).

Terms related to forest

Besides forest itself, there are other terms that are used in land classifications that may influence the forest area. The FAO forest assessment defines two classes similar to forests: 'Other Wooded Land' (OWL) and 'Other land with tree cover' (OLT). EUROSTAT and Forest Europe make use of the same categories. The FAO defines OWL as land with a canopy cover of 5-10 percent of trees able to reach a height of 5 m in situ, or a canopy cover of more than 10 percent when smaller trees, shrubs and bushes are included. Other Land with Tree cover (OLT) is defined as 'Other land' that is predominantly agricultural or urban land use and has patches of tree cover that span more than 0.5 hectares with a canopy cover of more than 10 percent of trees able to reach a height of 5 meters at maturity" and including both forest

The CORINE Land Cover Forest classes

Broadleaved forest (class 3.1.1): Vegetation formation composed principally of trees, including shrub and bush understorey, where broad-leaved species predominate, crown cover density is > 30 % or a minimum 500 subjects/ha density, and with broad-leaved trees representing > 75 % of the formation. The minimum tree height is 5 m.

Coniferous forests (class 3.1.2): Vegetation formation composed principally of trees, including shrub and bush understorey, where coniferous species predominate, crown cover density of > 30 % or a minimum 500 subjects/ha density, and with coniferous trees representing > 75 % of the formation. The minimum tree height is 5 m (with the exception of Christmas tree plantations).

Mixed forest (class 3.1.3): Vegetation formation composed principally of trees, including shrub and bush understorey, where neither broad-leaved nor coniferous species predominate, crown cover of > 30 % or a 500 subjects/ha density for plantation structure. The share of both coniferous and broad-leaved species exceeds 25 % within the canopy closure. The minimum tree height is 5 m.

'Transitional woodland and shrub areas' (class 3.2.4) represent 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.

'Transitional woodland and shrub' corresponds to the land cover and use as defined by the FAO as 'Forest' or ' Forest and other wooded land'. This is why all the four forest classes can best be applied when estimating forest land in Europe. A crosswalk table with a comparison of 'Transitional woodland and shrub' versus Forest and 'Other wooded land' is given in the Annex 4.

and non-forest tree species. Similarly to the FAO category 'Other wooded land', LUCAS also considers class 'Other wooded land', while the CORINE land cover classification includes a category called 'Transitional woodland and shrub'. More detail is given in Annex 1 and on CORINE land cover nomenclature. The IPCC guidelines do not foresee such a top level land use category but could allow for specific implementations at sub-category level. You can find more detail on the FAO definitions of 'Forest', 'OWL' and 'OLT' in Annex 1 and on (FAO terms and definitions GFRA 2020 fao.org).

'Trees outside forest' (TOF) are all trees as excluded by the definition of 'Forest' and 'Other wooded land' (fao.org). TOF have an essential role for biodiversity, climate change mitigation and health aspects. Likewise, there is a growing interest in monitoring TOF (Euronews) due to the ambition to plant 3 billion trees by 2030 in the EU. TOFs are not assigned an area in the overall land use classification but occur inside 'Other land'. Although the definition of TOF is based on trees, it also includes other vegetation and characteristics at the site.

The comparison of the forest area (including Other wooded land) from the different assessments shows that they result in a different forest area for Europe (Figure 3). This comparison is further complicated by the fact they have different assessment years (Depending on the data sources the EU outermost territories may or may not be included). The difference between to FAO's 2020 estimate for the EU27 forest area (159 million ha), and the LULUCF estimate from 2019 (163 million ha) is greater than 4 million hectares, or roughly the forest area of Latvia. The CORINE Land Cover reports the lowest forest area, even when the area for 'Transitional woodland and shrub' is included.

As an example, the forest area for the EU27 reported in the forest assessments of FAO-FRA, LULUCF, CLC, and LUCAS show large differences over the period 1990-2020 (Figure 4). The forest area according FAO-FRA (the sum of Forest and OWL) amounts to approximately 180 million ha in 2020, which is similar to the forest area reported by LUCAS (2018), but much higher than the area reported by CLC and LULUCF. FAO-FRA reported for 2020 a 10% higher forest area (ca. 17 million ha) than was reported by LULUCF, which could mainly be explained by the inclusion of the OWL class in the FAO-FRA forest area. Although the class Transitional woodlands and shrubs is included in the CLC forest area in the graph, which together with the CLC Forest class theoretically covers about the same land cover types as the FAO Forest and OWL classes, the area reported by CLC is 23 million ha lower than that reported by FAO-FRA.

The Member states use different forest definitions

All EU member states base their national forest definition on area, a percentage of tree crown cover and tree height. However, differences exist between member states for minimum values used for these criteria which lead to a difference in forest area.

A minimum tree height of 5 meter is used in most (63%) of the EEA member states its forest definitions, and almost half of the member states use a minimum tree cover of 10%. The criterium used for minimum area size is much more diverse, over a third uses the criterium of 0.5 ha as minimum area size for forest areas, and 18% uses a minimum area size of 0.1 ha.

Also the estimation method used in the national inventories is quite diverse: 32% of the surveys use field plots and 10% use photo interpretation. Other surveys use maps (11%), combined methods (25%) or is unkown (24%).

Figure 2. Quantitative forest criteria and estimation method used by EEA member states to define forest. Data is given in Annex 2.

Consequences of different definitions

All four assessments for the EU27 show an increase of the forest area for all periods considered, yet at a slower pace in the last 15 to 20 years. The hybrid land cover-land use CLC assessment (including forest and transitional woodland and shrub) even shows a slight decrease in forest area of 108.000 ha over the period 2012 to 2018. These assessments combined lead to some important conclusions:

1. The concept of forest and land cover, land use or a hybrid of both as well as their specific definitions and thresholds is a key consideration when assessing forest cover in the EU and Member States
2. Several assessments point to an increase in forest area in the last 30 years;
3. Growth in forest and tree-covered area has slowed in the last two decades.

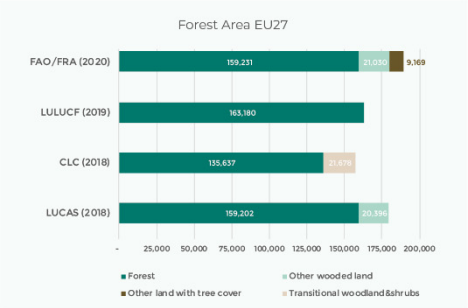


Figure 3. Forest area (1000 ha) for the EU27 according to different forest assessments of FAO-FRA, LUCAS, CORINE Land cover, and LULUCF (year of reporting for sources: FAO-FRA: 2020, LUCAS: 2018, CORINE-CLC: 2018, UNFCCC: 2019). LULUCF includes managed and unmanaged forests as defined by IPCC.

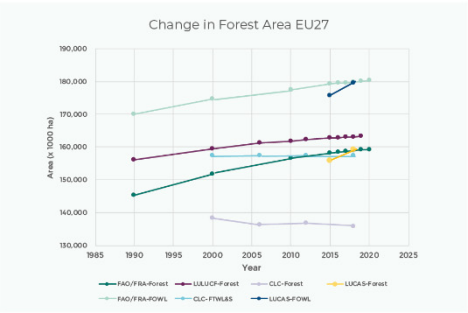


Figure 4. Forest area for the current EU27 Member States[3]. FAO-FRA data is presented for both "forest area" and "forests and other wooded land" (FOWL), and LUCAS data is presented in a similar manner ("forest" area and "forest and other wooded land" – FOWL). ; CLC data is presented as "forest" area (including broadleaved forest, coniferous forest, mixed forest) and "forest and transitional woodland and shrub' (FTWL&S). LULUCF includes managed and unmanaged forest as defined by IPCC.

[3] Data sources fig. 3 and fig. 4: FAO/FRA; CLC: Land cover and land cover changes in European countries in 2000-2018 — Copernicus Land Monitoring Service; LULUCF; LUCAS 2

Why are there different definitions of forests?

The different forest definitions are formulated to meet specific management, legal or policy purposes e.g., biodiversity (protected forest area), timber (forest available for wood supply), or land use designated as forest. Depending on the purpose, different definitions use different criteria which will yield different forest areas. Criteria may be used to assess:

- The value for timber;
- The value for biodiversity;
- The value for cultural services (e.g. recreation, tourism, spiritual);
- The value for drinking water quality;
- The value for carbon sequestration and storage;
- The value for other ecosystem services (SEEA);
- The improvement of livelihoods of forest-dependent people;
- Whether forests are natural or planted, unmanaged or managed;
- Whether forests are pre-existing or newly established;
- Whether forests are continuous or fragmented;
- Whether forests are composed of native or non-native species
- Whether forests are undisturbed.

How can we measure forest areas - Field surveys

Forest characteristics can be measured through roughly two different methods: field surveys and remote sensing surveys. These two approaches are usually combined.

Field surveys

Field surveys are carried out on the ground in the forest. Field surveys have a wide range of methodological approaches and aspects that are monitored. Some collect information on forest resources such as forest area, tree species, and wood volume. Others collect information on aspect such as forest presence, forest health, forest vegetation, biodiversity indicators etc. Common feature of all field surveys is that measurements are taken in the field. Here field surveys at the national and European level are explained.

National Forest Inventories

Most countries periodically assess their forests through a National Forest Inventory (NFI) to collect information on forest resources such as forest area, tree height, tree diameter, tree species, and tree age. Forest area is estimated from the point of view of land use and the definition of forest extent includes unstocked areas such as clearing areas, forest roads, nurseries etc. Other forest characteristics such as basal area, growing stock, or carbon sequestration are estimated based on this information. Some countries collect additional information such as whether the forest stand is planted or naturally regenerated, conservation status, amount of dead wood present, property status, and fragmentation. On some occasions, information is collected on flora and fauna. The information is collected through field surveys which are based on different designs for the sample points such as random stand selection or grid selection. Information is primarily presented through statistics and used by national governments for national policy goals and by forest owners for management purposes.

The results of the NFIs are reported to global and European reporting processes. Forest Europe reports on the state of Europe's forests. (State of Europe's Forests 2020), the FAO-FRA reports on forests worldwide Global Forest Resources Assessment 2020. Further, the European Forest Inventory Network (ENFIN) is working on harmonisation of collecting and reporting forest data.

European Forest Survey

The EUROSTAT-LUCAS survey is a European scale field survey. It works on harmonised land cover and land use data for European statistics carried out through direct field observations every three years since 2006. Collected data are comparable among the participating countries. The LUCAS survey forestry classes are aligned to that of the FAO. The LUCAS 'Woodland' land cover class is equal to the FAO Forest class and 'Shrubland' cover class is equal to the FAO class Other Wooded Land. One of the limitations of LUCAS with respect to forests is the missing of additional (non-agricultural) information on forest. More information on LUCAS can be found on the website Overview - Land cover/use statistics.

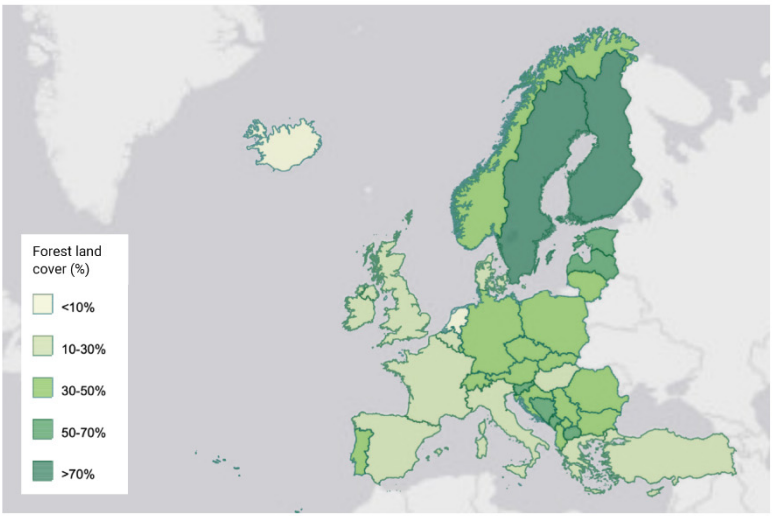


Figure 5. Forest land cover in 2018 for the EEA countries
Source: Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community | European Environment Agency (EEA), Copenrnicus Land Monitoring Service 2018

How can we measure forest areas - Remote sensed surveys

Remote sensing techniques occur through (semi) automatic methods. At European level, treed land is estimated based on satellite survey and measured as percentage of canopy cover. The canopy cover is often thresholded for classifying grid cells into forest/non-forest. No minimum size of forest area is considered for classifying grid cells into forest/non-forest. The Copernicus Land Monitoring Service (CLMS) is one of the most important European land cover surveys. Its pan-European component the CORINE Land Cover (CLC) datasets, and High-Resolution Layers (HRL) among which the HRL Forest layers.

The **CORINE Land Cover** is provided for 1990, 2000, 2006, 2012, and 2018. This vector-based dataset includes 44 land cover and land use classes, of which the four before mentioned forest classes. The time-series also includes a land change layer, highlighting changes in land cover and land-use.

The countries validate collected information before publishing and aligning forest definitions on forest cover and land use.

CLC uses a Minimum Mapping Unit (MMU) of 25 hectares (ha) for areal phenomena and a minimum width of 100 m for linear phenomena. The time series are complemented by change layers, which highlight changes in land cover with an MMU of 5 ha. The proposed MMU for the CLC-Backbone product is 0.5 ha and this could match with the national definition of about half of the MS. However, in the CLC-Core the MMU will be 1 ha.

The method used for the CLC map is a special remote sensing case because it is implemented by human delineation of the polygons using land use and land cover definitions. The definitions differ from the definitions of NFIs and other remote sense methods.
The definitions of the types are further explained on copernicus.eu. More information on the Corine Land Cover inventory is given in the Corine Land Cover Brochure.

The **High Resolution layers (HRL)** are raster-based datasets which provide information about different land cover characteristics and are complementary to land-cover mapping (e.g. CORINE) datasets. Three products are relevant for forest area that are available for the reference years 2012, 2015 and 2018:

1. Tree cover density (TCD) (level of tree cover density in a range from 0-100%);
2. Dominant leaf type (DLT) (broadleaved or coniferous majority);
3. Forest type (FTY) which estimates the forest type product to get as close as possible to the FAO forest definition.

The HRL-Forest 2018 has a resolution of 10m and the previous series a resolution of 20m. Forest cover is estimated based on tree cover density (TCD) detected with satellite images. TCD differs from the stand density (number of trees per ha) as esti-mated by field surveys. No information is extracted on specific stand characteristics such as tree species, tree height, and stem

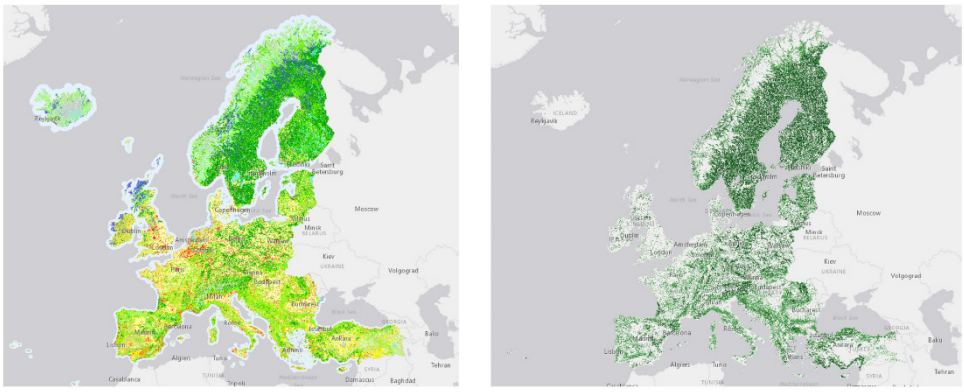


Figure 6. CORINE-Land Cover map (left) and Copernicus HRL-Forest map (right)
Source: CORINE/COPERNICUS

diameter. Therefore when using satellite data, it is very important to interpret and verify them against of national source e.g. from NFIs. More information on the HRL Forest map can be found on the website Forests — Copernicus Land Monitoring Service.

Airborne Laser Scanning (ALS) provides forest data through radar surveys such as crown projection and information on tree height and stem diameter, which is essential information to calculate growing stock and timber assortments. In several countries, e.g., Sweden, a wall-to-wall national forest map is created using ALS techniques[4]. The technique needs further development before it can be widely used in all forest types to collect forest information comparable with field surveys.

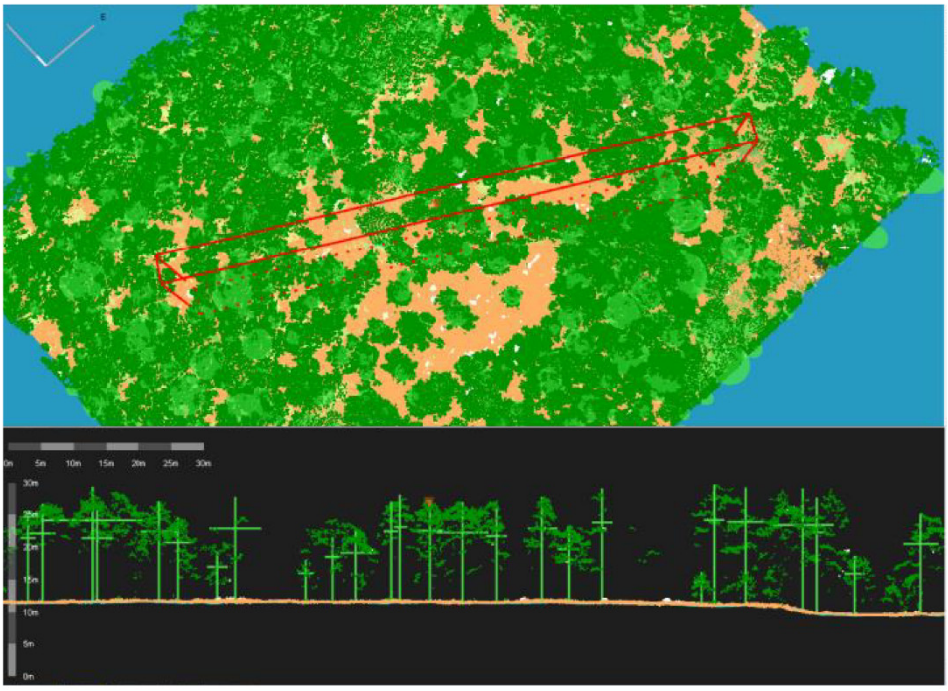


Figure 7. Example of a ALS/Lidar image of forest (Forest reserve Dieverzand, the Netherlands, image Wageningen Environmental Research)

[4] M. Nilsson, K. Nordkvist, J. Jonzén, et al. (2017) A nationwide forest attribute map of Sweden predicted using airborne laser scanning data and field data from the National Forest Inventory. Remote Sensing of Environment, Volume 194, 2017, pp 447-454. DOI 10.1016/j.rse.2016.10.022.

ANNEXES

Annex 1

International forest land definitions

FAO definitions

Forest

Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use.

Explanatory notes

1. Forest is determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 meters in situ.
2. Includes areas with young trees that have not yet reached but which are expected to reach a canopy cover of 10 percent and tree height of 5 meters. It also includes areas that are temporarily unstocked due to clear-cutting as part of a forest management practice or natural disasters, and which are expected to be regenerated within 5 years. Local conditions may, in exceptional cases, justify that a longer time frame is used.
3. Includes forest roads, firebreaks and other small open areas; forest in national parks, nature reserves and other protected areas such as those of specific environmental, scientific, historical, cultural or spiritual interest.
4. Includes windbreaks, shelterbelts and corridors of trees with an area of more than 0.5 hectares and width of more than 20 meters.
5. Includes abandoned shifting cultivation land with a regeneration of trees that have, or are expected to reach, a canopy cover of 10 percent and tree height of 5 meters.
6. Includes areas with mangroves in tidal zones, regardless whether this area is classified as land area or not.
7. Includes rubber-wood, cork oak and Christmas tree plantations.
8. Includes areas with bamboo and palms provided that land use, height and canopy cover criteria are met.
9. Includes areas outside the legally designated forest land which meet the definition of "forest".
10. Excludes tree stands in agricultural production systems, such as fruit tree plantations, oil palm plantations, olive orchards and agroforestry systems when crops are grown under tree cover. Note: Some agroforestry systems such as the "Taungya "system where crops are grown only during the first years of the forest rotation should be classified as forest.

FRA2020 Terms and definitions

Other wooded land

Land not classified as 'Forest', spanning more than 0.5 hectares; with trees higher than 5 meters and a canopy cover of 5-10 percent, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban land use.

Explanatory notes: The definition above has two options:

1. The canopy cover of trees is between 5 and 10 percent; trees should be higher than 5 meters or able to reach 5 meters in situ. or
2. The canopy cover of trees is less than 5 percent but the combined cover of shrubs, bushes and trees is more than 10 percent. Includes areas of shrubs and bushes where no trees are present. - Includes areas with trees that will not reach a height of 5 meters in situ and with a canopy cover of 10 percent or more, e.g. some alpine tree vegetation types, arid zone mangroves, etc.

FAO terms and definitions GFRA 2020

Other land with tree cover

Land considered as 'Other land', that is predominantly agricultural or urban lands use and has patches of tree cover that span more than 0.5 hectares with a canopy cover of more than 10 percent of trees able to reach a height of 5 meters at maturity. It includes both forest and non-forest tree species.
The difference between Forest and Other land with tree cover is the land use criteria. Includes groups of trees and scattered trees (eg trees outside forest) in agricultural landscapes, parks, gardens and around buildings, provided that area, height and canopy cover criteria are met. Includes tree stands in agricultural production systems, for example in fruit tree plantations and agroforestry systems when crops are grown under tree cover. Also includes tree plantations established mainly for other purposes than wood, such as oil palm plantations. Excludes scattered trees with a canopy cover less than 10 percent, small groups of trees covering less than 0.5 hectares and tree lines less than 20 meters wide.

FAO terms and definitions

Forest Europe definitions

Forest

See FAO

Terms and Definitions

CORINE LAND COVER definitions

Forest

Areas occupied by forests and woodlands with a vegetation pattern composed of native or exotic coniferous and/or broad-leaved trees and which can be used for the production of timber or other forest products. The forest trees are under normal climatic conditions higher than 5 m with a canopy closure of 30 % at least. In case of young plantation, the minimum cut-off-point is 500 subjects by ha.

Corine Land Cover classes

LULUCF definitions

Forest

Following the FAO Forest definition, but countries can adapt the threshold settings for the criteria on crown cover, area size, and tree height. See Annex 2

UNFCCC Biome-specific forest definitions

Annex 2

Quantitative thresholds used to define forests as selected by individual EU MS, UK and Iceland as used in LULUCF National Forest Inventories (NFI) surveys and reporting

Country	Crown cover [1] (%)	Height [1] (m)	Area [1] (ha)	Minimal width [1] (m)	Estimation method [2]
Albania					
Austria	30	2	0.05	10	Field plots
Belgium	20	5	0.5		Photo grid
Bosnia and Herzegovina					
Bulgaria	10	5	0.1	10	
Croatia	10	2	0.1		
Cyprus	10	5	0,3		Photo interpretation
Czech Republic (FAO definition) [3]	20	5 – in situ	0.5	20	Field plots
Denmark	10	5	0.5	20	Photo interpretation and field plots
Estonia	30	2	0.5		Field plots
Finland	10	5	0.25/0.5*	20 **	Field plots
France	10	5	0.5	20	Photo interpretation and field plots
Germany	10	5	0.1		Field plots
Greece	25	2	0.3		Photo grid
Hungary	30	5	0.5		Photo interpretation
Kosovo under UNSCR 1244/99					
Latvia	20	5	0.1	20	Photo interpretation
Iceland	10	2	0.5	20	Field plots
Lichtenstein					

Country	Crown cover (%)	Height (m)	Area (ha)	Minimal width (m)	Estimation method
Lithuania	30	5	0.1	10	Field plots
Ireland	20	5	0.1	20	Photo interpretation and field plots [3]
Italy	10	5	0.5		Photo interpretation
Luxembourg	10	5	0.5		Photo grid
Malta	30	5	1		
Montenegro [3]	10	5	0.5	20	Photo interpretation and field plots
Netherlands	20	5	0.5	30	Map
North Macedonia					
Norway	10	5			Field plots
Poland	10	2	0.1		Maps and field plots
Portugal	10	5	1	20	
Romania	10	5	0.25	20	Photo grid
Serbia	10	5	0,5		Field plots
Slovakia	20	5	0.3	20	Field plots
Slovenia	30	2	0.25		Map
Spain	20	3	1	25	Map
Sweden	10	5	0.5		Field plots
Switzerland	20	3	0,0625		Field plots
Turkey	10	5	1		Wall to wall land use map

Sources

1. Regulation (EU) 2018/ of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU (europa.eu) Annex II

2. Lawrence, M. R.E. McRoberts, E. Tomppo, T. Gschwantner, and K. Gabler (2010) Comparisons of National Forest Inventories). Tomppo, E., T. Gschwantner, M. Lawrence, R.E. McRoberts (Eds.) National Forest Inventories. Pathways for common reporting. (Table 2.1. p21) DOI 10.1007/978-90-481-3233-1

3. Values provided by the countries.

Annex 3

National Definitions: each country has its own Forest definition (source LULUCF)

Country	National forest land definition
Austria	Permanently unstocked basal areas that are directly connected with forest in terms of space and forestry enterprise and contribute directly to its management (such as forestal hauling systems, wood storage places, forest glades, forest roads) also represent forests. Areas which are used in short rotation with a rotation period of up to thirty years as well as forest arboretums, forest seed orchards. Christmas tree plantations and plantations of woody plants for the purpose of obtaining fruits such as walnut or sweet chestnut do not account as forests. Rows of trees (except shelter belts for wind protection) and areas with woody plants in a park structure are not forest land.
Belgium	This category includes all land with woody vegetation consistent with thresholds used to define forest land as described in paragraph 6.1 of the NIR. It also includes systems with vegetation that currently fall below, but are expected to exceed, the threshold of the forest land category.
Bulgaria	Areas of natural forest regeneration outside urban areas with a size of more than 0.1 ha also represent "forest". Forests are also: areas which are in a process of recovering and are still under the parameters, but it is expected to reach forest crown cover over 10% and tree height 5 meters; areas, which as the result of anthropogenic factors or natural reasons are temporarily deforested , but will be reforested; protective forest belts, as well as tree lines with an area over 0.1 ha and width over 10 meters; cork oak stands. City parks with trees, forest shelter belts, and single row trees do not fall under the category "forests.
Croatia	Forest includes land under forest management (forest land without tree cover): Productive forest land without tree cover, non-productive forest land without tree cover, barren wooded land (e.g. forest roads wider than 3 meters, quarries)
Cyprus	Forests include forest roads, cleared tracts, firebreaks and other small open areas within the forest as well as reforested areas or burnt areas or other areas that temporarily have low plant cover due to human intervention or natural causes, but does not include municipal parks and gardens.
Czechia	Forests excludes the areas of permanently unstocked cadastral forest land, such as forest roads, forest nurseries and land under power transmission lines.
Denmark	Temporarily non-wooded areas, fire breaks and other small open areas, that are an integrated part of the forest, are also included. Christmas trees are also included.
Estonia	All temporarily unstocked forest areas and regeneration areas which have yet to reach a crown density of 30 per cent and a tree height of 2 meters are also included as forest, as are areas which are temporarily unstocked as a result of human intervention such as harvesting, or natural causes (fires, etc.) but which are expected to revert to forest.
Finland	Productive forest land, part of the poorly productive forest land and forest roads. Parks and yards are excluded regardless of whether they meet the forest definition.
France	Forest roads, forest openings less than 20 m wide (e.g. for fire control) , windbreaks and forest belts, as well as the poplar plantations and short rotations woody crops, if the criteria for Forest land are met. 5% of France's European forests are unmanaged on lands such as strong slopes or used for leisure, esthetic, cultural or military. Also, 40% of France's dependencies Forest land is considered as unmanaged.
Germany	Any area of ground covered by forest vegetation, irrespective of the information in the relevant cadastral survey or similar records. "Forest" also refers to cutover or thinned areas, forest tracks, firebreaks , openings and clearings, forest glades, feeding grounds for game, landings, rides located in the forest, further areas linked to and serving the forest including areas with recreation facilities, overgrown heaths and moorland, overgrown former pastures, alpine pastures and rough pastures, as well as areas of dwarf pines and green alders. Heaths, moorland, pastures, alpine pastures and rough pastures are considered to be overgrown if the natural forest cover has reached an average age of five years and if at least 50% of the area is covered by forest. Forested areas of less than 1,000 m^2 located in farmland or in developed regions, narrow thickets less than 10 m wide, watercourses up to 5 m wide do not break the continuity of a forest area.
Greece	No additional criteria available.
Hungary	Forest land (includes **FL-FL, L-FL** sub-categories) includes areas covered by trees, as well as roads and other areas that are under forest management but that are not covered by trees.
Ireland	Land with a minimum area of 0.1ha, a minimum width of 20 m, trees higher than 5 m and a canopy cover of more than 20% within the forest boundary, or trees able to reach these thresholds in situ.

Country	National forest land definition
Italy	Forest roads, cleared tracts, firebreaks and other open areas within the forest as well as protected forest areas are included in forest. Plantations, mainly poplars, characterised by short rotation coppice system and used for energy crops are included and also other plantation as chestnut and cork oak, have been included in forest land.
Latvia	Young natural stands and all plantations established for the forestry purposes, which have to reach a crown density of 20 % or tree height of 5 m are considered under forest land; as well as the areas normally forming part of the forest area, which are temporarily unstocked as a result of human intervention or natural causes, but which are expected to revert to forest.
Lithuania	Tree lines up to 10 meters of width in fields , at roadsides, water bodies, in living areas and cemeteries or planted at the railways protection zones as well as single trees and bushes, parks planted and grown by man in urban and rural areas are not defined as forests.
Malta	No additional criteria available.
Luxemburg	Permanently unstocked basal areas that are directly connected with forest in terms of space and forestry enterprise and contribute directly to its management (such as forestal hauling systems, wood storage places, forest glades, forest roads) also represent forests. Areas which are used in short rotation with a rotation period of up to thirty years as well as forest arboretums, forest seed orchards, Christmas tree plantations and plantations of woody plants for the purpose of obtaining fruits such as walnut or sweet chestnut do not account as forests but represent cropland. Rows of trees (except shelter belts for wind protection) and areas with woody plants in a park structure are not forest land.
Netherlands	The Netherlands has chosen to define the land-use category "Forest Land" as all land with woody vegetation, now or expected in the near future (e.g. clear-cut areas to be replanted, young afforestation areas)
Poland	Young stands and all plantations that have yet to reach a crown density of 10 percent or a tree height of 2 m are included under forest. Areas normally forming part of the forest area that are temporarily unstocked as a result of human intervention, such as harvesting or natural causes such as wind-throw, but which are expected to revert to forest are also included.
Portugal	Forests (areas occupied by forests and woodlands which can be used for the production of timber or other forest products) and agroforestry areas (annual crops or grazing land under the wooded cover of forestry species). The forest trees are under normal climatic conditions higher than 5 m with at least 30% canopy closure.
Romania	It comprises deciduous forest, coniferous forest, mixt forests, clear-cut areas and nurseries, as defined by presence of deciduous trees, coniferous trees, deciduous and resinous trees, dead trees, clear-cuts and forest nursery.
Slovakia	This category includes the land covered by all tree species serving for the fulfillment of forest functions and the lands on which the forest stands were temporarily removed with aim of their regeneration or establishment of forest nurseries or forest seed plantation.
Slovenia	It includes abandoned agricultural land with natural expansion of forest. Abandoned agricultural land on area more than 0.5 ha, which have been abandoned for more than 20 years, with minimal tree height 5.00 m and have a tree crown cover between up to 75 % are defined as forests.
Slovenia	It includes abandoned agricultural land with natural expansion of forest. Abandoned agricultural land on area more than 0.5 ha, which have been abandoned for more than 20 years, with minimal tree height 5.00 m and have a tree crown cover between up to 75 % are defined as forests.
Spain	Any land having woody vegetation with no agricultural use/activities fulfilling the threshold of forest and any other land which is expected achieve these parameters (including for "dehesa" where tree cover meet the thresholds).
Sweden	Land with a tree crown cover (or equivalent stocking level) of more than 10 % at maturity, with a minimum area of 0.50 hectare. The trees should be able to reach a minimum height of 5 m at maturity in situ. No minimum width is considered. Permanent forest roads (width>5m) are not considered forest land. All forests are considered managed.
United Kingdom	Forestry statistics definition used for GHG inventory includes integral open space and felled areas that are waiting restocking.
Iceland	All forested lands, not belonging to Settlement, that is presently covered with trees or woody vegetation that reach the defined thresholds. Natural birch woodland is included in the IFR national forest inventory (NFI). In the NFI the natural birch woodland is defined as one of the two predefined strata to be sampled. The other stratum is the cultivated forest consisting of tree plantation, direct seeding or natural regeneration originating from cultivated forest.

Annex 4

Crosswalk table comparing Corine Transitional woodland and shrub versus FAO Other wooded land

Transitional woodland and shrub	Forests according to FAO (Forest / Other wooded land)
clear cuts in forest areas;	Forest
open clear-felled or regeneration areas in the transitional stage of regrowth, which lasts for usually 5-8 years or until trees reach the 5 m height;	Forest and other wooded land
young forest plantations;	Forest
forest nurseries inside forests area;	Forest
electric line corridors, fire breaks (if wider than 100 m);	Fires breaks = forests
natural grassland areas with small patches of forest < 25 ha and/or with trees intermixed which cover < 30 % of the surface;	Forest and other wooded land
burnt forest or burnt natural shrubland areas that do not show black tones any more in the satellite imagery, but damage is still visible;	Forest
forests heavily damaged by wind, snow-brake, avalanche, insects, acid rain or other pollution with > 50 % of trees severely affected;	Forest
areas of recultivation of mineral extraction sites and dump sites by means of afforestation or natural / semi-natural succession with shrubs;	Forest
agricultural lands (classes 2xx) under recolonization process with occurrence of young forest trees, which cover > 30 % of the surface (scattered trees or small plots of young trees);	Forest and other wooded land
abandoned fruit tree plantations and orchards;	No (class 323)
afforestation on former natural grasslands or natural shrubs (322, 323), even when original vegetation still dominates;	Forest and other wooded land
arborescent matorrals that are pre- or post-formation of broad-leaved evergreen forest with a usually thick evergreen shrub stratum composed of evergreen oaks (Quercus suber/ilex/ rotundifolia), olive trees, carob trees or pines, with crown cover density < 30 %;	Forest and other wooded land
marginal zones of bogs with vegetation composed of shrubs and pines, which cover > 50 % of the surface.	Forest and other wooded land
young broad-leaved and/or coniferous trees;	Forest
damaged or dead trees and shrubs;	Forest and other wooded land
fully grown trees, covering < 30% of area;	Forest and other wooded land
shrubs;	Other wooded land
herbaceous vegetation (grasses and herbs);	No (yes if former forest cover)
bare soil or natural bare surfaces.	No (yes if former forest cover)

Annex 5

Forest area according the assessments of FAO, CLC, LULUCF, Other wooded land (OWL), Other land with tree cover, transitional woodlands and shrub for the EU27 and EEA38

	Year of assessment	Area (1000ha)	Land area
Land area EU27	2020	399,636	
Land area EEA38	2020	541,478	
Forest EU27 FAO	2020	159,231	39.8%
Forest EU27 LUCAS	2018	159,202	39.8%
Forest EEA37 FAO	2020	202,487	37.4%
Other wooded land (OWL) EU27 FAO	2020	21,030	5.3%
Other wooded land (OWL) EU27 LUCAS	2018	20,396	5.1%
Other wooded land (OWL) EEA37 FAO	2020	25,789	4.8%
Other land with tree cover (OTC) EU27 FAO	2020	9,169	2.3%
Other land with tree cover (OTC) EEA38 FAO	2020	9,653	1.8%
Forest EU27 CLC	2018	135,637	33.9%
Forest EEA38 CLC	2018	166,154	30.7%
Transitional woodland and shrub -EU27 CLC	2018	21,679	5.4%
Transitional woodland and shrub -EEA38 CLC	2018	32,592	6.0%
Forest LULUCF EU27	2019	163,180	40.8%
Forest LULUCF EEA32	2018	199,370	36.8%

SOEF2020 Terms and Definitions

FRA2020 Terms and definitions

Source: FAO, Forest Europe, CORINE-CLC and UNFCCC


FOREST INFORMATION
SYSTEM FOR EUROPE
WWW.FOREST.EEA.EUROPA.EU

3.4 Nature

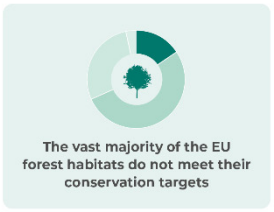
The state of nature in forest areas

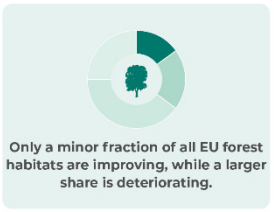
Forests harbour most of the earths terrestrial biodiversity, including plant, animal and fungi species. These species are bound to and essential for healthy forest habitats.

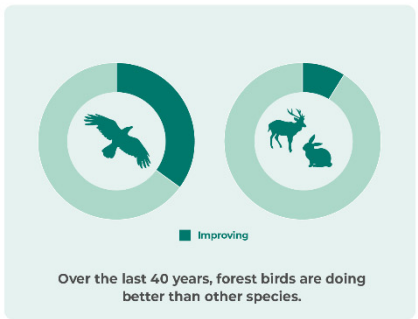
To preserve forests and the biodiversity that they host, they are protected by regulations such as Natura 2000 and its Birds and Habitats Directives. Species and habitats are monitored to evaluate the quality of sites and effects of management and policy strategies. Assessments show that the state of nature of forest habitats is deteriorating worldwide as well as at the European level.

KEY MESSAGES

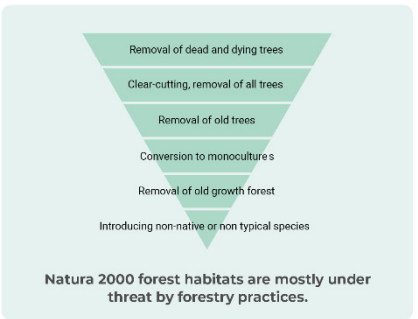

Over one third of the European protected areas consists of forests.


The vast majority of the EU forest habitats do not meet their conservation targets


Only a minor fraction of all EU forest habitats are improving, while a larger share is deteriorating.



Over the last 40 years, forest birds are doing better than other species.



Natura 2000 forest habitats are mostly under threat by forestry practices.

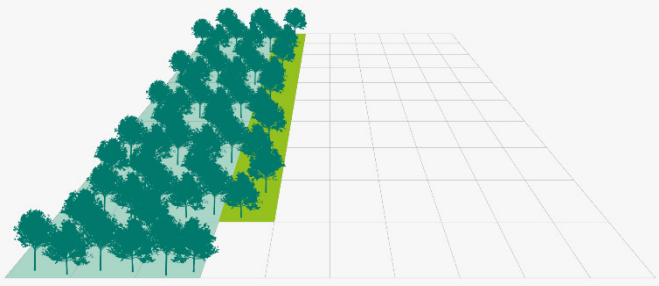
The conservation efforts made by nature networks like Natura 2000 are vital for the protection of Europe's forests.

Forests inside and outside of Natura 2000 conservation areas

Natura 2000 represents the largest coordinated network of nature conservation areas in the world. It stretches out over one fifth of EU27s land area and over approximately ten percent of the marine environment. The Natura 2000 network comprises over 25.000 sites which are designated under the Birds- and Habitat Directives. The sites include Special Protection Areas (SPAs) for conservation of threatened and migratory birds and Special Areas of Community Importance (SCIs)/Special Areas for Conservations (SCAs) for the conservation of the habitat types (Annex I) and species (Annex II).

Map of Natura 2000 areas with forests inside / outside Natura 2000.

GRAPHIC
European forest coverage and forests under protection.



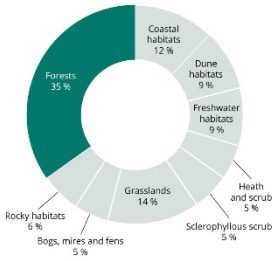
Approximately 39% of the EU27 land surface is covered by forests (159 million ha).
Natura 2000 protects only a minor share of the total EU27 forest area (37 million ha).

Beech forests are the most wide spread of the European forest habitats. Source: Unsplash

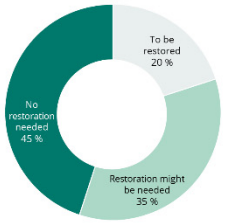
Forest habitat under Natura 2000 protection

Habitats are the environments in which particular plants and animals live. The conservation of natural habitats aims to promote the maintenance of biodiversity. Protecting habitats forms the cornerstone of Europe's nature conservation policy.

GRAPH
The majority of the Natura 2000 protected habitat types are forest habitats.



GRAPH
At least one fifth of all Natura 2000 protected forests need to be restored



Restoring and maintaining carbon-rich forest habitats can make a significant contribution to climate change mitigation. It is therefore a major focus in the new EU Biodiversity Strategy to 2030.

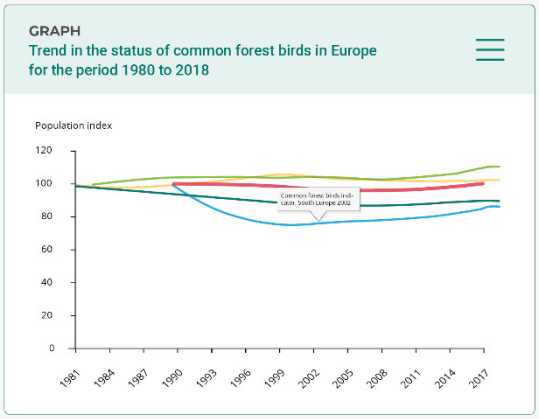
TABLE
10 most common forest habitats as defined in Annex 1 of the EU Habitats Directive

Habitat	Surface area (km^2)	Percentage of total EU27 forest area
Atlantic acidophilous beech forests with *Ilex* and sometimes also *Taxus* in the shrublayer (*Quercinion robori-petraeae* or *Ilici-Fagenion*)	220 866	29%
Galicio-Portuguese oak woods with *Quercus robur* and *Quercus pyrenaica*	98 399	13%
Bog woodland	44 469	6%
Quercus ilex and *Quercus rotundifolia* forests	43 819	6%
Western Taïga	35 112	5%
Asperulo-Fagetum beech forests	33 120	4%
Pannonian-Balkanic turkey oak – sessile oak forests	33 028	4%
Luzulo-Fagetum beech forests	25 069	3%
Nordic subalpine/subarctic forests with Betula pubescens ssp. *Czerepanovii*	19 420	3%
Sub-Atlantic and medio-European oak or oak hornbeam forests of the *Carpinion betuli*	18 248	2%

The Grey-headed woodpecker (*Picus canus*) is a wide spread common forest bird in Europe and shows a moderate increasing trend. Source: Unsplash

Forest Birds in Natura 2000

Birds are indicator species for the condition of nature, because there is an abundance of monitoring data available. Birds are found in most habitats and are more easily studied than almost any other large animal. They can be well observed and are active during the day. As a result, there is long term information about their population sizes and ranges.



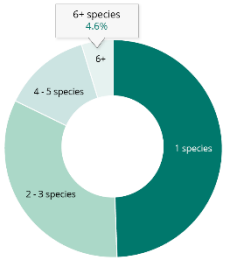
Although the overall trend is stable, trends differ for groups of birds. Forest management doubtless affect trends in forest birds, however the birds are also influenced by other factors, such as climate change impacts and conditions during bird migration.

Deadwood provides habitat for many species and is an important indicator used to assess the nature value of forests.

Other nature indicators

In addition to birds and habitats, also other indicators are used to assess nature values of forests. These include tree species and age composition, the degree of fragmentation, the amount of dead wood and the management intensity.

GRAPH
Most European forests are composed of very few tree species.

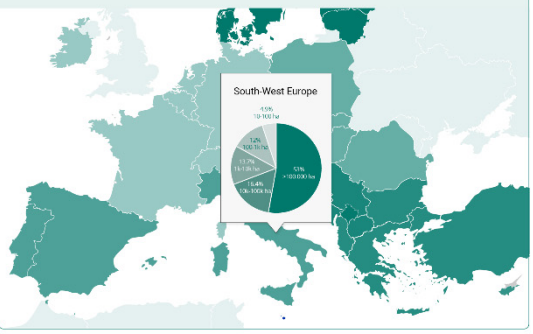


Two-thirds of the European forest area is composed of two or more tree species. One-third contains just one tree species, typically a coniferous species. Since the beginning of this century, more effort is being made towards diversification.

GRAPHIC
Three-quarters of European forests are even-aged.

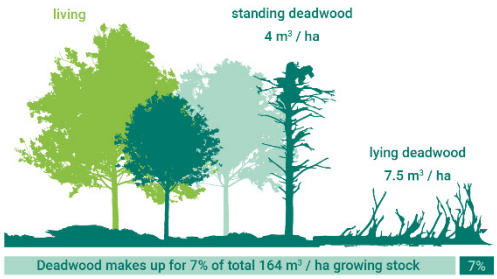
Even-aged forests are susceptible to storm damage. Since the beginning of this century, there is an increase in uneven-aged forests.

GRAPHIC
Forests in central Europe are most fragmented



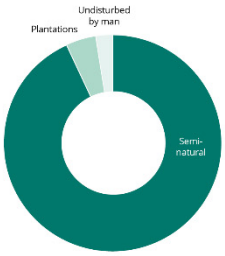
Forest patch size is important for nature. Large contiguous forest areas provide connectivity between areas, which supports species dispersion, gene flow and genetic adaptation. These are essential processes for viable populations and for species range shifts in adaptation to climate change. Forest fragmentation is the breaking up of larger, contiguous, forested areas into smaller patches of forest. Forest fragmentation is likely to negatively affect forest species richness and such as wide-ranging predators.

GRAPH
Deadwood is a natural part of the forest ecosystem



Deadwood in forest provides an important source of habitat, shelter and food source for many rare and threatened species, such as insects (especially beetles), fungi and lichens, birds and bats. Deadwood is often removed in commercial forests and even in protected areas, especially after large disturbances such as storms. The removal of large amounts of deadwood is sometimes needed to reduce the risk of forest fires and insect or pest outbreaks. The amount of deadwood varies per EU28 region. Over the last decades, the amount of deadwood has increased in all regions. The amount of deadwood varies per region. Over the last decades, the amount of deadwood has increased in all European regions.

GRAPH
The majority of European forests have semi-natural management regimes



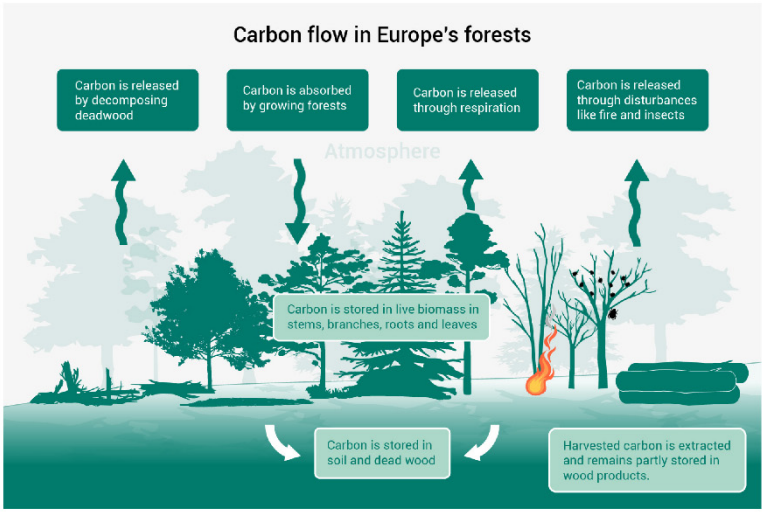
Undisturbed forests have a natural tree composition, age structure, regeneration processes and occurrence of substantial amounts of dead wood. Such forests provide natural habitat to forest plants and animals and flora. 90% of the forest is assessed as semi-natural, which is forest in which management may take place ranging from extensive to intensive.

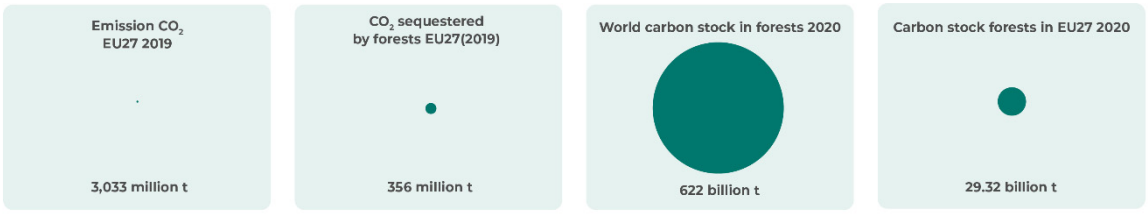
Old growth and pristine forest represent high biodiversity values and ecosystem services such as carbon sequestration and recreation. However forest management effects naturalness of forests, it also favours some species which in some situations stimulates biodiversity (e.g. some types of coppice forests)
The amount of deadwood varies per region. Over the last decades, the amount of deadwood has increased in all European regions.

3.5 Climate change

Forests play a significant role in fighting climate change. EU forests take up currently around 10% of the total EU emissions. Around 6% of the carbon stored in forests around the world is stored in Europe's forest. They are an important carbon sink.

Via photosynthesis, forests remove CO_2 from the atmosphere and store carbon in biomass, soil and wood products. They emit carbon through respiration and decay when (natural) disturbances (harvesting, fires, insects and storms) take place. The annual net additional CO_2 to the total stock is small (1-2% per year) compared to the existing forests' biomass and soils carbon stock. This also explains why it is so difficult to measure the net carbon sink or source of a forest. Generally, it can be stated that the older the forests become, the smaller the net additional CO_2sequestration will be. Still, old forests do sequester some CO_2.





Source: Global Forest Resources Assessment 2020 / EEA

!! Comments !!

If possible display dots in sizes that match the values.

Carbon storage and sinks

Forest and climate change mitigation

When forest capture carbon from the atmosphere, they accumulate it in five different pools: above-ground biomass (stem, leaves, branches), below-ground biomass (roots), deadwood, litter and the soil.

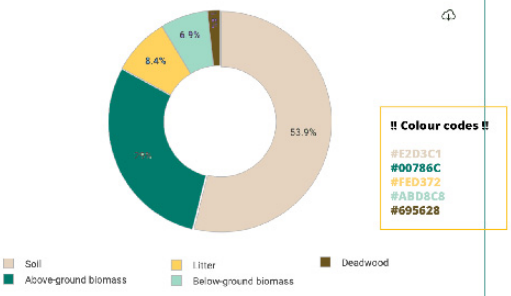
In Europe the amounts that are stored differ greatly, for instance between Central and Southern Europe, as the growing stock in m3/ha also differs. This might be influenced by ecological conditions and management. Most carbon in biomass in Europe is stored in Central Europe where around 92 tonnes C/ha is stored, while in Southern Europe around 40 tonnes C/ha is stored.

In European forests, most of the carbon is stored in the soil (53.9%) and in the above-ground biomass (29%).

ESA - New biomass map to take stock of the world's carbon,

Source: ESA

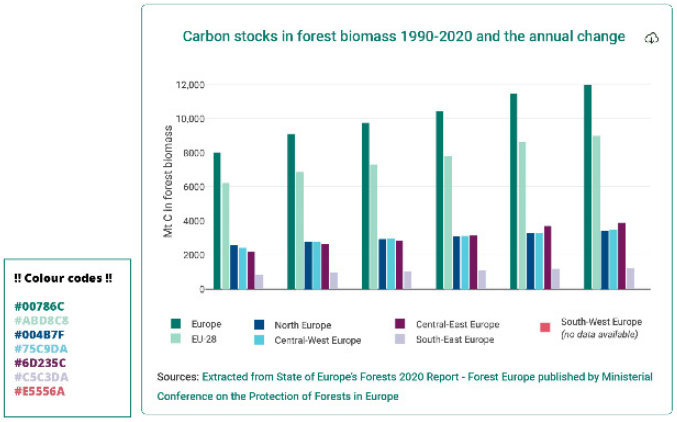
Proportions of forest carbon pools in Europe, 2020

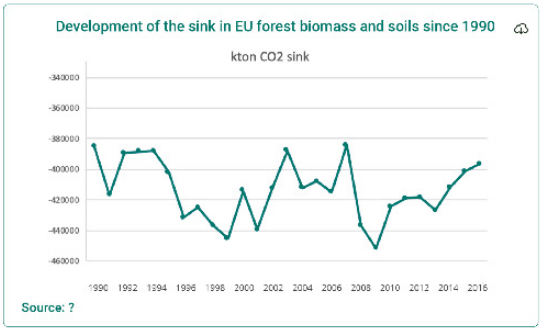


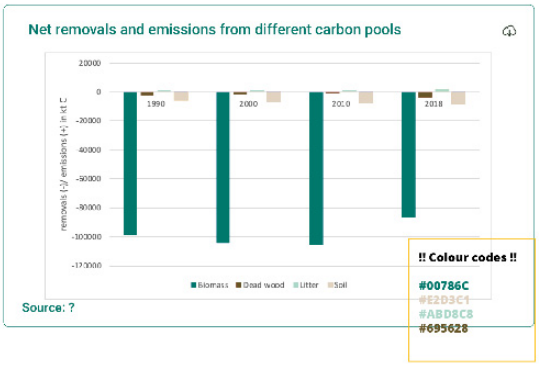
Source: Extracted from State of Europe's Forests 2020 Report - Forest Europe published by Ministerial Conference on the Protection of Forests in Europe

The carbon stock in Europe has been increasing since 1990. Central-East Europe has the highest annual change in total forest biomass carbon stocks of Europe.

The net carbon removal of forest is highest in biomass. The time carbon persist in a certain pool differs. While the carbon in fresh litter can be released to the soil or atmosphere in months or years, carbon stored in deadwood can remain there for decades.







Why European forests act as carbon sink?

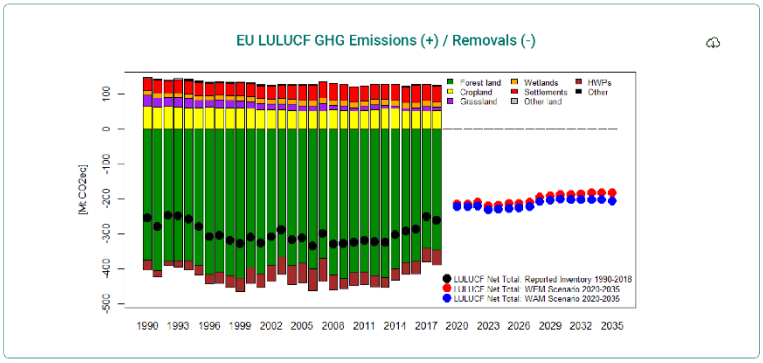
- European forest have not always been a carbon sink.
- For centuries (maybe since the Roman era) a gradual process of deforestation and degradation took place; most likely losing carbon overall.
- How much forest was left around 1700 – 1800 is pretty much unknown.
- Since then, gradual reforestation took place, partly deliberate, partly spontaneous regeneration.
- After the second world war this process of reforestation intensified, further stimulated by set aside subsidies in the eighties, and programmes investing in fertilisation and tree breeding.
- Thus Europe currently has relatively young, fast growing forests and that is why there is a sink now.

Land Use and Land Use Change

Forest and climate change mitigation

LULUCF stands for Land Use, land Use Change and Forestry. The EU strives to be climate-neutral by 2050 and all sectors need to contribute by reducing emissions or increasing removals. Reporting by countries of their Greenhouse Gas balance of emissions and sinks is done distinguished by sectors.

The LULUCF sector is one of them and comprises Forest biomass, its wood products, as well as the carbon and methane from wetlands, and carbon in cropland, grassland and settlement soils. In Europe the LULUCF reports are usually dominated by a forest sink, and then small emissions from grasslands, croplands and wetlands. LULUCF historical trend was a rather constant sink, with average annual net removals of CO_2 of approx. 300 Mt.

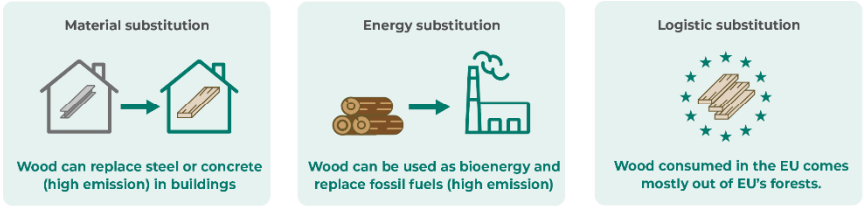


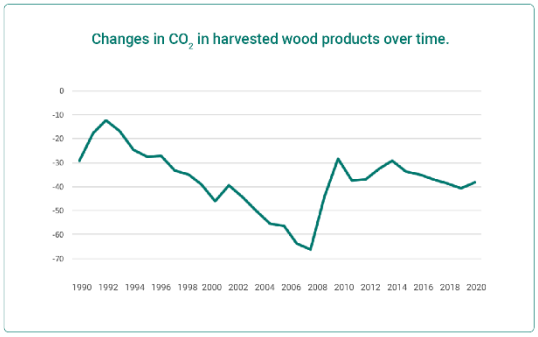
Harvested wood products

Carbon is not only stored in the forest, but part of it is taken off site through harvest of timber. Depending on wood assortment, a certain share of the carbon stored in harvested trees stays in wood products in use. For how long the carbon is stored, depends on the type of product the wood is used for.

When more carbon flows into wood products pool than what is abandoned, then a small build up of carbon in products occurs. This is the case in Europe with a sink in products roughly 10% of that in live biomass (see figure). This can be counted as addition of carbon to the pool, because the full harvest was subtracted from the live forest biomass at harvest.

There is one more effect of forest management and its products: When the usage of wood avoids the use of energy or materials with higher emissions, less carbon is released in other sectors like energy or industry. This is the substitution effect of wood.

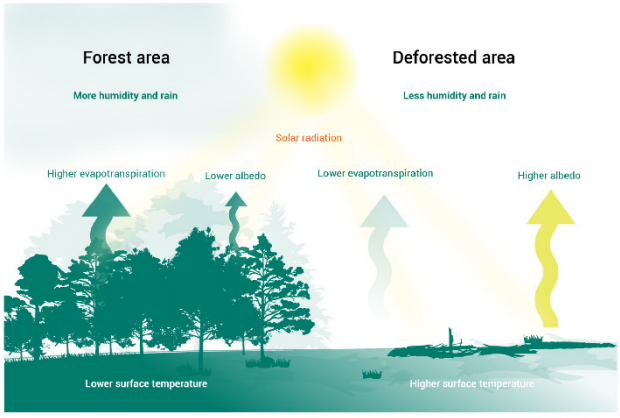




The role of forest is much wider than just exchange of CO_2 (biochemical effect). Other effects are called the biophysical effects. These are albedo, evapotranspiration and surface roughness which can effect temperature and precipitation locally.

Albedo (or the proportion of radiation that is reflected by a surface) is influenced by the forest surface. Open sand or snow has a high albedo (a lot of reflection), forests have a low albedo (they hold the radiation). Thus more forests, certainly coniferous forest high north, lower the albedo and have a warming effect.

However, due to evapotranspiration cooling takes place in the growing season of forests. The cooling effect of broadleaved trees is higher than of coniferous trees by evapotranspiration. The net of all these effects together are highly uncertain.



Schematic representation that illustrates the biophysical and effects of deforestation.

Forests also influence the climate by the emission of biogenic volatile organic compounds (BVOCs). The degree in which the climate is affected by BVOC emission is uncertain. BVOCs are compounds that are rapidly oxidised in the atmosphere. The reaction of these compounds with atmospheric oxidants leads to the pollutant O_3 and secondary organic aerosols which can lead to cloud formation. O_3 is a greenhouse gas which warms the atmosphere. The formed aerosols and thus the formed clouds can reflect the radiation and can lead to cooling. Stress factors can cause a higher emission of BVOCs by trees. The degree in which the climate is affected by BVOC emission is uncertain.

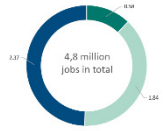
Altogether the net outcome of these biophysical processes is highly uncertain and depends on season, cloudiness, and forest management. The large uncertainty is the reason why these processes are not reported nor accounted.

3.6 Bioeconomy

European forests and the forest sector have the opportunity to take a leading role in the sustainable development of a circular bioeconomy.

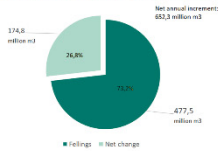
The forest-based bioeconomy provides millions of jobs and relies on wood and non-wood materials as basis for sustainably sourced bio-based products and renewable energy, while maintaining livelihoods and a plethora of regulating and cultural ecosystem services, ultimately contributing to climate change mitigation and a sustainable future.

Forest-based bioeconomy provides employment to 4.8 million people in the EEA area.[1]



Employment in the forest-based and down-stream bioeconomy sectors in the EEA in 2018

Fellings of wood represent 73% of the net annual increment in the EEA area.[2]



Net annual increment, fellings and net annual change in Europe's forests in 2015

Forests provide many regulating and cultural ecosystem services as well as non-wood forest products (NWFP).

- 4 billion € worth of marketed NWFP in 2015.[3]
- >80% of the weight of NWFP im Europe are self consumed and not marketed.
- 90% of households in Europe consume NWFP[4], 26% are actively collecting them.[5]

Key facts of non-wood forest products in Europe

Bioeconomy definition

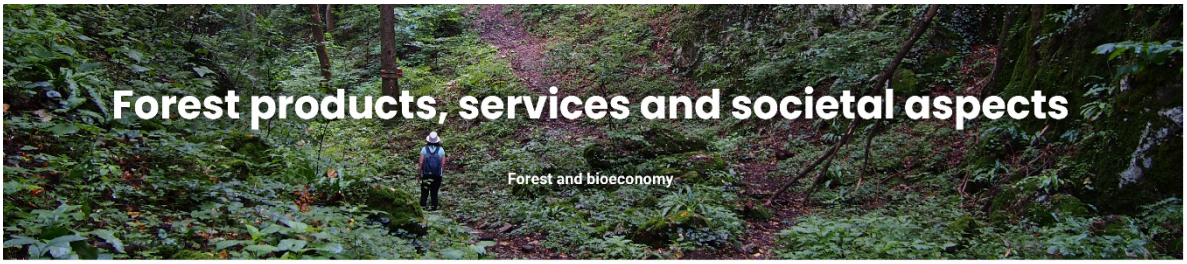
The bioeconomy generally refers to the production and use of biological resources to provide products, processes and services in all economic sectors within the frame of a sustainable economic system.[6] However, there are many other international and national definitions.

The European Commission definition of bioeconomy

"All sectors and systems that rely on biological resources (i.e., animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources, i.e. agriculture, forestry, fisheries and aquaculture; and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services[7].

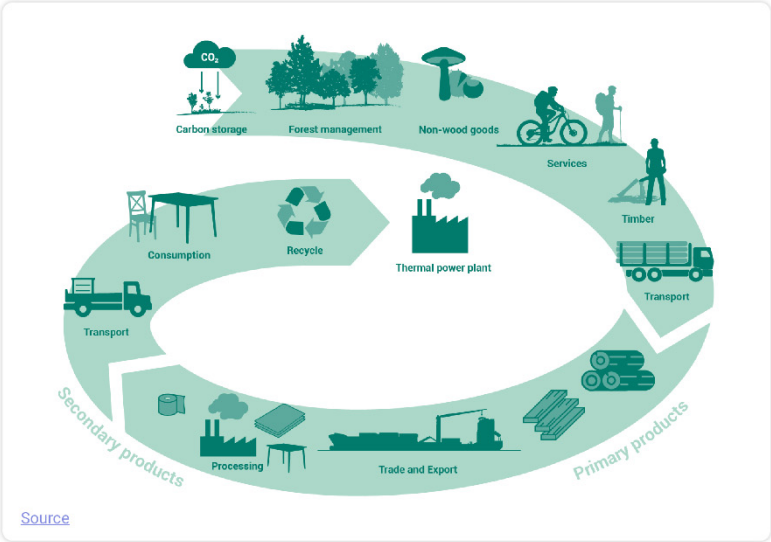
A forest-based bioeconomy can contribute to climate change mitigation via sustainably sourced, innovative, bio-based products (e.g., construction materials, chemicals, plastics, textiles, insulation materials, packaging) that store carbon from the atmosphere and can substitute non-renewable materials and energy[8]. Forests are also important for biodiversity and also provide a plethora of other regulating and cultural ecosystem services, including many NWFP.

[1] Eurostat & correction factors according to Robert et al. 2020 methodology
[2] Forest Europe (2020) - State of Europe's Forests 2020. Table 3.1.1
[3] Forest Europe (2020) - State of Europe's Forests 2020. Table 3.3.3
[4] Collection and consumption of non-wood forest products in Europe
[5] Non-wood forest products in Europe – A quantitative overview. Forest Policy and Economics
[6] International Advisory Council of the Global Bioeconomy Summit 2015. (2015). Communiqué.
[7] EU Bioeconomy strategy 2018
[8] Foresteurope.org



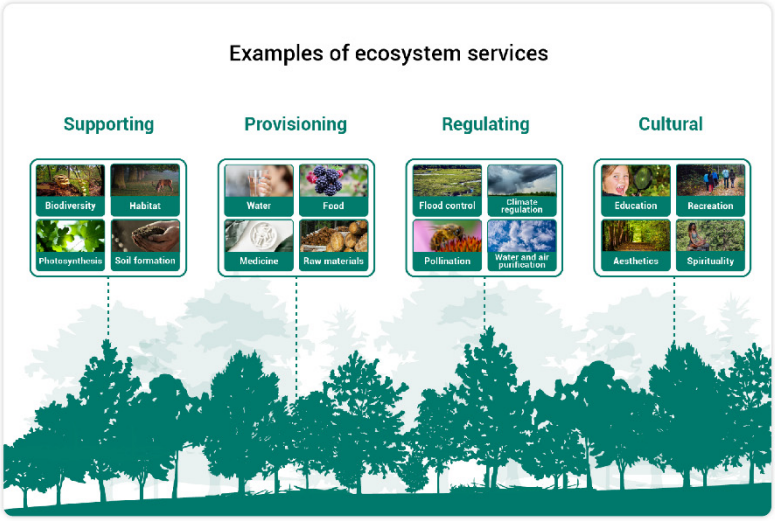
Forest-based value chain and ecosystem services

The forest-based bioeconomy covers the entire value chain. It links the management of forests, to the processing of raw materials for producing goods, energy, and services, as well as to the reuse and recycling of products and materials.



Source

Ecosystem functions and services of forests provide important contributions to a sustainable bioeconomy and society. Such functions and services include protective functions, climate regulation (e.g., carbon sequestration), air purification, fresh water supply, soil protection, biodiversity (habitat and gene pool protection), recreation and tourism, socially and culturally relevant services and many others.



Non-Wood Forest Products

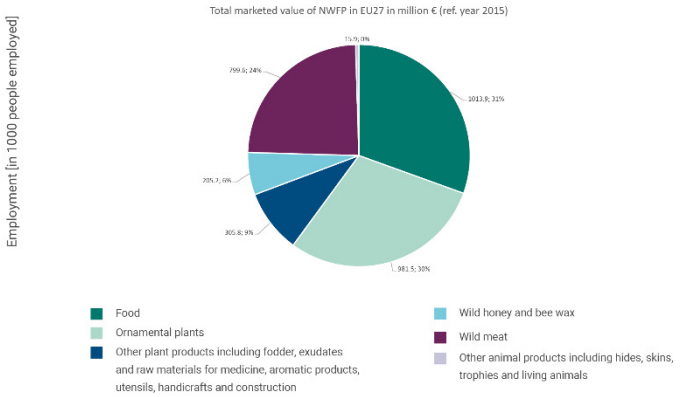
Next to woody biomass, as the main economic product sourced from forests, they provide a wide variety of non-wood forest products(NWFP) such as berries, mushrooms, aromatic and decorative plant material, saps and resins, nuts, honey and wild meat. Their economic and social importance is considerable but available data on NWFP are mostly incomplete and difficult to compare.

The reported value of marketed NWFP in Europe is more than twice higher for plant products (EUR 2.8 billion) than for animal products (EUR 1.2 billion), adding up to EUR 4 billion in 2015.[1]

The total value for marketed plant-based NWFP is most likely underestimated as the marketed NWFP represent only a small share of all consumed goods. It is estimated that 86% of the weight of NWFP are self-consumed and not marketed. Around 90% of households in EU-28 consume NWFP and more than a quarter of households (26%) actively collect them.[2]

Shares (%) of the total reported value of plant and animal related marketed non-wood goods (informal use and self-consumption is excluded even if they could represent a substantial part of the total, NWFPs harvested), 2015

Non-wood forest products



Source: SoEF 2020 table 3.3.1 p. 98 & table 3.3.2 p. 100.

Employment, turnover and value added of forest bioeconomy in the EEA

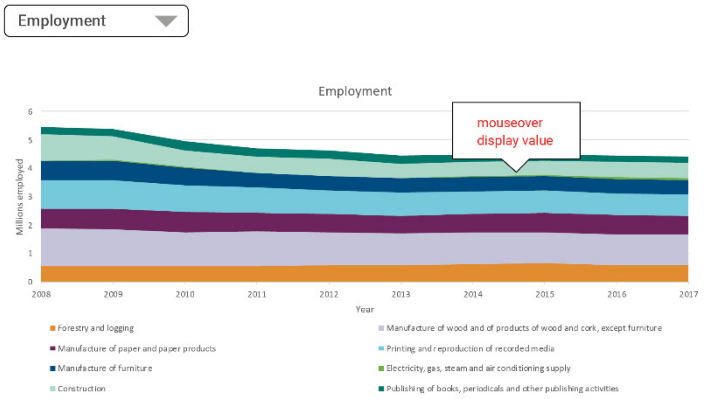
Employment, turnover and value added across Europe are typically reported for economic activities. The forest and forest-based sector is typically composed of three types of economic activities: Forestry and logging (A02 in the European Classification of Economic Activities, NACE rev. 2), *Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials (NACE C16), and Manufacture of paper and paper products* (NACE C17).

The manufacture of wood and paper products yields mainly intermediate goods, which require further processing to become final commodities. A substantial part of the employment, turnover and value added in Europe's wood-based sector takes place in downstream parts of value chains.

Here, we show a more comprehensive analysis of economic indicators in the wood-based value chains as the main component of the forest-based bioeconomy, ranging from activities in the forest-based sector (forestry and logging and the primary processing activities), as well as wood-based secondary processing and manufacturing activities. Wood-based secondary processing and manufacturing activities refers to the collection of industries—outside the forest-based sector—that use wood-based products and services in their production activity offer employment and income opportunities for diverse economic actors.

Forest-based employment is a major source of employment in rural areas, and it is recognized as an integral part of sustainable development.[3] Forest-based employment numbers decreased after economic crisis, followed by a more stable situation since 2013. Mechanisation in logging operations, digitalization technologies in the processing industry and new applications of the versatile forest resources lead to a positive trend in turnover and value addition after the economic crisis of 2008.

Employment, turnover and value in forest-based bioeconomy sector in the EEA



Source: EUROSTAT; correction factors according to Robert et al. 2020[4]

[1] Forest Europe (2020) - State of Europe's Forests 2020.
[2] Lovrić, M., Da Re, R., Vidale, E., Prokofieva, I., Wong, J., Pettenella, D., Verkerk, P.J., Mavsar, R., 2020. Non-wood forest products in Europe – A quantitative overview. Forest Policy and Economics 116, 102175. DOI
[3] Food and Agriculture Organization (FAO). State of the World's Forests 2018: Forest Pathways to Sustainable Development; Food and Agriculture Organization of the United Nations: Rome, Italy, 2018; ISBN 978-92-5-130561-4.
[4] Robert, N.; Jonsson, R.; Chudy, R.; Camia, A. The EU Bioeconomy: Supporting an Employment Shift Downstream in the Wood-Based Value Chains? Sustainability 2020, 12, 758.

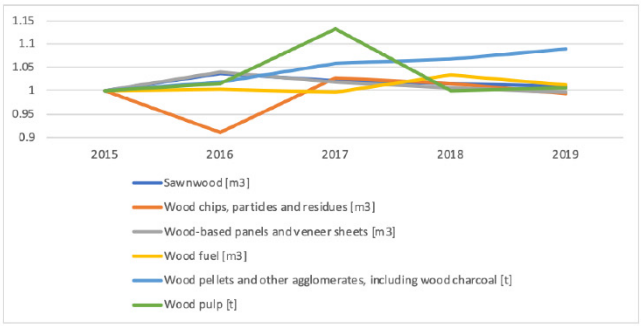
Wood uses and wood flow

Forest and bioeconomy

The trends in wood consumption mainly depend on the overall economic development. Within the EU, 51% of all woody biomass resources is used to produce materials. The rest of woody biomass, which includes use of industrial residues and post-consumer wood goes to energy production.[1] The largest subsector for material use is solid wood products, followed by pulp and paper. The construction sector is of particular importance for the use of solid wood products in form of sawnwood and wood-based panels. This is partly supported by public policies which encourage the use of wood for construction and renovation and implementation of energy-efficient practices[2], while further impact stems from the packaging and paper industry, as well as from overall and renewable energy demand.

Only a relatively small volume of woody biomass is now used for wood-based textiles and chemicals. However, with increased implementation of sustainability efforts and the necessity to reach international climate goals these sectors have the potentials to grow substantially.

Index values in comparison to previous year of production change of commodity classes in the EEA

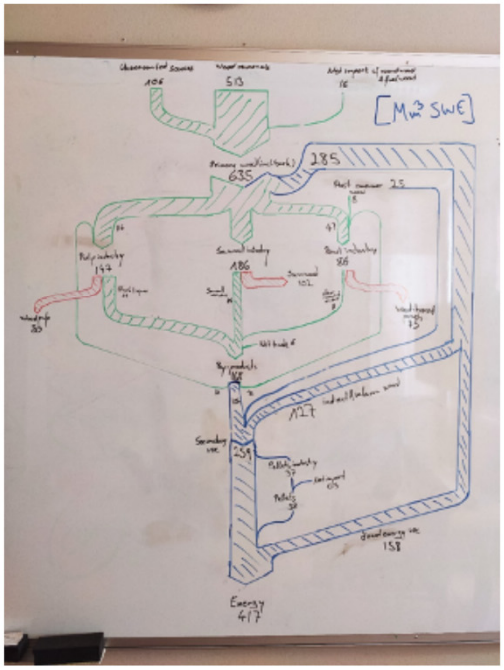


Commodity class	Production
Sawnwood [million m3]	122.0
Wood chips, particles and residues [million m3]	118.7
Wood-based panels and veneer sheets [million m3]	71.9
Wood fuel [million m3]	132.4
Wood pellets and other agglomerates, including wood charcoal [million t]	20.3
Wood pulp [million t]	90.6

Source: FAOSTAT

When producing sawnwood from roundwood, by-products that can be used energetically or be further processed to wood-based panels or wood pulp emerge. If the utilization of forest biomass, main products and side streams are visualized, a more detailed view of the wood flows unfolds, illustrating cascade uses, the competition and synergies as well as the importance of different sub-sectors. Cascading use refers to the efficient utilisation of resources by using residues and recycled materials to extend total biomass availability within a given system. Cascading at the market level (sectors and products) can be quantified through wood flow analysis.[3]

Title



The biomass flow diagram represents in a unique view the flows of biomass of different sectors of the bioeconomy, from supply to uses including trade, where the width of the arrows is proportional to the magnitude of the flow in question.

Biomass flows within the forest-based sector illustrate material and energy practices along a quite complex value chain. Starting from primary sources of wood, removals or imports, wood can either feed wood processing industries for the manufacturing of wood-based products, or be used for energy production.

The central role of the sawnmill industry is clearly visible. Sawmilling within EU is at the same time the largest industrial user of woody biomass and the main source of secondary wood fibres, used by wood-based panel and pulp industries as well as for energy.[4]

Captions in mouse over parts of the sankey

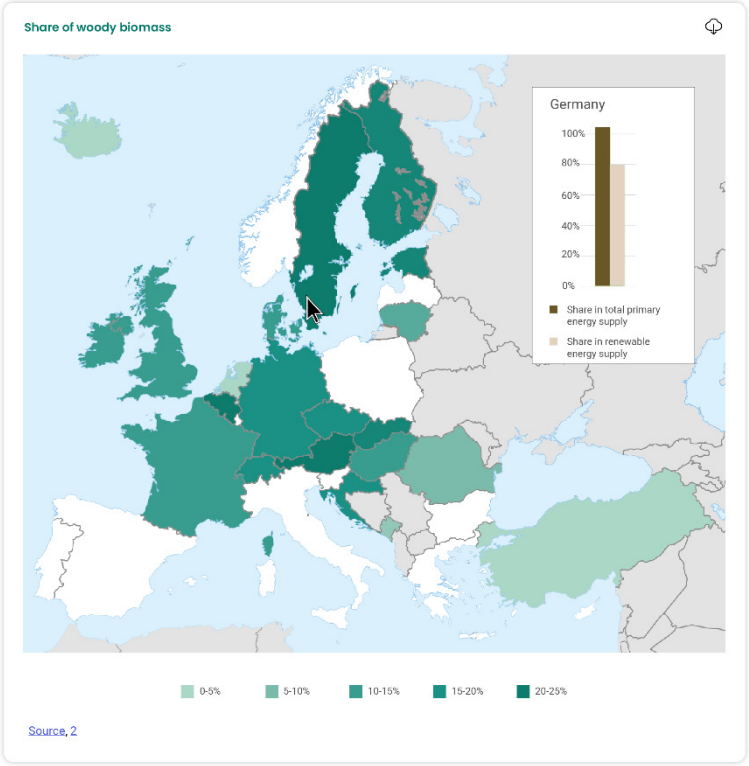
...As sawlogs represent the economically most valuable part of trees, the sawmill industry is key in mobilising woody biomass from forest owners.[5]

... In EU-28, 49% of woody biomass was used for heat and power generation in 2015[6]...

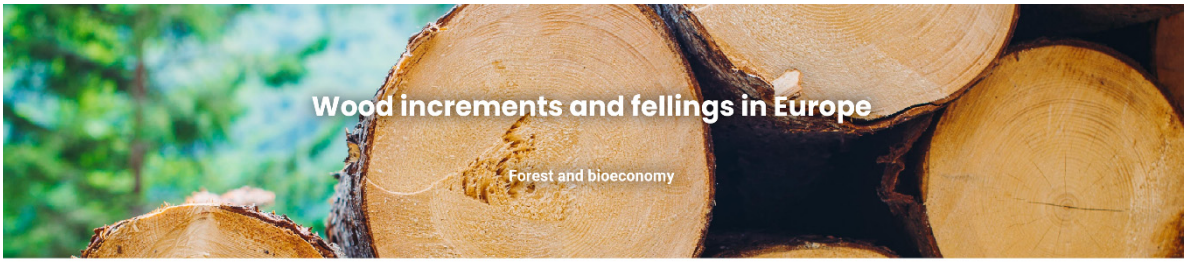
Source

Energy from woody biomass

The consumption of wood for bioenergy is increasing as well as the share of wood energy in the total energy consumption.[7] Wood energy was the main source of renewable energy in the EU, with almost 60% in 2018.[8] Biomaterials and bioenergy systems are tightly linked. In 2015 Approximately 49% of the wood used in EU for bioenergy comes from waste and form industrial side streams, while 37% come from primary sources. Statistics also report a certain amount of woody biomass used for energy whose origin, primary or secondary, is not known. This "uncategorised" woody biomass for energy, accounts for 14% of total energy uses.

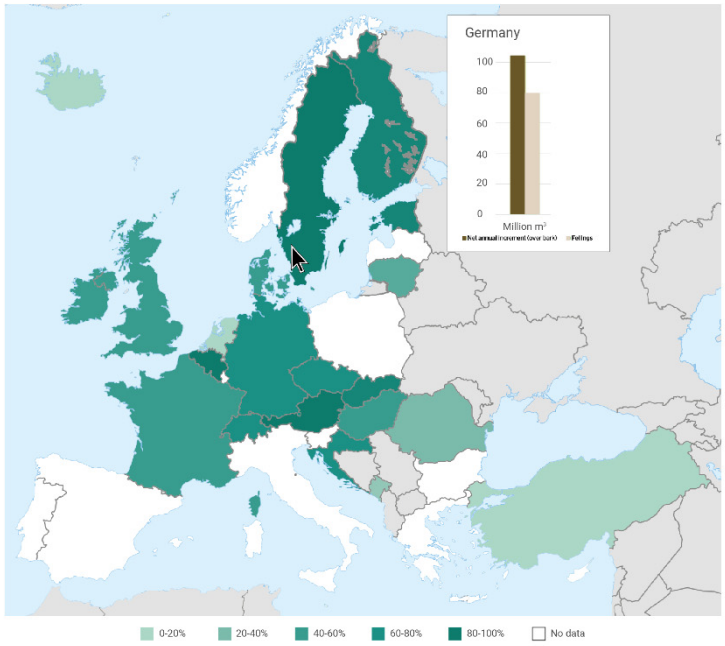


[1] Wood resource balance 2015 ; Camia et al. 2021. The use of woody biomass for energy purposes in the EU, EUR 30548 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-27867-2, doi:10.2760/831621
[2] Forest Europe – SoEF 2020 p.184
[3] Link
[4] Camia et al. 2018
[5] Prokofieva et al. 2015 in Camia et al. 2018
[6] WRB 2015
[7] SoEF 2020
[8] (ref year 2018) (updated every two years)



The maintenance or increase of productive functions of forests (wood and non-wood) are a prerequisite for a sustainable utilisation of forest resources. Today´s management and wood use must not compromise management options for future generations, thus feedstock extracted from forests should not exceed increment in the long term.

Annual fellings as percentage and net annual increment countries, 2015



Source: SoEF 2020 p. 91. Country specific values in SoEF 2020 "Annexes to Part II", starting on page 351. Row 3.1 "Fellings as % of net annual increment on forest available for wood supply". SoEF 2020 p. 90. Country specific values to be found in SoEF 2020 table 19, page 287. (Net annual increment in 1000 m3 for 2015)

The ratio of annual wood fellings to annual increment is relatively stable and remains under 80 % for most countries across Europe. This utilisation rate and the fact that forest area in Europe is expanding has allowed the forest stock in Europe to continuously increase over the last decades.

Further reading

Forest and bioeconomy

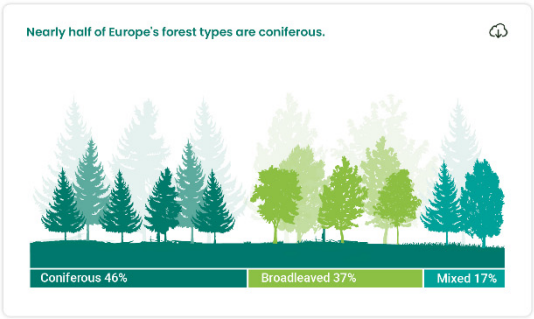
Forests are increasingly affected by climate change, which threaten the provisioning of important ecosystem services as well as forests' support for biodiversity. Increasing temperatures, coupled with changes in precipitation and disturbances such as droughts and storms are already pervasively altering vegetation dynamics. Active management of forest structure and composition play an important role in developing adaptive solutions to secure the long-term delivery of forests' ecosystem services and to manage carbon stocks, while contributing to halting biodiversity loss and mitigating climate change. To read further on topics related to the environmental aspect of sustainability in forests, examine the following factsheets.

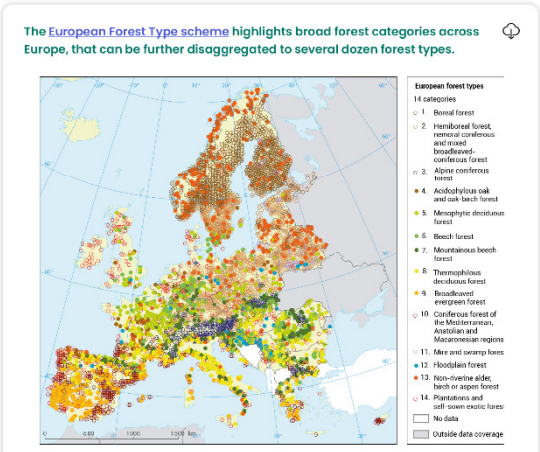
Topic	Factsheet
Biodiversity, protected areas, pressures	Forest nature Factsheet & forest biodiversity factsheet
Disturbances	Natural disturbances and forests
Carbon stock changes, carbon balances	Forests and climate change mitigation

3.7 Biodiversity

Europe's forest ecosystems can be described according to different classification systems, which reflect structural aspects and/or functional interactions at an ecosystem level, while others emphasize species and their associated habitats, or their genetic variation.

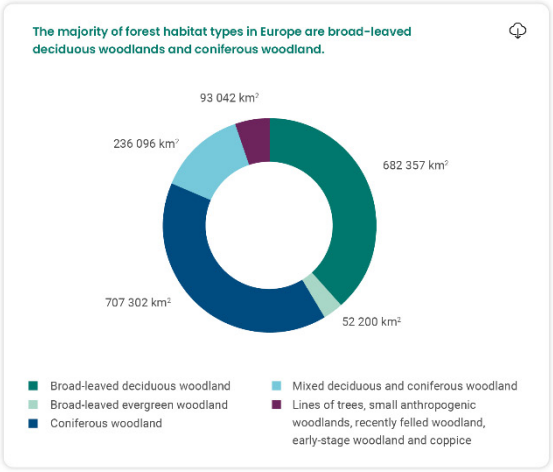
The Corine Land Cover classifies forest types at the broadest level, distinguishing native or exotic forested areas composed of coniferous, broadleaved and mixed forest types.



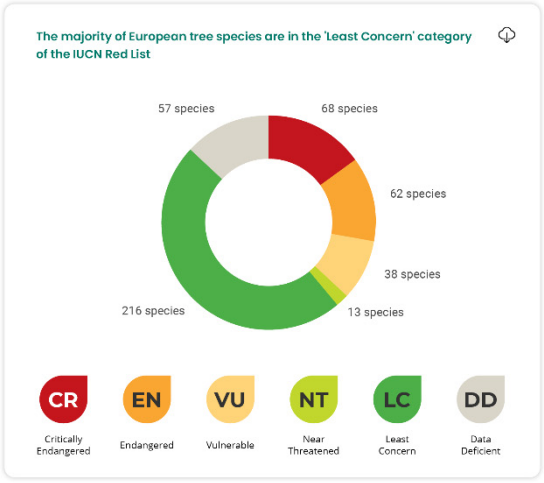


Source: Classification of the ICP Forests Level 1 plots with respect to main categories of the European Forest Types — European Environment Agency (europa.eu)

Complementary to the European Forest Type scheme, the European nature information system (EUNIS) distinguishes a couple of spatially represented level 2 forest habitat types, that are further disaggregated into forest habitat types at level 3. Level 3 habitat types are cross-referenced to the European Forest Types with a recent update[1] also available.



Characteristic tree species of each of the European Forest types are defined in the European Atlas of Forest Tree Species, which provides up to date information on over one hundred key tree species in Europe using a combination of extensive field observations and habitat suitability modelling. According to the IUCN European Red List of trees, almost half of the native tree species in Europe have been assessed as threatened (i.e. Critically Endangered, Endangered or Vulnerable) and therefore have high risk of extinction.



Genetic variety across the many different forest types in Europe is essential for adapting to climate change. The European Information System on forest genetic resources (EUFGIS) acknowledges this variety and seeks to document the genetic variety of targeted tree populations. Although this database is steadily increasing, geographical coverage is still low and does not yet depict genetic variety comprehensively within forest trees in Europe.

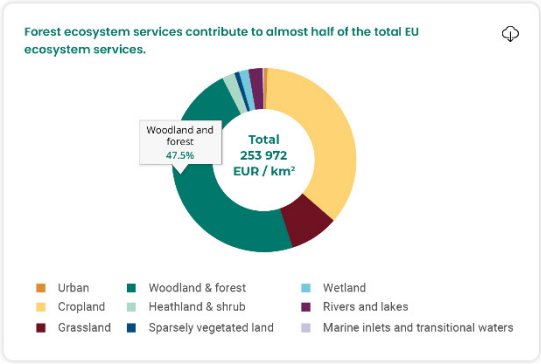
[1] Schaminee, J.H.J., M. Chytry, S.M. Hennekens, J.A.M. Janssen, I. Knollova, J.S. Rodwell and L. Tichy (2018) Updated crosswalk of the revised EUNIS Habitat Classification with the European vegetation classification and indicator species for the EUNIS grassland, shrubland and forest types. Wageningen, Wageningen Environmental Research, report, 508p.

Forest ecosystem services

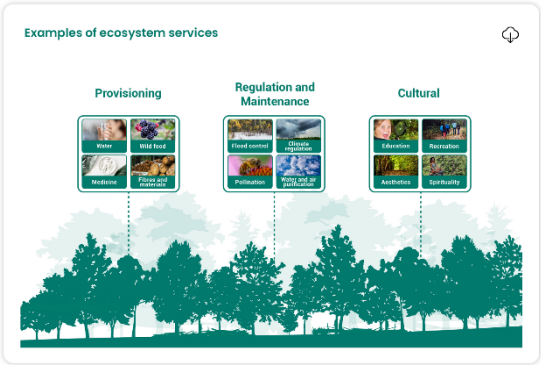
FOREST BIODIVERSITY & ECOSYSTEMS

Forest biodiversity provides us with timber and non-forest wood products, and also supports numerous other benefits, such as withdrawing vast amounts of carbon emissions from the atmosphere, regulating water flows, controlling soil erosion, cleaning the air we breathe and places of recreation and spirituality.

The EU ecosystem accounts recently assessed a number of ecosystem services. The ecosystem accounts indicated that forest ecosystems contribute to almost half of the total ecosystem services. This large contribution makes the value supplied by a unit of area of forests almost nine times more than the value supplied by a unit of urban area.



Multiple ecosystem services flow from a forest stand, which are often measured as three types of ecosystem services: provisioning, regulating and cultural ecosystem services. An over-emphasis on the supply of provisioning services can erode the capacity of ecosystems to supply regulating and cultural services. Thus, sustaining multiple ecosystem services that occur in a particular area requires decision making on the synergies and trade-offs between different provisioning, regulating and cultural services



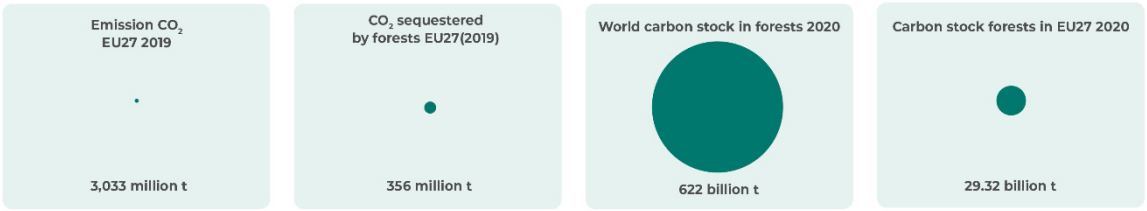
Provisioning services

Timber provision is the basis for many economic activities (e.g. construction, energy). The EU ecosystem assessment estimated that between 2000 and 2010, the amount of fellings reported in the EU did not exceed the amount of timber that forests can annually offer. These data only account for officially reported country statistics, and do not account for illegal logging, which remains a problem in many regions of Europe.

Non-wood forest products are also important sources of income, and include products such as mushrooms, berries, herbs, nuts, honey, game and fodder, resin, bark, ornamentals, cork, Christmas trees and medicinal plants.

Regulation and maintenance ecosystem services

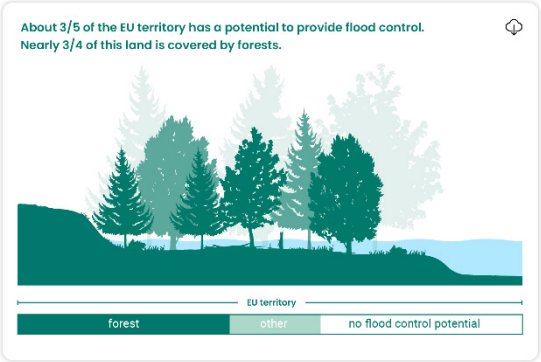
Carbon sequestration as ecosystem service is the net removal by ecosystems of carbon dioxide (CO_2) from the atmosphere, thus contributing to climate change mitigation. These benefits extend beyond the EU to global society, since CO_2 is considered to be equally distributed over the global atmosphere.



Source: Global Forest Resources Assessment 2020 / EEA

Flood control

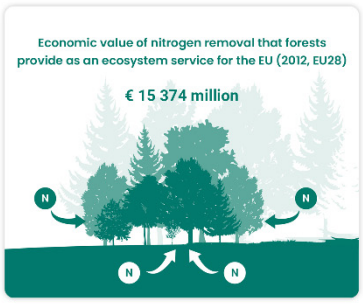
Upstream ecosystems and wetlands protect cities, farmlands and infrastructure from flooding. Ecosystems such as forests, wetlands and grasslands regulate water flows. They reduce the speed of runoff water during heavy rain or they infiltrate and store water temporarily in the soil. Thus the risk of downstream flooding is reduced, people and infrastructure are protected, and damage costs related to floods are avoided. Different ecosystem types differ in their ability to provide the flood control ecosystem service – forests and wetlands are particularly effective in holding water.

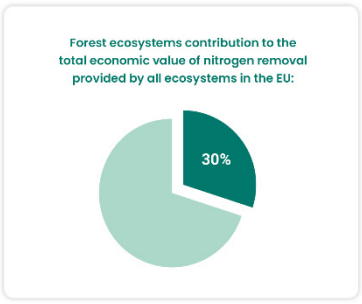


Water purification

Water purification as an ecosystem service is the removal of pollution from the environment by ecosystems.

The economic value of nitrogen removal that forests provide as an ecosystem service for the EU (2012, EU28), based on replacement costs (the total costs of water purification through alternative means – constructed wetland – to replace this ecosystem service if ecosystems were not providing it):





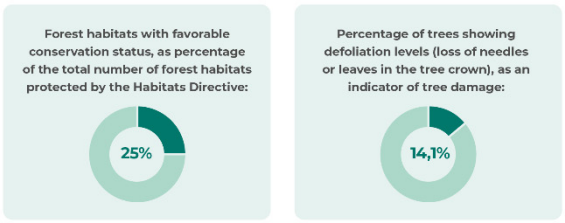
Cultural ecosystem services

Nature-based recreation as an ecosystem service is considered as the biophysical characteristics or qualities of ecosystems that are viewed, observed, experienced or enjoyed in a passive, or active, way by people. The covid-19 pandemic has spotlighted the importance of daily access to nature for recreation.

Major pressures on forest ecosystems

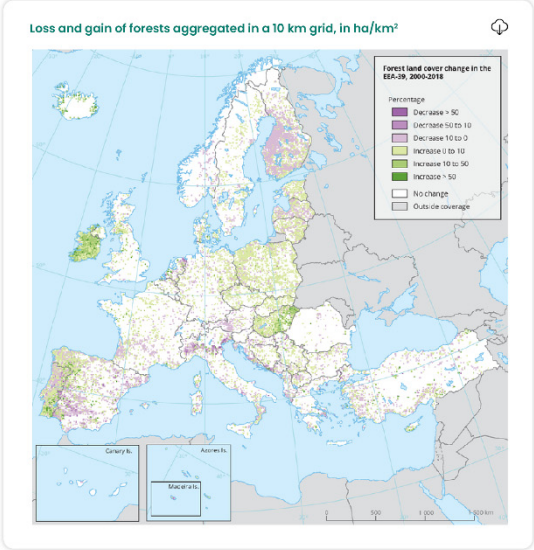
FOREST BIODIVERSITY & ECOSYSTEMS

Forests are exposed to multiple pressures that often act together and exacerbate impacts on biodiversity: habitat changes, climate change, overexploitation, invasive alien species and pollution or nutrient enrichment. As a result of increasing, or merely stabilized but ongoing, pressures, forest ecosystem condition in Europe continues to decline, and is considered 'Degraded' according to the EU ecosystem assessment.



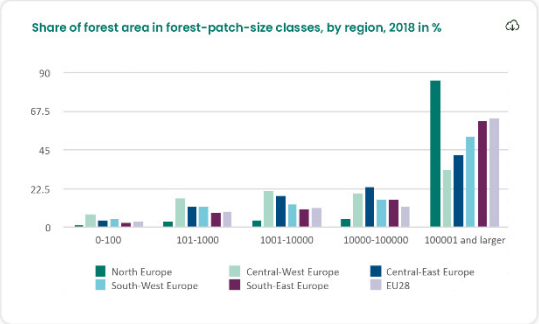
Habitat Changes

The pressure from conversion of forested land to land for other uses has decreased substantially across Europe, and on average forest cover is increasing according to the EU ecosystem assessment. Changes in forest area, as defined by the net changes in Corine Land Cover 2000-2018, show that there are several localized regions within Europe where forested area is decreasing.



While forest area is increasing, the EU ecosystem assessment found a reduction in tree cover[1] of almost ¾ (between 2000 and 2018) and a decline in tree density[2] (2001-2018) of more than 1/4. This information is derived from Global Forest Change dataset[3], which enables assessment on finer spatial and temporal scales. It thus provides complementary information on forest dynamics over time, compared to the net change in forest area measured in by Corine Corine Land Cover 2000-2018.

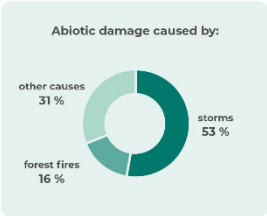
Forest fragmentation impacts ecological processes, such as habitat provision, gene flow, pollination, and wildlife dispersal. At a European level, almost two third of the forests form continuous areas larger than 100 000 ha (i.e. without considerable separation by other land uses). However, there is considerable variation across Europe, as in Central-West Europe continuous large area forests make up only one third of the share of forests there. This can negatively impact some species that require large continuous forest areas for habitat or for vital populations. Large areas also allow large scale natural processes to create diversity in forest composition, structure and habitat for species. The trend between 2000-2018 was stable.

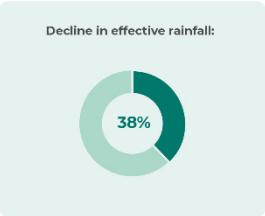


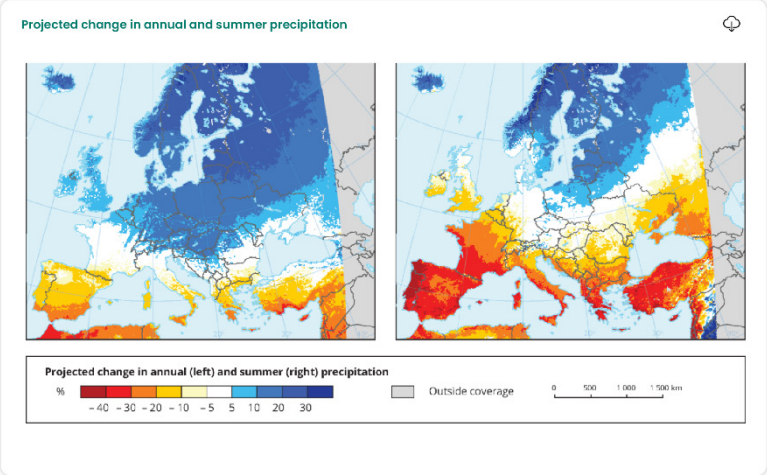
Climate Change

Pressures from climate change on forests are increasing, most notably through storms, droughts, forest fires, pests and pollution. The total burnt area in 2016 was higher than in each of the previous 3 years. The effective rainfall – the amount of precipitation that is actually added and stored in the soil – is declining, and this decline is most pronounced in the Mediterranean region. Climate change accentuates previously hidden vulnerabilities from invasive alien species and pests, pollution and diseases. It affects forest fire regimes, leading to conditions under which the extent and intensity of forest fires in the EU will increase in the next years. The ability of species to disperse to new habitats with suitable climates in the face of climate change is reduced by forest fragmentation.

Cross-reference to the section/map above







Invasive alien species

Invasive alien species are non-native plants, animals, pathogens and other species that may cause harm to the native biodiversity and ecosystems of Europe. Dense stands of invasive alien trees lower biodiversity. Invasive alien species can also lead to high economic and health costs. Such examples include:

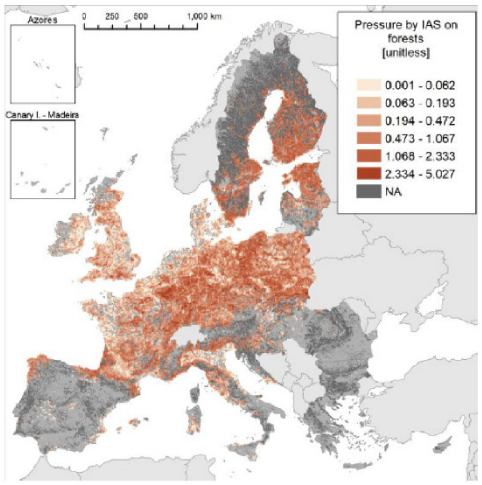
- Insects that bore into the bark and wood of living trees may kill healthy trees, which in turn can alter ecosystem structure and function. Over one hundred invasive alien insect pests of woody plants have been introduced in Europe. *Anoplophora glabripennis* (Asian long-horned beetle) is one of the most dangerous, killing deciduous trees.
- *Ophiostoma novo-ulmi* (Dutch elm disease) is a fungal pathogen that is highly contagious and lethal to European elms.
- *Cryphonectria parasitica* (chestnut blight fungus) is another example of a fungus that has devastated large plantations of sweet in southern Europe.

Asian longhorned beetle boring into a tree.
By R. Anson Eaglin - CC

Chestnut blight fungus.
By Joseph OBrian CC

The European Alien Species Information Network (EASIN) includes information on some 14,000 alien taxa in Europe and facilitates timely notifications of invasive alien species of Union concern as required by the EU IAS Regulation 1143/2014. Almost half of the forest ecosystem extent is affected by invasive alien species, as calculated in the EU ecosystem assessment. The widespread distribution of invasive alien species across almost half the European forest cover is particularly concerning since certain species are at higher risk of becoming invasive with climate change.

Pressure by the 49 invasive alien species of Union concern on forests.



Source: EU ecosystem assessment

The IUCN European Red List of trees recognizes about 150 invasive alien tree species in Europe. Dense homogenous stands of invasive alien trees pose serious risk to forest habitat types protected by Article 1 of the Habitats Directive. *Robinia pseudoacacia* (black locust) is the most commonly reported invasive alien species covering more than 1.4 million ha. *Ailanthus altissima* (tree of heaven) is another frequently reported invasive alien tree species. In spite of its modest coverage, it is considered as very aggressive due to its fast-spreading and toxicity. Many other invasive alien tree species are black-listed or controlled in Europe, including *Acer negundo*, *Acacia* spp., *Prunus serotina*, and *Quercus rubra*.

[1] Tree cover loss is defined as a stand-replacement disturbance, or a change from a forest (tree) to a non-forest (non-tree) state in a stipulated time period, representing the effects of logging, forest fires, windstorms and other disturbances leading to a change in the tree cover.

[2] Tree canopy cover is defined as canopy closure for all vegetation taller than 5m in Height in a stipulated time period.

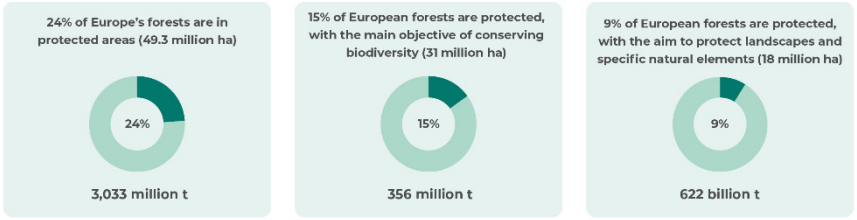
[3] Please see Annex 3.3.102 of the MAES assessment. They refer to the Global Forest Change dataset of https://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.0.html. Year or time-series range: 2001-2012 (v.1) and 2001–2018 (v1.6); Version: v.1 and v.1.6; Access date: 07/01/2019 and 05/05/2020; Reference: Hansen, M. C., Potapov, P. V., Moore, R., Hancher, M., Turubanova, S. A., Tyukavina, A., et al. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. Science, 342(6160), 850-853, doi:10.1126/science.1244693.

The EU Biodiversity Strategy for 2030 works in close conjunction with the EU Forest Strategy for 2030 to manage major pressures on forests, increase forest protection (including all primary and old-growth forests), restore forests (including planting at least 3 billion trees), and putting sustainable forest management plans in place (including for all publicly-owned forests).

The EU Biodiversity Strategy for 2030 aims to put Europe's biodiversity on a path to recovery by 2030. It foregrounds the role of protecting and restoring forest ecosystems for the benefit of people, climate and the planet, and provides for specific actions and commitments around protecting forests, increasing the quantity of forests, and improving forest health and resilience. The policy links strongly to the EU Forest Strategy for 2030.

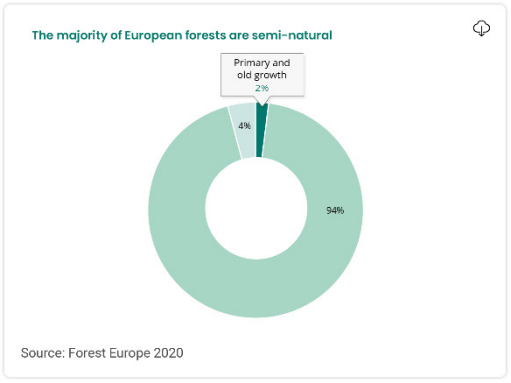
- Protection commitments include protecting all remaining EU primary and old growth forests, and further protection to build a truly coherent Trans-European Nature Network.
- Increasing the quantity of forests and improving forest health and resilience are actions that are viewed to drive a joint agenda for achieving both biodiversity targets and climate neutrality.
- All public forests and an increased number of private forests should have management plans that include biodiversity-friendly afforestation and reforestation and closer-to-nature-forestry practices.

Further development of the Forest Information System for Europe will enable up-to-date assessments of the condition of European forests and link all EU forest-data web-platforms.



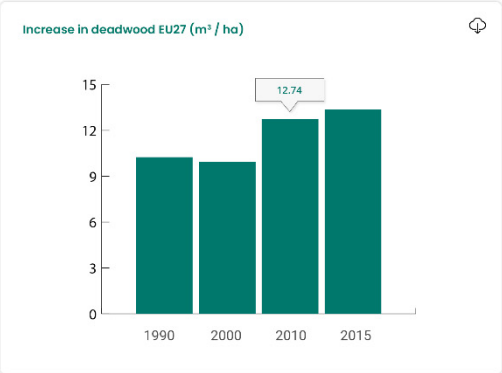
The EU Biodiversity Strategy for 2030 and EU Forest Strategy for 2030 provide for the protection of all primary and old-growth forests. They are not only among the most biodiverse EU forest ecosystems, but also store significant carbon stocks and remove carbon from the atmosphere. They are generally small and fragmented, but when they form large continuous forest areas, particularly with semi-natural forests, it allows natural ecosystem dynamics to occur.

ABB: Link to the recent primary forest database by Sabbatini et al which we are building in FISE

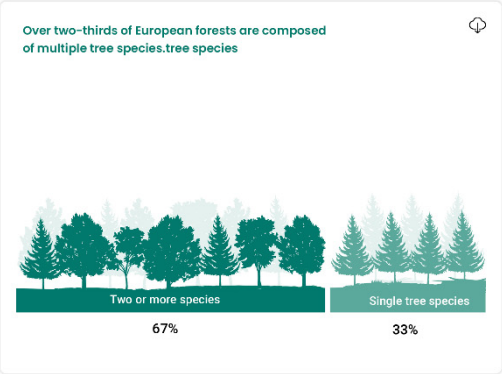


Europe's sustainable forest management framework provides a Pan-European common understanding of sustainable forest management. It already covers deadwood and tree species diversity as indicators. The EU Biodiversity Strategy for 2030 and EU Forest Strategy for 2030 provides for extending this set of indicators in FISE for measuring and monitoring ecosystem health, biodiversity and climate change, which includes defining thresholds or ranges for achieving a desirable condition for each indicator.

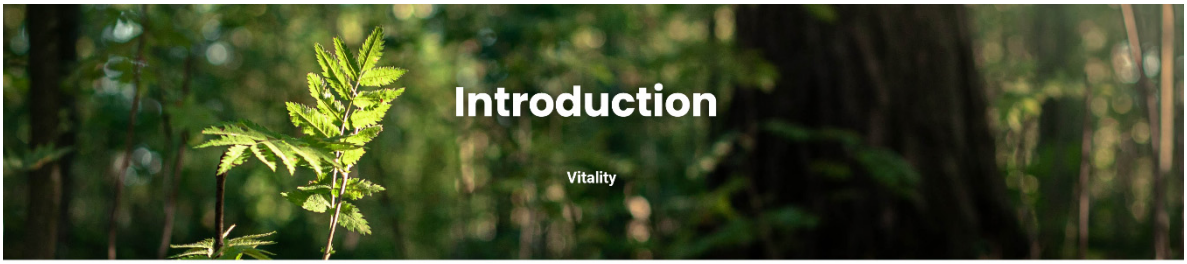
Deadwood provides habitats for numerous species of forest animals, plants and fungi, and plays an important role in carbon and nutrient cycles. The volume of deadwood is much lower in intensively managed forests than in semi-natural forests.



One third of Europe's forest area comprises stands of only one tree species, especially in South-East Europe. The remaining area is covered with 2 or more species. Especially in South-West Europe, a considerable share of the forest area consists of forests where six or more tree species occur. Monocultures harbour less biodiversity than mixed stands and are more vulnerable to invasive alien species, pest and diseases outbreaks, and disturbances.



3.8 Vitality



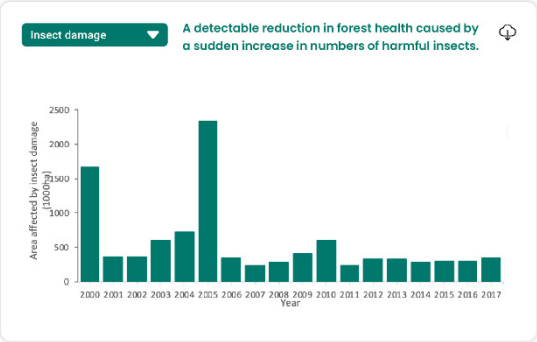
This page highlights major pressures that are affecting the vitality of European forests, and what is being monitored. We also show examples of how we measure forest health with different indicators, and what make a forest vital, healthy and resilient to disturbances.

Forests are managed to minimize the risks and impacts of disturbances like wildfires, storms, invasive species, and diseases. These disturbances impact not only environmental but also social and economic dimensions of forests.

Important management strategies include reducing even-aged and single-species forest stands, awareness and management of forest connectivity and fragmentation and policies regarding native and invasive species.

Disturbance events like droughts, fires, windstorms and floods are pressures from extreme weather events exasperated by climate change. Human activities can affect the vulnerability of forests to disturbances. For example, 87-95% (European Commission) of forest fires are ignited by human activities. Globalisation, human travel and trade of goods may directly cause the spread of invasive pest and pathogen species. Below are time series on how much these pressures have affected the forests in Europe.

Through the Global Forest Resources Assessment (FRA), the FAO has regularly collected, analysed, interpreted and disseminated information on the status and trends of the world's forest resources. (FAO). These are standardized and validated definitions, subject to update every five years to increase country participation. Read more on the FRA site.

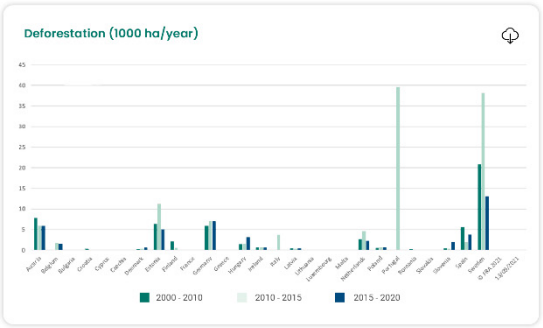


Climate change, pollution and deforestation

Forests are directly linked to climate change by removing or emitting greenhouse gasses. While forests normally remove carbon dioxide from the atmosphere, they also emit large quantities of carbon dioxide back to the atmosphere after a destructive natural disturbance or large-scale forest management operation. The highest emissions occur when a forest area is lost permanently through land use change i.e., an area is deforested.

In addition to climate change, pollution is a significant pressure for European forests. While nitrogen deposition has significantly decreased in many parts of Europe, it still causes a risk of eutrophication to many forests stands (ICP, 2018).

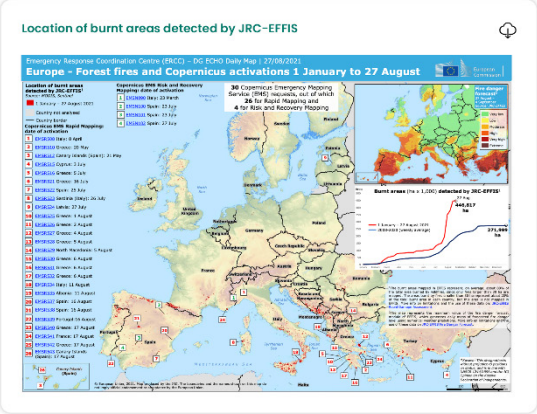
In Europe, common cause for deforestation is building of new infrastructure, e.g., urban expansion and mining.



Source: FAO

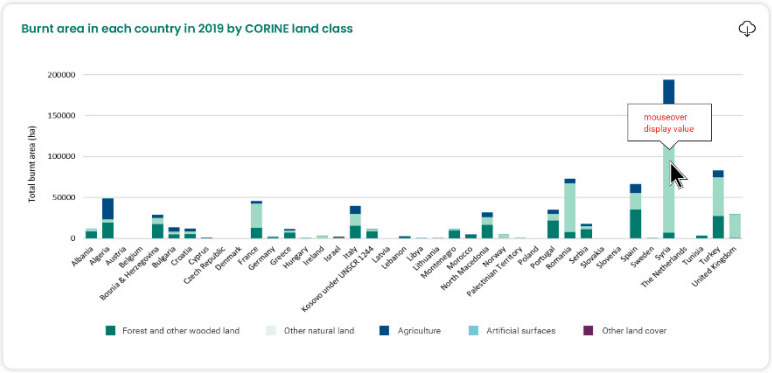
Forest Fire

Forest losses due to fires have increased in the past years. Fires have more than doubled (an approximately 210% increase) for the years 2016–2018 compared with the average number of fires from 2004–2015. There is great variability between years in the amount of burned area but last years have been extreme. For example, 2020 and 2021 were many times over the long-term average.

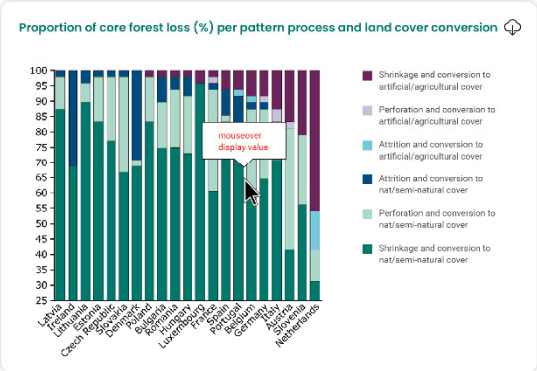


Source: ERCC

European Forest Fire Information System (EFFIS) became operational in 2000, and monitors the fire activity in the EU. The total burnt in protected areas in 2019 was over three times that recorded in 2018.



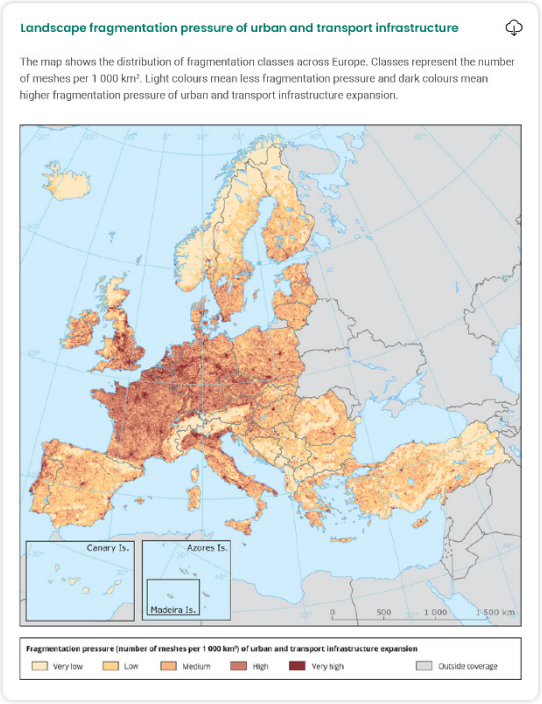
Source: Advance EFFIS Report on Forest Fires in Europe, Middle East and North Africa 2019



Landscape fragmentation

Fragmentation is the partitioning of ecosystems by infrastructure like roads, powerlines and railways. Human traffic channels fracture the landscape and affect animal populations in four main ways. They decrease habitat amount and quality; enhance mortality due to collisions with vehicles; prevent access to resources on the other side of the road; and subdivide animal populations into smaller and more vulnerable fractions.

Pressure from forest fragmentation is increasing at the local scale due to agricultural expansion or abandonment, housing or transport infrastructure. Forest fragmentation impacts ecological processes, such as habitat provision, gene flow, pollination, and wildlife dispersal. Forest fragmentation redu seed dispersal, limits pollination and hinders animal mobility. This in turn limits the resilience of forests to pressures like storms, reduces biodiversity, and also the adaptability of forest species to climate change.



Source: EEA

Native Species causing large-scale disturbances

Many native species can cause large-scale forest disturbances. Below are some examples of such species.

Ips typographus by Gilles San Martin. CC BY 2.0

Lymantria dispar by Ettore Balocchi. CC BY 2.0

Cervidae by Jin Kemole. CC BY 2.0

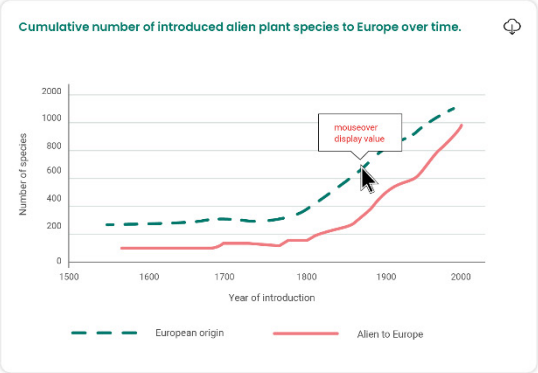
European spruce bark beetle (*Ips typographus*) is one of the most serious and destructive pests of spruce in its native range of Asia and Europe. It is common throughout the entire natural range of Norway spruce in Europe and also occurs in plantations in Western Europe, outside the natural range of the host (Source). In recent years, large outbreaks have occurred in Czech Republic, Germany, Poland, Slovakia and Sweden. Climate change may facilitate the spread of this pest as it benefits from the longer growing seasons, hot and dry summers that weaken its host Norway spruce as well as storms that damage the trees producing ideal breeding habitats.

Gypsy moth (*Lymantria dispar*) is a significant defoliator of a wide range of broadleaf and even conifer trees. While low population levels can exist for many years without causing significant damage, severe outbreaks can occur resulting in severe defoliation, growth loss, dieback and sometimes tree mortality. This moth is considered a significant pest in both its native and introduced ranges. (Source)

Deer (*Cervidae*) can significantly hinder forest regeneration. Roe deer, red deer, fallow deer and elk can hinder the regeneration of some tree species as they browse on the tree saplings. For example, in Scandinavia, elk limit the regeneration of broadleaved trees and Scots pine. In Central and Estern Europe red and roe deer are the main herbivores. For example, the regeneration of the silver fir has been low for years due to heavy browsing pressure.

Invasive species

Invasive species are non-native plants, animals, pathogens and other species that may cause harm to the native biodiversity and ecosystems of Europe. For example, pine-wood nematode has caused mortality of pine trees in large parts of Portugal and also in Spain, forbidding the wood trade from those regions to others to prevent the spread of the pest. **Invasive species introductions in Europe are increasing across all taxonomic groups**. The introduction of invasive species has been increasing exponentially in the last 50 years, and show no signs of slowing. (For more see the Biodiversity FISE page)



Source: Lambdon et al. 2008

Examples of invasive species of concern to European Forests

Racoon dog (*Nyctereutes procyonoides*)

- The Racoon dog is native to Eastern Asia and wild populations are currently established in 14 Member States
- Successful carnivore with high reproductive capacity and adaptive behaviour is a threat to biodiversity since it is a generalist that feeds on many native species like rodents, reptiles, waterfowl, and insects.
- Vector of rabies, ticks, worms, and other parasites which are a threat to native wildlife and humans
- The EU plan of action includes eradication of new populations and ban on keeping or selling this species

Grey squirrel (*Sciurus carolinensis*)

- Native to North America
- Introduced in Italy, Ireland and UK
- Main threat of the red squirrel due to its competitive nature and preference for urban areas.
- Causes significant ecological and economic damage through habitat stripping

Asian Hornet (*Vespa velutina nigrithorax*)

- Native to Southeast Asia
- Introduced likely through imported goods
- Predator of honeybees, wasps, hoverflies and other important pollinators
- Losses of many hives and due to its aggression, high adaptability have had serious effects on native biodiversity, and caused significant economic damage
- Nests are actively being destroyed as an EU-policy action

Muntjac deer (*Muntiacus reevesi*)

- Native to South Asia
- Introduced to European parks in 1900s
- Established in 5 member states (BE, DE, DK, IR, NL)
- This species can overgraze, especially in large herds, and can destroy protected areas. Grazing can also prevent coppice growth.
- EU has a sales ban, phasing out of zoos and ownership prevention.
- Nests are actively being destroyed as an EU-policy action

Kudzu vine (*Pueraria lobata*)

- Native to Asia
- So far it has been introduced only in Italy and Switzerland
- Difficult to manage if established. It can affect structures and recreational facilities, overgrow native forest species and negatively impact crop production.
- There is a ban on sales, and planting and eradication off new populations is advised to reduce damage if growth continues.

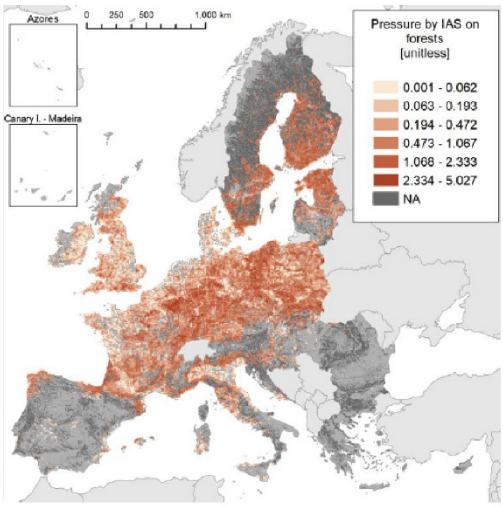
Pallas squirrel
(*Callosciurus erythraeus*)

- Native to Southeast Asia
- Introduced to France in 1970s as a pet and since escaped to parks, forests and gardens
- Established in 4 member states (IT, NL, BE, FR)
- Very adaptive, generalist feeder, can strip bark and have important economic damage, as well as outcompete native species
- EU has a sales ban, phasing out of zoos and ownership prevention.
- Banned for trade

Source: EC

Biodiversity in forest stands of introduced tree species is generally lower than in stands of native tree species as native tree species have had a long co-evolution with surrounding environment. However, some introduced tree species might have higher biodiversity than native ones. In contrast, invasive species tend to spread and conquer local ecosystems and reduce biodiversity by outcompeting other vegetation and changing the food chain. (Source: Introduced tree species in European forests: challenges and opportunities)

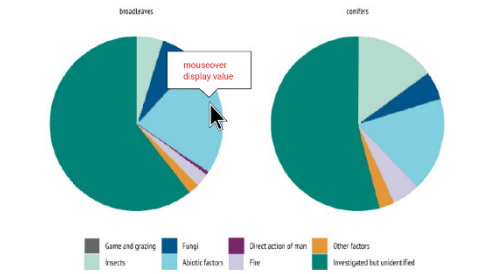
Pressure by IAS on forests shows that the pressure from invasive is greater in central and north eastern Europe.



Source: EU ecosystem assessment

Generally the damage to forests is difficult to identify, but insects and abiotic factors are the most predominant sources of disturbance and forest damages.

Percentage of damaging agent groups causing mortality of broadleaved and coniferous trees in 2019 (n = 911).

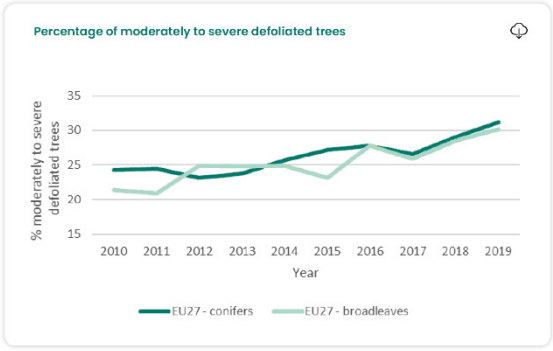


Source: ICP Forests

There is no consensus on a clear definition of 'Forest Health'. The origin of the term Forest Health is strongly connected to the concern of acid rain and forest decline ('Waldsterben') in the 1980s. Since then, the condition of the air quality and the forest evolved and Forest Health became relevant in a broader area of interest e.g. climate change, biodiversity, resilience, sustainable forest management[1]. Forest Health is one of the criteria for sustainable forest management (SFM) used by Forest Europe (FE).
European member states record forest health indicators in a standardised way in the ICP Forest monitoring network.

Important indicators for Forest Health are tree crown condition (expressed as degree of defoliation), soil condition and foliar nutrient status.

Tree crown condition

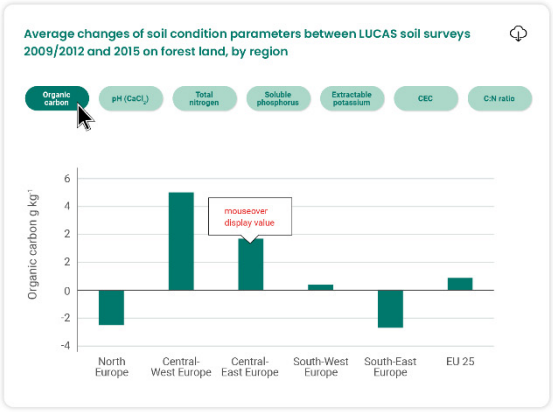


Defoliation increased for broadleaved trees and conifers in the last twenty years for the EU27 member states (source ICP Forests).

In 2019, damage cause assessments by ICP forests were carried out on 103 297 trees in 5 654 plots and 26 countries. Most of the damage was reported on broadleaved trees, mostly by insects.

Soil condition

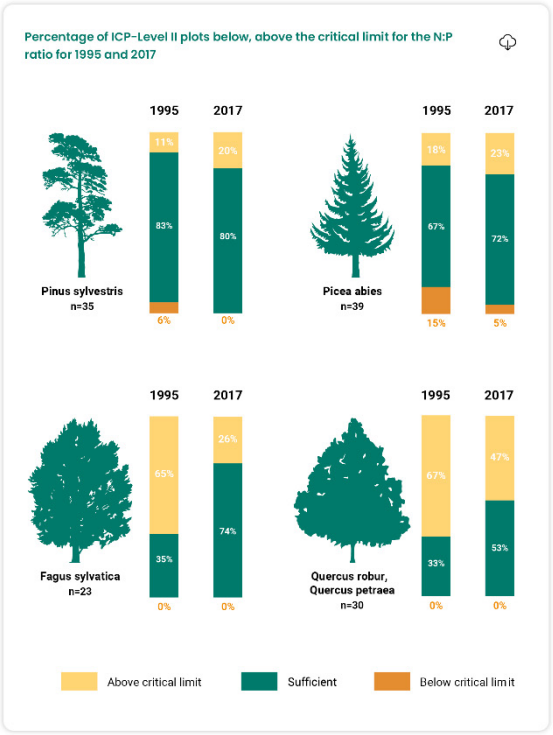
Soil acidity is an important soil property that influences concentrations of important nutrients and minerals. Low soil acidity may cause unfavorable growing conditions for forests. The soil acidity in European forests stayed more or less at the same level over the period 2009-2015 (approximately 0.1 unit change pH $CaCl_2$).



Source Forest Europe SoEF_2020.pdf (foresteurope.org) Table 2.2-2 p 68

Foliar nutrient content

Foliar nutrient ratio's below or above the critical limits are related to decreased resilience and susceptibility of trees to plagues and diseases and to decreased growth levels.

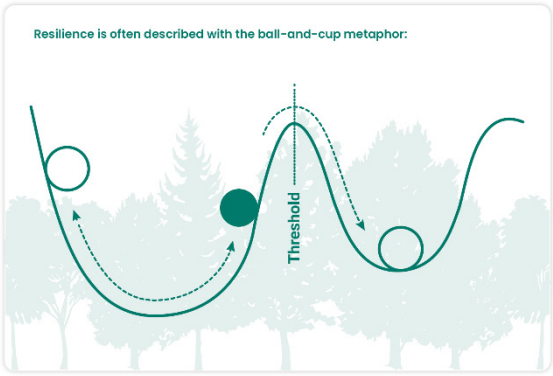


Source: M. van Doorn (2020) Temporal trends and spatial variability of foliar nutrients in Europe (wur.nl)

The percentage of plots with a foliar N:P ratio above the critical limit increased for *Pinus sylvestris*, *Picea abies* and *Fagus sylvatica*. For *Quercus spp*. it decreased.

1 Ferretti, M. (2004) Health and protection. Diagnosis, Monitoring and evaluation. Elsevier, Encyclopedia of Forest Sciences, pp. 285-299.

There is no consensus on clear definition of resilience. The International Panel for Climate Change (IPCC) uses the following: "The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/ or transformation" (Arctic resilience report).

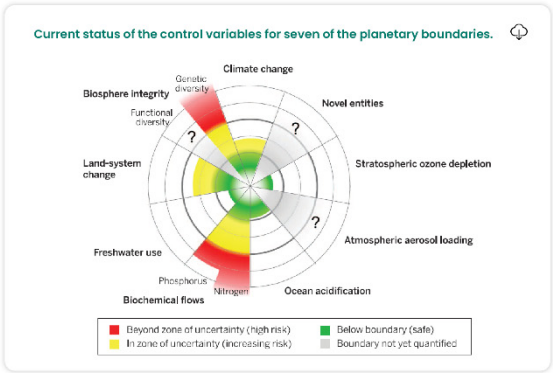


The ball and cup metaphor of resilience where the ball represents the ecosystem and the cup represents the different possible states the ecosystem could have. Resilience is expressed by how difficult it is to move the ball from one cup to the next. The harder the moving is, the more resilient the system is. Figure source.

As a response to climate change, increased tree mortality and decline of biodiversity, the European Green Deal, EU Biodiversity strategy for 2030, and the new EU forest strategy for 2030 call for increasing resilience of forests to natural disturbances.

Resilience is influenced by planetary boundaries and tipping points. Planetary boundaries identify the levels of human-caused perturbations below which the risk of destabilization of the Earth system is likely to remain low (Science.org). When planetary boundaries are crossed, tipping points may occur.

Climate change, biodiversity loss and land-system change are parts of the planetary boundaries (Science.org).



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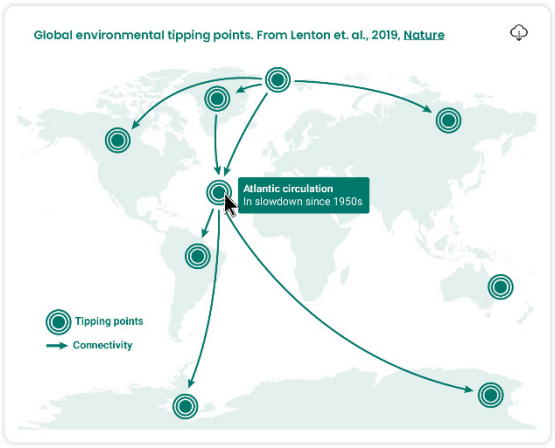
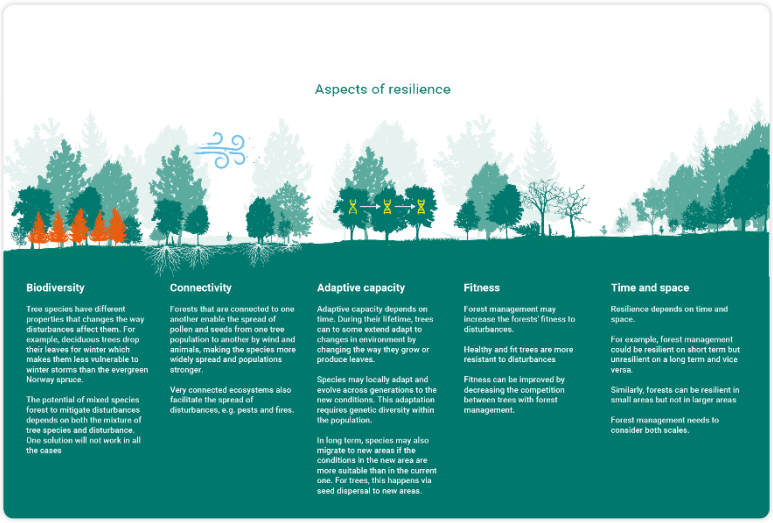
Tipping points are points in which a small perturbation can cause a fundamental and often irreversible change in the ecosystem (Environmental Tipping Points). For example, a drought period leading into a widespread tree mortality and lack of regeneration potential might turn a forest into a shrubland.



NOTE:
Mouse over on tipping points displays texts

Forest resilience has several important components, e.g., biodiversity, adaptive capacity and connectivity. These components play an important role in making forests more resilient to disturbances.

Forest management should consider all aspects of resilience and manage the possible trade-offs that may occur when forests have many users who value different things, for example recreation and timber production.



3.9 Management

This mockup is for visual reference only. Please use the Forest Management Word document for the final text and data.

Forest management in Europe

Forests are complex ecosystems that fulfil diverse environmental, economic, social, and cultural functions. To ensure the provision of resources and the fulfilment of other functions, management techniques are implemented over forest lands. Therefore, forest management is the process of planning and implementing practices to better administrate and use forests and their resources.

In Europe, forest management is a common practice, around 85% of all forests are under management plans or equivalent. The planned and implemented techniques applied during the process of forest management are dependent on the forest specificities and the targeted benefits. Forest management involves many decisions at different growth stages of a forest. Major traditional forest management decisions are shown in the following table:

Suggestion for future improvement:Table could be replaced by infographic presenting the different forest management decisions

TABLE
Major decisions involved in forest management and the associated silvicultural operations, modified from Duncker et al. (2012)

Decision	Silvicultural operations	Aspects to be considered
Naturalness of tree species composition	Selection of tree species	Species composition in relation to the potential natural vegetation, share of site-adapted tree species, and share of introduced tree species
Type of regeneration	Stand establishment	Natural regeneration, planting, seeding and coppice
Forest reproductive materials	Selection of populations and tree genotypes	Selection of site adapted forest genetic material, use of improved breeding material
Machine operation	Fertilizing, liming, soil preparation, thinning, final harvest	Use of forest machinery for soil preparation, thinning and final harvest
Soil cultivation	Soil preparation, drainage, prescribed burning	Physical site preparation (mechanical and use of prescribed burning) and drainage
Fertilization / Liming	Fertilization, Liming	Fertilization to increase yield (amelioration), compensation for nutrient extraction, and re-establishment of natural biogeochemical cycles
Application of chemical agents	Pest control	Application of pesticides and herbicides
Integration of nature protection	Tree retention, special habitats	Retention of biotope/habitat trees, tolerance of deadwood, and biotope protection within stands
Cutting regimes	Cutting regime of final harvest	Continuous cover, shelterwood, clearcutting, coppice, coppice with standards
Tree maturity	Final harvest	Felling age in relation to the potential life span of a given tree species
Wood removal	Thinning, final felling	Tree components (stem, stem tops, branches and stumps) extracted in thinning and harvesting operations

Besides the traditional aspects that involves management decisions, disturbances are events that can have major impact on forest management activities. While Tab 1 to 5 describe traditional forest management activities, Tab 6 describes forest management activities after disturbances events.

This factsheet provides an overview of forest management across Europe and is structured as follows

- Tree species
- Regeneration (Type of regeneration, Forest reproductive materials)
- Tending (Soil cultivation, Fertilization / Liming, Application of chemical agents, Integration of nature protection)
- Harvest (Harvest regimes, Tree maturity, Wood removals)
- Post disturbance forest management

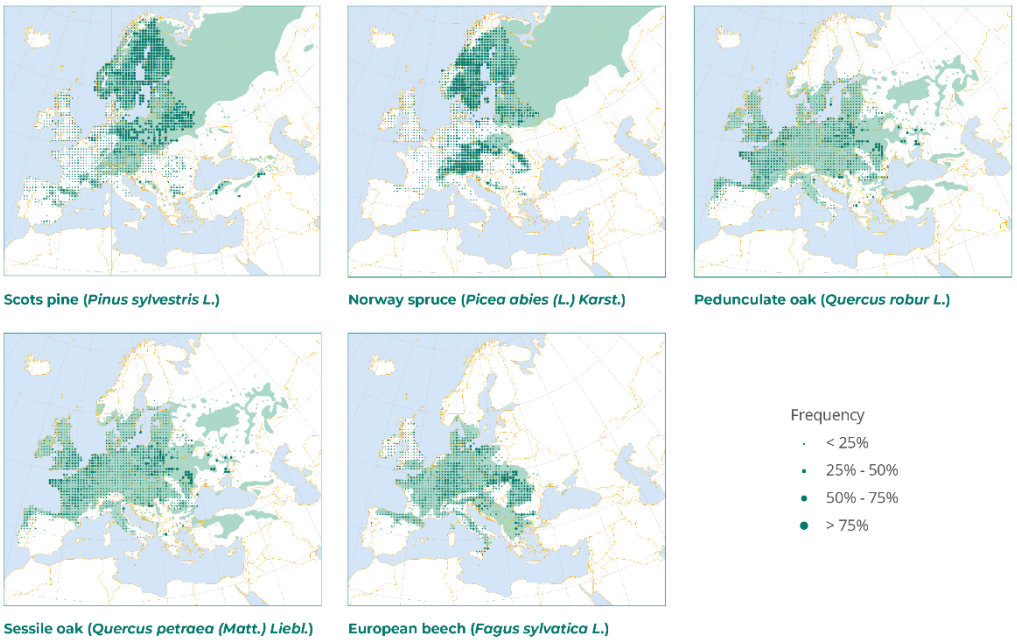
This factsheet is based on a review conducted in the GENTREE project

TREE SPECIES SELECTION

Forest managers have long favoured relatively few tree species for timber and fuelwood production, as well as other amenities. European forests therefore deviate substantially from the potential natural vegetation.

At the European level, economically important and widespread tree species include Scots pine, Norway spruce, pedunculate and sessile oak, as well as European beech (Figure 1.1).

Figure 1.1
Distribution of tree species according to observations in national forest inventories and their native range.



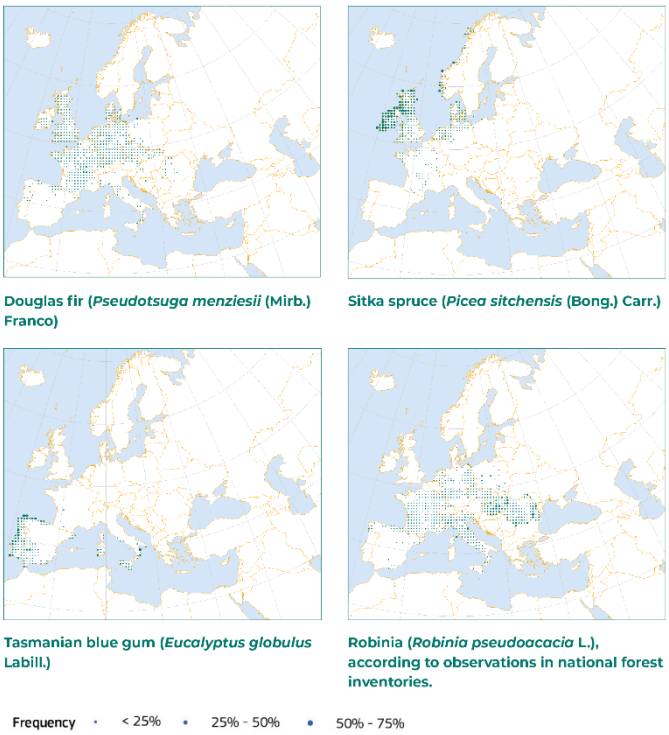
Source: [4]

A shift towards an increased share of broadleaved species can be observed, especially in Central Europe. Since the 1990s, forest managers have been increasingly favouring broadleaved species motivated by the realization of the susceptibility of pure coniferous forests to disturbances by storms, wildfires, insect outbreaks and climate change, as well as the onset of close-to-nature silviculture and nature-oriented forest management [3].

At least 150 non-native tree species have been introduced in Europe, either intentionally or accidentally. These species are not necessarily invasive and are currently growing in European forests and provenance trials, covering an area of approximately 8.5 million ha.

These species mostly originate from North America and, to a lesser extent, from Asia and Australia. *Eucalyptus*, *Pinus*, *Acacia* and *Abies* are the most common genera in Europe, while the most occurring non-native species are Douglas fir, Sitka spruce, Tasmanian blue gum and black locust (Figure 1.2). The area covered by introduced trees has increased steadily in the European Union and Europe between 1990 and 2015 but decreased slightly in Central-West Europe between 2005 and 2015 [4].

Figure 1.3
Distribution of non-native tree species according to observations in national forest inventories.



Source: [2]

REGENERATION

2.1 Type of regeneration

Regeneration refers to the silvicultural operation of establishing forest stands. There is a range of methods that can be applied in the regeneration process of a forest.

Natural regeneration

Natural regeneration, which is the establishment of forests stand through natural seeding or coppice.

Natural seeding is largely determined by the availability of seeds from nearby stands. This method relies to a large extent on the composition with regards to tree species and genotypes of the previous generation.

Coppice is the stimulation of the development of new shoots from stumps and roots of cut trees. The feasibility of this method relies mainly on the capability of trees species to coppice, which is far more common on broadleaves.

Artificial regeneration

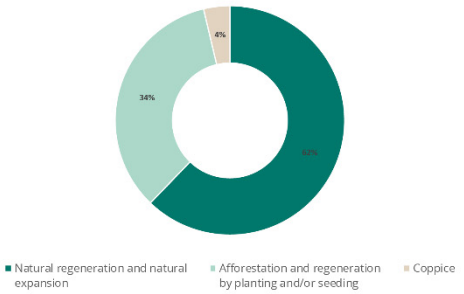
Artificial regeneration encompasses planting and artificial seeding activities, allowing the selection of tree species. It is guided by the environmental site conditions that ultimately determine whether a species will survive and remain healthy, as well as its growth rate [5]. Artificial regeneration provides more direct control over the tree species, genotypes and placement of trees in the new stand [5].

Combination of natural and artificial regeneration

Combination of natural and artificial regeneration are also possible. The choice of a regeneration method is guided by the management goal (e.g., timber production, biodiversity protection), the preferred tree species, and the availability and cost of reproductive material (such as seeds and seedlings). Furthermore, the choice of a regeneration method is closely linked to the harvest regimes that are applied.

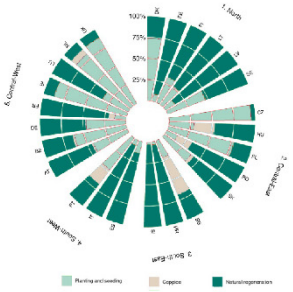
Over 60% of forests in the EU originate from natural regeneration. Coppicing has been more widespread in the past, but nowadays only about 4% of the total forest area are originated by this method, mainly in South-East European countries (Figure 2.1).

Figure 2.1
Forest area by stand origin types in the EU, in 2015



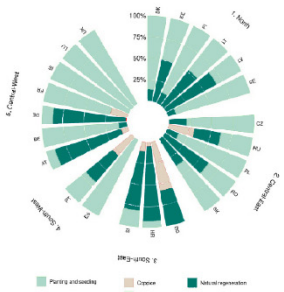
Source: [6]

Figure 2.2 (a)
Regeneration origin distribution by country



Source: [6]

Figure 2.2 (b)
Annual regeneration by country and type in 2015



Source: [6]

Overall, planting is the most common artificial regeneration method in Europe and regenerating by means of sowing is limited to regenerating stands of light demanding conifers on sites that have been clear-felled in North and Central-East Europe (Figure 2.1) [6].

2.2 Forest reproductive material

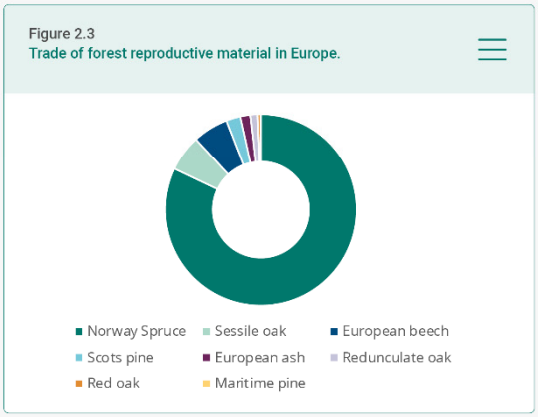
The choice of forest reproductive material refers to the decision by a forest manager on the material (i.e. seeds, or seedlings produced from seeds, cuttings or other propagating parts of a tree) to be used during the regeneration stage. The choice is closely related to the choice of the tree species composition and regeneration method (mainly artificial regeneration. The choice of breeding material is also important in the context of afforestation of new forest lands.

When applying artificial regeneration (or afforestation), a forest manager can choose whether to use seeds (or seedlings produced from seeds) that have been collected in registered seed stands, or to use improved forest reproductive material developed from seed orchards. Improved forest reproductive material relates to material that has been selected and/or tested in order to obtain benefits, such as increased productivity, improved timber quality, better resilience to climatic conditions, pests and diseases. Another option is to use forest reproductive material that has been genetically modified, but genetically modified trees are currently not used in European forestry due to regulatory restrictions and limited public acceptance.

Use of forest reproductive material

Information on the use of tree breeding material in forest management is limited and can only be inferred from statistics on production and trade of seedlings and seeds, as well as information on tree breeding programmes. In the period 2004–2014, on average 30 million plants and 400,000 kg seeds were traded annually. Coniferous FRM trade is dominated by Scandinavian and Baltic countries, while about 15% of traded seedlings were hardwood tree species, especially in Central Europe [7].

Figure 2.3
Trade of forest reproductive material in Europe.



Source: [6]

3.1 Soil cultivation

Soil cultivation operations are typically carried out to prepare a site for seed germination, seedling survival and early growth [10] either to prepare for a new stand when afforestation is taking place, to facilitate access to a site after harvesting activities or to reduce wildfire risk.

Operations may include:

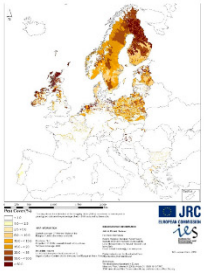
- **Scarification**: an operation that removes the upper organic layers to uncover the bare soil, as well as competing vegetation [11] to create desirable planting spots in mineral soils or in mixed-organic soils, improving temperature, nutrient availability and moisture status [11].
- **Subsoiling or ripping**: a surface treatment applied in case of dry soils or compacted surface layer, which restricts the root growth and plant development. This practice fractures soil structure without mixing the soil horizons.
- **Mounding**: an operation that creates elevated planting spots free from water logging and with low weed competition [14]
- **Drainage**: an operation that through the establishment of ditches or other techniques seek to improve the terrain water drainage.
- **Fertilization**: the process of applying fertilizer to the soil to some extent, improve growth in forest stands. While the average annual rates of fertilizer application per hectare are generally low, the amounts and types per application could be similar as in agriculture [18]. The application of fertilizers is common in nurseries and (containerized) planting material.

TABLE
Major decisions involved in forest management and the associated silvicultural operations, modified from Duncker et al. (2012)

Northern Europe	Southern Europe
Scarification Scarification is applied in Northern Europe to reduce competition from field vegetation and damage by insects (e.g., pine weevil) [12]. In Sweden, the combination of shelterwood system and scarification is a standard practice applied for a long time to stimulate natural dynamics of Scots pine [13] and it is most commonly applied by disc trenching using rotating disks in continuous rows	Subsoiling or ripping In Mediterranean dry sites, subsoiling may lead to positive effects on water and nutrient availability. In this area, the traditional methods include deep subsoiling, with 50-70 cm depth, in combination with mechanical terracing, having 2-3 meters wide, and mechanical or manual holes for planting [11]. In Spain, terracing is applied on hill slopes and may be followed by subsoiling to improve water infiltration and plant root development for example [11]. In Portugal, sub-soiling is applied in Stone pine plantations.
Mounding In Northern Europe spot-wise mounding is becoming an alternative to scarification and in Finland, mounding has become much more common than patch scarification and disc trenching over the last 15 years.	Fertilization Fertilization is common within intensively managed plantation forests. In Italy, fertilization is applied to hybrid poplar plantations and in Spain and Portugal, fertilization is common in Eucalyptus plantations. Fertilization in these Eucalyptus plantations is applied during planting for root establishment, during stand development to stimulate growth and after harvest to promote growth and development of new sprouts. Different fertilization practices are used by non-industrial owners and Spanish pulp companies, with more intensive harvesting and fertilizing in the last case [20].
Drainage Drainage of forest soils is connected to the presence of peatlands. The total area drained peatlands used for forestry in Finland, Sweden, Estonia, Latvia, Lithuania and Poland is approximately 10 million ha. Finland and Sweden have the largest area and density of drained peatlands [16]	
Fertilization Fertilization peaked in Finland and Sweden in the 1970s, but decreased substantially in later years.	

Figure 3.1: Disc trenching in Finland. Credits: PJ Verkerk

Figure 3.2
Presence of peatland in Europe

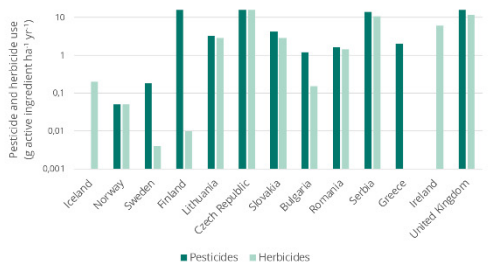


Source: [17]

3.2 Application of chemical agents

The use of pesticides in European forestry appears to be limited [21] and significantly less than in agriculture. Available information in thirteen European countries in 2009 indicates that the use of pesticides and herbicides ranges from 0.0002 to 0.69 kg active ingredient ha^{-1} yr^{-1} over the whole forest area in these countries, with a tendency of lower rates in northern countries (see Figure 3.3) [22]. When applied, the amounts per application range between 0.1 and 2.2 kg active ingredient ha^{-1} yr^{-1} [22].

Figure 3.3
Pesticide and herbicide use in 13 European countries in 2009.



Source: [22].
Note the logarithmic scale on the y-axis.

3.3 Integration of biodiversity conservation

The integration of biodiversity conservation refers to the extent that forest dependent species and habitats, as well as natural processes are considered in the management of forests. Nature protection is implemented by protecting designated forest features or by integrating nature protection objectives in the multifunctional management of forests. The difference between these two complementary strategies may, however, not always be very clear as protected forests may be actively managed, and managed forests may include sites that are voluntarily or temporarily protected.

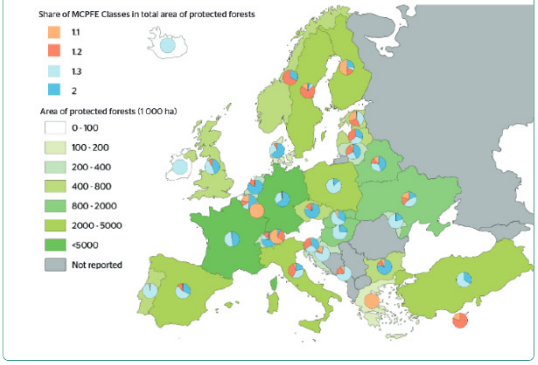
Management decisions related to biodiversity protection in managed forests also include decisions on for example naturalness of tree species composition, type of regeneration and cutting regimes.

Forest protection

In the European Union, 25 million hectares were protected for biodiversity purposes in the year 2015, corresponding to 11% of total forests areas of these countries. The extent of protected forest for biodiversity and landscape purposes has increased in Europe between 2000 and 2015 and especially the area protected with active management has increased [6].

Map presenting the main percentage of protected forest area per country. Our map should show the percentage of protected forest area in relation to the country total forest area. Not making distinction in relation to the MCPFE classes. Something similar to the following map:

Figure 3.4
Total forest area for biodiversity protection in 2015.



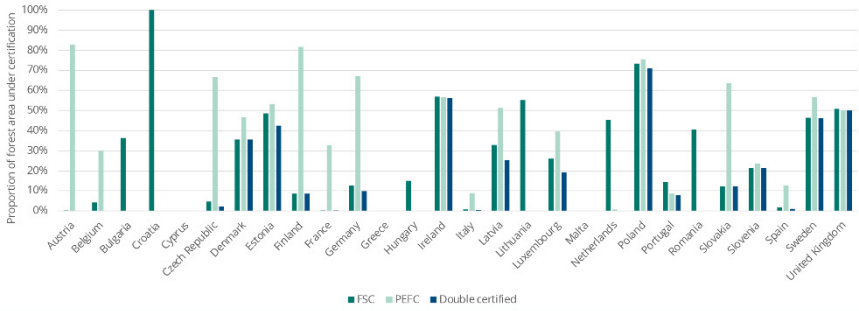
Categorization based on MCPFE classes 1.1 (no active intervention), 1.2 (minimum intervention) and 1.3 (conservation through active management). Source: [6]

Biodiversity conservation in managed forests

Biodiversity conservation in managed forests is typically arranged by forest management certification schemes and national or regional forestry guidelines. Existing guidelines and certification standards typically include a range of measures to integrate biodiversity conservation in forest management, including maintenance of deadwood and habitat trees and tree retention by leaving single trees, groups of trees and buffer zones surrounding waterbodies.

The Forest Stewardship Council (FSC) and the Program for Endorsement of Forest Certification (PEFC) are the most common international certification standards in Europe. In 2019, about 36 million ha was certified by FSC [23] and 70 million ha by PEFC [24] (Figure 3.5). About 21 million ha was certified both by PEFC and FSC in 2016 and the double certified area increased to 26 million ha in 2019 in 17 European countries [25].

Figure 3.5
Proportion of forest area certified according to FSC or PEFC certification standards.



Source: [6; 23-25]

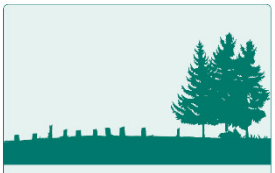
Further information can be found on integrate network and Balance Forest and biodiversity.

HARVEST

4.1 Harvest regimes

Harvesting regimes relate to the extent that a forest area is cleared – or to which the forest canopy is opened – by a (final) harvest operation. This intervention allows the opening of canopies, permitting the regeneration and development of new trees. There are numerous harvest regimes and they can broadly be separated by the extent to which the canopy layer is removed and the distribution of harvest over the forest area [22]

The extent to which the canopy layer is removed relates to the choice whether a stand is cleared by a single felling through a clearcut. While clearcuts results in an even-aged forest, two or more successive fellings may result in the future stand developing under the shelter of the old stand. Also, consecutive small scale cuttings promote continuous forest cover [22].

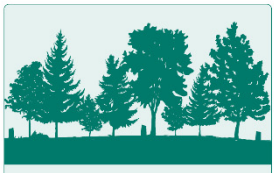


Clear cutting

In a clear-cutting regime, the forest stands are completely cleared and then regenerated.

Shelterwood regime

Shelterwood regime can encompass a wide variety of systems, not all trees are harvested on the stand, creating a more than one forest layer.



Single tree selection

In single tree and group selection systems, scattered single trees or small groups of trees are selected over the whole area and removed.

While the choice of the harvesting system is made by forest management, there is rather limited information on which harvesting systems are applied in Europe. Figure 4.1 indicates common management systems in Europe.

FIGURE 4.1
Common management systems in Europe
(darker shading indicates a management system is more common in a European region)

Management system	Species group	North	Central-West	Central-East	South-West	South-East
Even-aged forest: Uniform clear-cut system	Light demanding conifers					
	Shade tolerant conifers					
	Mediterranean conifers					
	Fast growing deciduous					
	Slow growing light demanding deciduous					
	Slow growing shade tolerant deciduous					
Even-aged forest with shelterwood	Light demanding conifers					
	Shade tolerant conifers					
	Mediterranean conifers					
	Fast growing deciduous					
	Slow growing light demanding deciduous					
	Slow growing shade tolerant deciduous					
	Mediterranean evergreens					
Continuous cover forest management	Shade tolerant conifers					
	Slow growing shade tolerant deciduous					
Coppice	Fast growing deciduous					
	Slow growing light demanding deciduous					
	Mediterranean evergreens					
Coppice with standards	Slow growing light demanding deciduous					
	Slow growing shade tolerant deciduous					
Short rotation	Light demanding conifers					
	Fast growing deciduous					

Source: [23]

4.2 Maturity

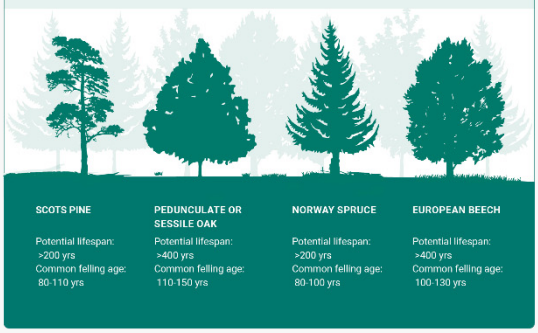
Maturity in forest management generally refers to the felling age in relation to the potential lifespan of a given tree species.

The potential lifespan of tree species is affected by multiple factors including the climate, soil quality, abiotic and biotic events, and competition. Some species, often labelled as pioneer species, are characterised by fast, early growth rates and limited shade-tolerance and life expectancy. Other species may be considered late-successional species that often regenerate under the shade of other trees and are usually characterised by slow, early growth rates and longer lifespans.

In actively managed forests, the felling age is typically significantly shorter than the potential lifespan of a tree species. The felling age (or rotation length) is often based on the growth period required to derive a maximum value from a forest stand. The calculation of this period is specific to the forest considered and to the management goals. Such goals may be to maximize the economic return from wood production, conserve biodiversity, provide protective functions, etc.

Information on the potential lifespan and common felling age of economically important and widespread tree species in Europe is shown in Table 1. It should be noted that the shown information is indicative only as felling ages vary across Europe and maximum tree age is rarely systematically measured or reported. Finally, the reported longevity refers to trees inside forests as individual trees outside of forests trees may get much older.

FIGURE
Lifespan and felling ages of tree species



Source: Common felling age: EFISCEN database. Potential lifespan: [24]

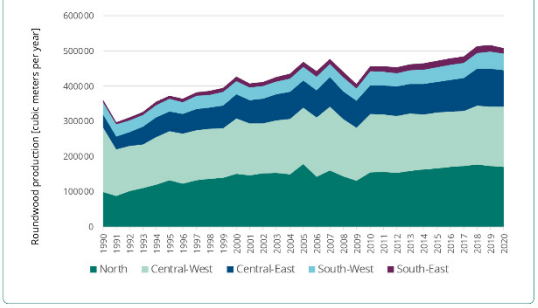
4.3 Wood removals

Wood removal is one of the main interventions carried out during the management of forest areas. Wood removal refers to the extraction of tree's wood components (mainly stem wood but also logging residues) during the tending, thinning, and harvesting operations from the forest. Often, the main motivation to remove wood is to produce raw materials for products. In addition to planned wood removals, wood may also be removed (or salvaged) after a catastrophic event.

The tree stems are the main part of the tree that is removed from the forest during harvest operations. Stemwood is still mostly used to produce solid wood products and pulp and paper or as fuelwood.

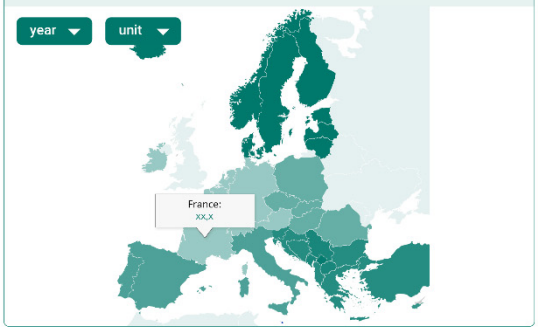
The amount of wood removals in the EU has been steadily increasing over recent decades. About 300 million m^3 of roundwood were produced in the early 1990s and this volume increased to over 500 million m^3 (without bark) in recent years [25].

Figure 4.2
Development of roundwood production in Europe



Source: [28]

Figure 4.3
Roundwood production in Europe.



Typically, more wood is felled than what is removed from the forest. The difference is due to harvest losses in the form of for example stem tops, stem parts near the stump of a tree or larger branches. Some smaller or crooked trees may also be felled but not removed from the forest. Statistics on wood removals and fellings may also not be directly comparable because of differences in reporting methodologies and definitions.

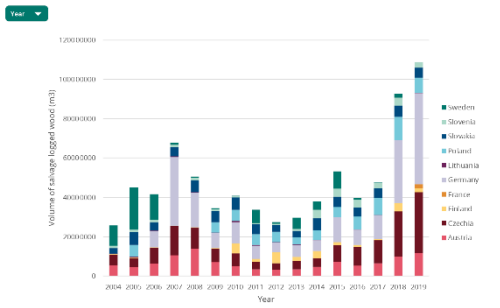
Logging residues typically include stem tops, branches and small trees that are felled during harvest activities, but which are not removed commercially as roundwood. These logging residues and stumps are often left in the forest to decompose, they may be collected as firewood or extracted during site preparation. Since the start of the millennium, there has been an interest in using these residues as feedstock for bioenergy production [add link to Bioeconomy – wood use]. However, limited information exists on the extent by which logging residues are currently extracted in Europe.

POST DISTURBANCE FOREST MANAGEMENT

In unmanaged forests, disturbances such as wind, insect outbreaks and fire are the main factors changing forest structures. In managed forests, disturbances often affect the provisioning of wanted goods and services (e.g., wood, carbon sequestration, recreation). Therefore, forest management measures are taken to minimize the risk of disturbances.

The post-disturbance management depends on the type of disturbance. The most broadly applied post-disturbance forest management is salvage logging. Salvage logging is the felling and removal of trees in naturally disturbed forests, with the primary intention to recoup economic losses, reduce hazards to infrastructure and ensure human safety. It is used in case of windstorms, wildfires and insect outbreaks. Salvage logging is also used to prevent further disturbances such as bark beetle outbreaks in Norway spruce forests after a windstorm or severe drought period.

Figure 5.1
The volume of salvage logged wood in Europe.



Source: [26]

Figure 5.2. Salvage logged timber in Czech Republic. Photo by R. Castañeda

Another widely used post-disturbance management measure is to restore forests with planting quickly after disturbance to aid recovery. Other measures are for example applying pesticides or fungicides to remaining trees and/or tree stumps to prevent further spread of insects, pathogens and harmful fungi.

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3.10 Country factsheets

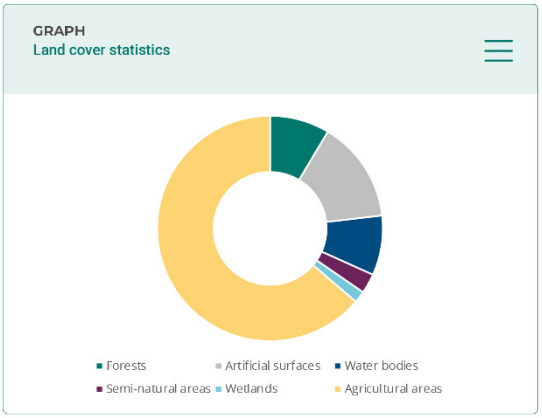
3.10.1 The Netherlands

ALL ABOUT THE FOREST IN THE NETHERLANDS

This country factsheet covers the basic statistics about this country's forest, but also, the aspects of climate and nature, biodiversity, bioeconomy, and vitality.

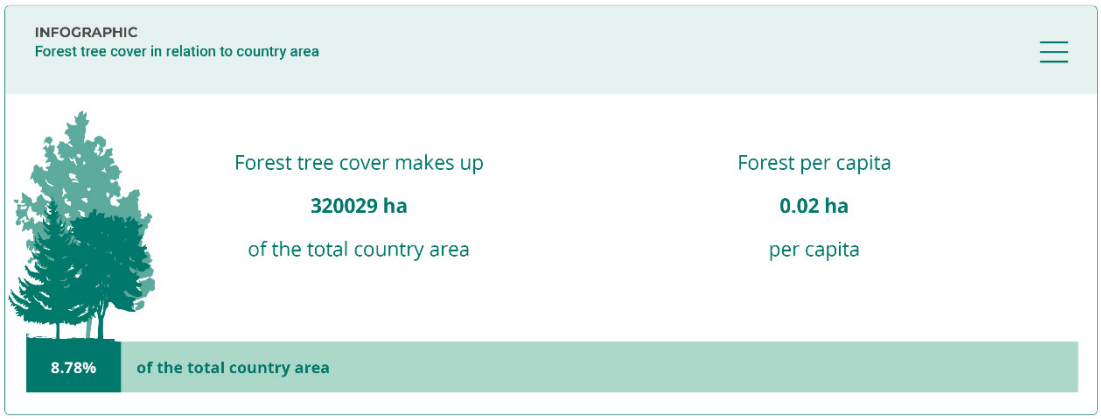
Forest tree cover map. The darker areas show where most of the forests are located.

Forest tree cover



Agricultural areas are the dominant land cover in the Netherlands.

Measuring forest tree cover helps tracking changes, both gain and losses and supports policies related to reforestation, afforestation and ecosystem restoration. Forest per capita gives an indication of how much forest is available per person, can be an indication of the role forests play in the general culture and livelihoods of people.



Forest tree cover is basic for sustainability assessments.

Forest cover over time: Forest cover has remained stable since the year 2000.

Growing stock

Growing stock is the average volume (m^3) of forest per hectare. Increment is the increase of volume (m^3) per year.

Growing Stock

216.6 m^3/ha (NBI6)

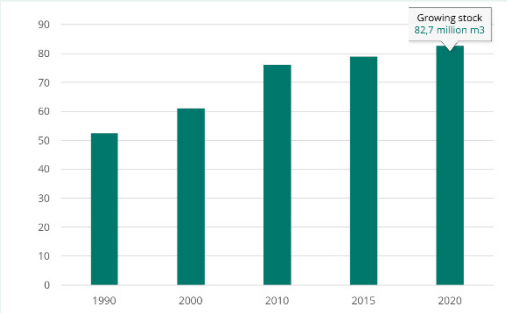
Source: WUR

Increment

7.3 m^3/ha (NBI6)

Source: WUR

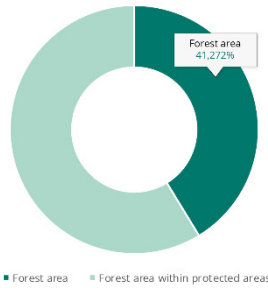
GRAPH
Growing stock per year, million m^3



The growing stock volume has increased steadily over the last decades.

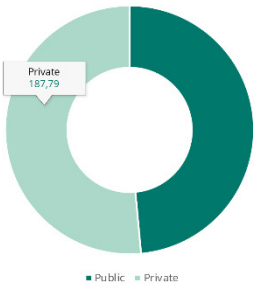
Forest area and ownership

GRAPH
Forest area within protected areas 2020 (% of forest area)



About 3/5 of the forest is within protected areas.

GRAPH
Forest ownership



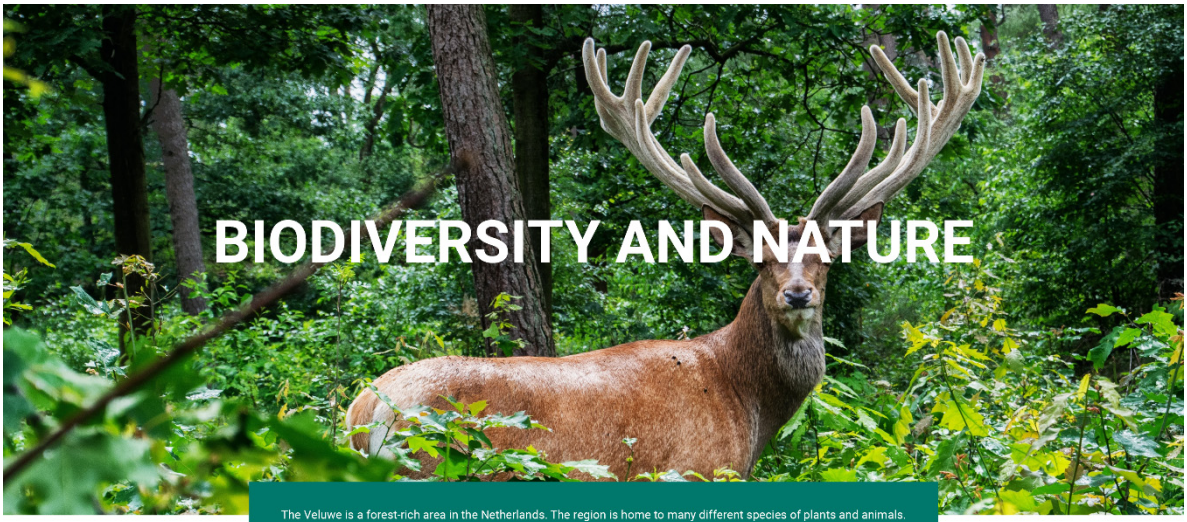
Source

About half of the country's forest is privately owned.

Harmonised forest data

Since every country has their own criteria for measuring what classifies as forest, there has been a harmonised area established so that country statistics could be fairly compared to each other.

Harmonised living aboveground biomass	Forest area	Forest and other wooded land (FOWL) area
XX.X m^3/ha	XX	XX
Harmonised NFI statistics	Harmonised NFI statistics	Harmonised NFI statistics



BIODIVERSITY AND NATURE

The Veluwe is a forest-rich area in the Netherlands. The region is home to many different species of plants and animals.

Forest biodiversity is being protected by specific areas in Europe through the Natura 2000 program, in this section you can see the areas which are protected and the conservation status of the forest habitat types. The diversity of tree species and biodiversity indicators are also described.

The Netherlands has more forest outside Natura 2000 areas than inside Natura 2000 areas.

The east of the Netherlands has the highest percentage of forest inside Natura 2000 (54%).

Over 65% of forests is protected for conservation of biodiversity (MCPFE Classes 1 and 2). (State of Europe's forests)

MAP
Dutch forest Natura 2000

Light green areas are protected Natura 2000 areas and dark green is forest area (where they overlap this is protected forest within Natura 2000)

GRAPH
Dutch forest Natura 2000

GRAPH
Most of the protected habitat types are coastal

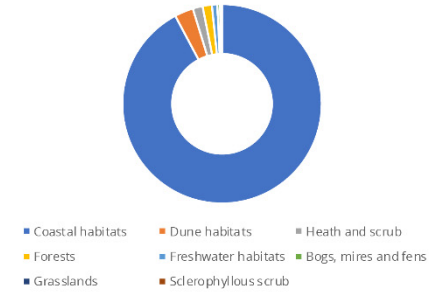


TABLE
Area of Annex I habitat types per group

Habitat	Surface area (km²)
Coastal habitats	15185
Dune habitats	500
Heath and scrub	263
Forests	248
Freshwater habitats	144
Bogs, mires and fens	72
Grasslands	48
Sclerophyllous scrub	5
Grand total	16465

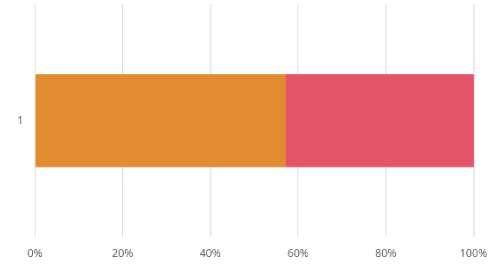
2 % of the Dutch protected habitats (Annex 1) are forests. The forest habitats that are protected are:

- Bog woodland
- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*)
- Riparian mixed forest of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus agustifolia*, along the great rivers (*Ulmenion minoris*)
- Luzulo-Fagetum beech forests
- *Atlantic acidophilous* beech forests with Ilex and sometimes also Taxus in the shrublayer (*Quercion robori-petraeae* or *Ilici-Fagenion*)
- Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli*
- Old acidophilous oak woods with *Quercus robur* on sandy plains.

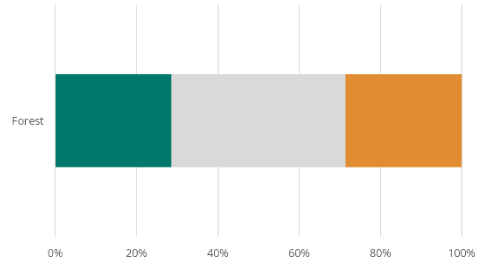
Conservation status of forest in the Netherlands

The conservation status of these protected forests habitats are assessed as poor and bad. Almost 30% of the protected forest habitats are improving.

GRAPH
Conservation status forest



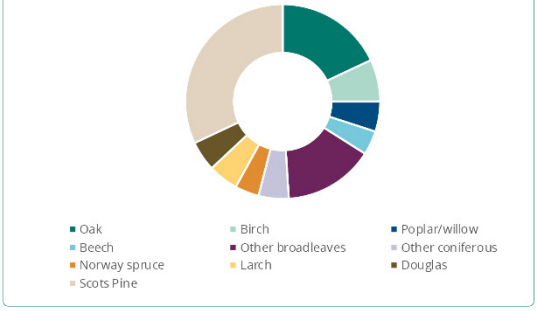
GRAPH
Trends in conservation status



Species

- No forest tree species are classified threatened according to IUCN Red List categories (Forest Europe)
- One cryptogams and fungi forest species is assessed as vulnerable according to IUCN Red list categories. (Forest Europe)

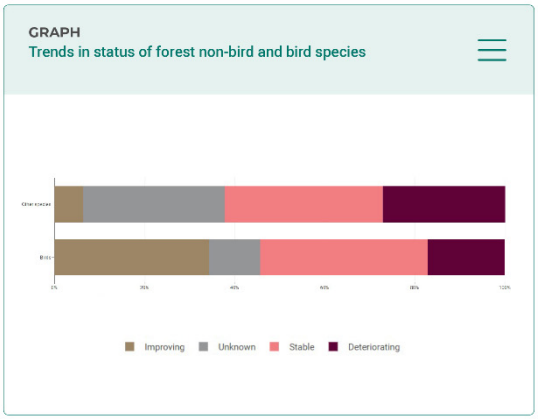
GRAPH
Tree species distribution



Trends in status of forest non-bird and bird species

Based on the Birds and Habitats directive there are monitoring programmes in each country in which the conservation status of forest species (population status) can be assessed as improving, stable, deteriorating, or unknown.

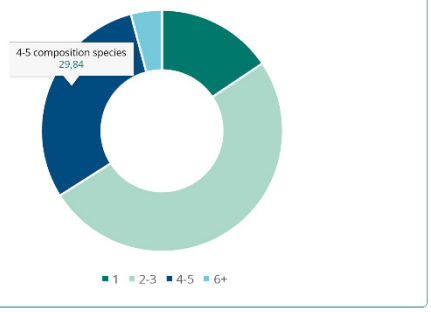
GRAPH
Trends in status of forest non-bird and bird species



Other biodiversity indicators

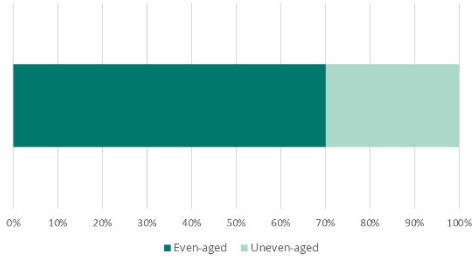
Diverse forests in terms of species and structure are important for several ecosystem services.

GRAPH
More than 75% of Dutch forests are composed by two or more tree species.



Around 15% is composed with only one tree species. 99.2% of the forest is semi-natural in the Netherlands.

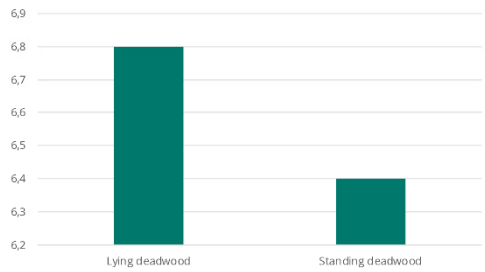
GRAPH
Most forest are even-aged stands



The forests in the Netherlands are mostly even-aged.

Deadwood in forest provides an important source of habitat, shelter and food source for many rare and threatened species, such as insects (especially beetles), fungi and lichens, birds and bats.

GRAPH
Deadwood in Dutch forests m^3/ha



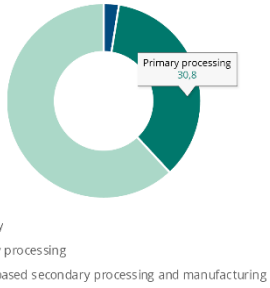
The volume of standing deadwood (m^3/ha) in the Netherlands is higher than the average of Europe's forest. The volume of lying deadwood is a bit lower than Europe's average. An increase in both standing and lying deadwood is measured during the last national forest inventory. Source: State of Europe's forest.

The Veluwe is a forest-rich area in the Netherlands. The region is home to many different species of plants and animals.

Key-messages

Forest-based bioeconomy employment encompass the workforce distributed in different sectors, comprising forestry, primary processing and secondary processing and manufacturing.

GRAPH
Employment in the forest-based and downstream sectors (2017) [in 1000 people]



The forest-based and downstream processing sectors provided employment to around 86.600 people in 2017.

Fellings as % of net annual increment

Fellings as % of net annual increment

To achieve a sustainable utilisation of forest resources it is necessary to ensure the maintenance or increase of productive functions of forests resources. The balance between annual felling and net annual increment can be used as an indicator of the wood production sustainability, as an adequate growing stock must be maintained to ensure a continuous provision of wood and non-wood products.

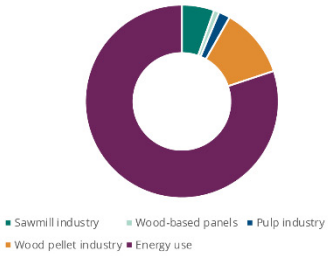
GRAPH
Fellings and increment in 1000 m³

Fellings in Netherlands remain on a sustainable level, using about 48% of the net annual increment in 2015.

Wood use for materials and energy

Whiten a range of products and services generated by forests, wood is highlighted as the main raw material for the Forest Bioeconomy sector. Wood is a versatile material used in different industries. Sawmill, panel, pulp, pellet, and energy are some of the traditional industries of the Forest sector.

GRAPH
Wood use in the Netherlands 2015



Fellings in Netherlands remain on a sustainable level, using about 48% of the net annual increment in 2015.

Non-wood forest products

Forests provide many types of products, which include a wide variety of NWFP such as berries, mushrooms, aromatic and decorative plant material, saps and resins, nuts, honey and wild meat. Their economic and social importance is considerable but available data on NWFP are mostly incomplete and difficult to compare.

TABLE
Values of marketed NWFP in the Netherlands

	Marketed value
Ornament plants	363.000 €
Wild meat	2664.000 €

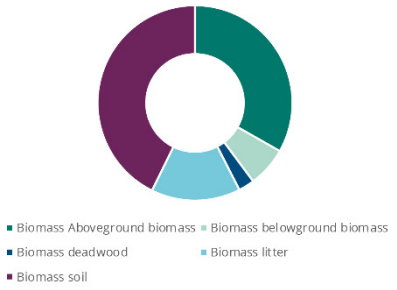
Values of marketed NWFP in the Netherlands are only reported for ornament plants and wild meat, according to Forest Europe, adding up to over 3 million Euros in 2015.

Forests play a vital role in regulating levels of carbon dioxide in our atmosphere. Forests accumulate and store large amounts of carbon in the trees and in the soil as they remove CO_2 from the atmosphere but may also emit greenhouse gases by harvest, decay, or disturbances. The annual net addition of CO_2 to the total stock is usually small compared to the existing forests' biomass and soils carbon stock.

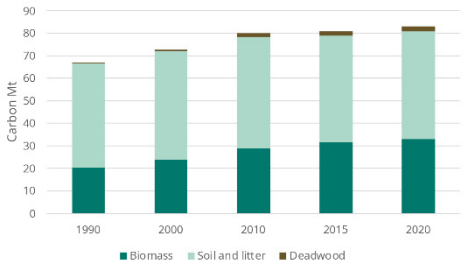
3 192 mt	180 mt	29 320 mt	83.2 mt	2 mt
emissions CO_2 equivalent in EU in 2019	emissions CO_2 equivalent in NL in 2019	carbon stored in EU27's forests in 2020	carbon stored in Dutch forests in 2020	2 mt CO_2 eq sink in Dutch forests in 2020

Dutch forests take up around 1% of the total Dutch emissions.

GRAPH
Carbon pools in Dutch forest



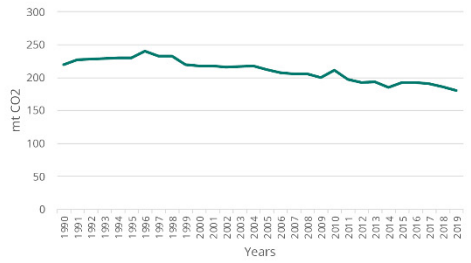
GRAPH
Carbon stock in forest 2019 - 2020 Mt



Source: state of Europe's forest

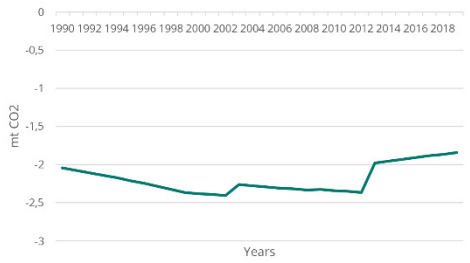
Carbon is stored in 5 different pools in forest; aboveground biomass, belowground biomass, deadwood, litter and soil. In general forests act as a carbon sink. The EU27 countries together are a net sink.

GRAPH
Emissions in the Netherlands



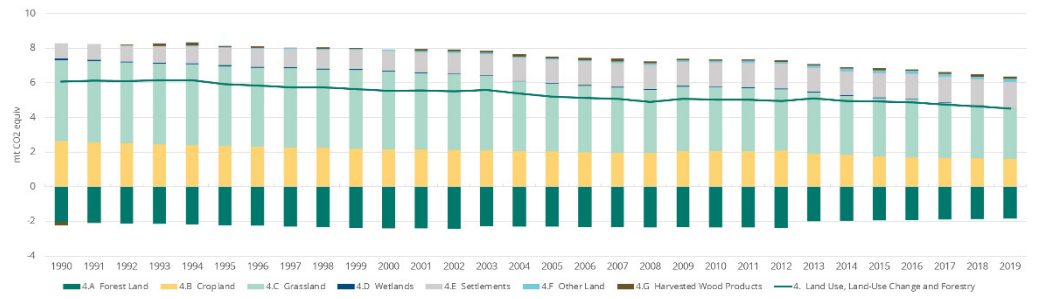
The total emissions have decreased slightly the last decades.

GRAPH
Forest land in Netherlands removals (-) (2019)



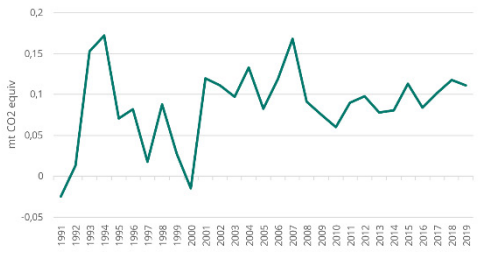
In the Netherlands the sink in forests recovers only 1% of the total emissions in the Netherlands.

GRAPH
Dutch LULUCF GHG Emissions (+)/ Removals (-) (2019)



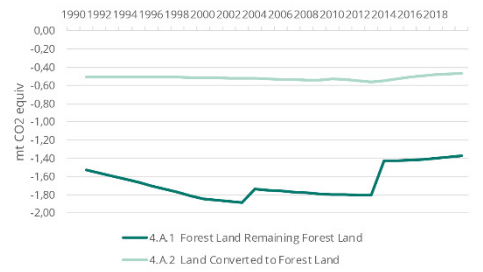
Historically, the LULUCF sector in the Netherlands is a net source with a decline over time.

GRAPH
Harvested Wood Products Emissions (+)/Removals (-) (2019)

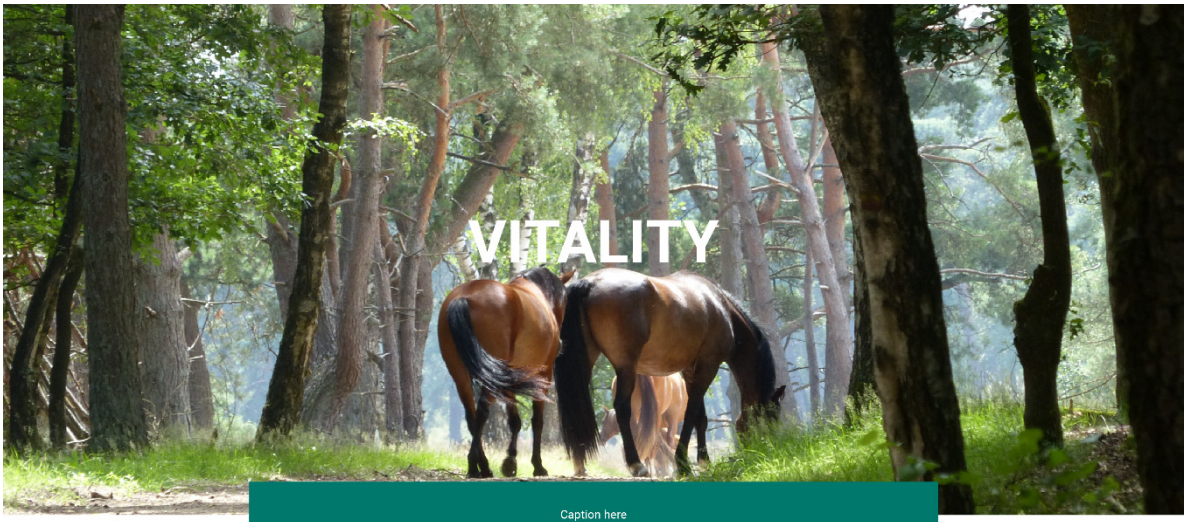


Since 1992 harvested wood products are a source of CO2 with exception for the year 2000. In general the EU27 harvested wood products are a sink.

GRAPH
CO_2 mt removals (-)/emission (+) Forest land

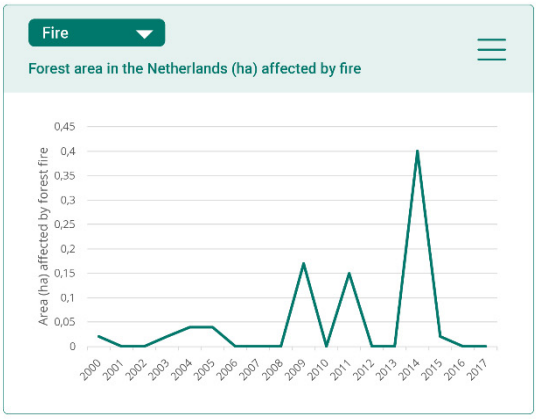


The light line shows the removal of CO_2 by converting land to forests.
The dark line shows the removal of CO_2 by forests remaining forests.



This section shows the major pressures affecting forests and how forest health is measured with different indicators. Find out what can make the forest resilient and adapt to these pressures.

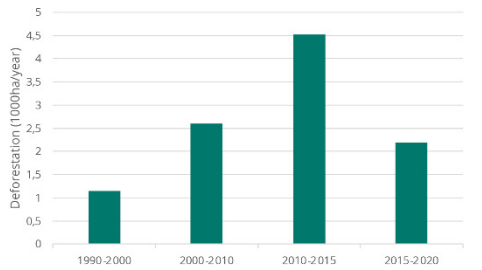
Disturbances and Pressures



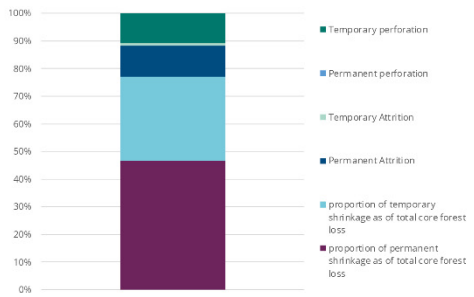
The occurrences of forest fires has increased in the last 10 years.

Deforestation

GRAPH
Deforestation (1000 ha / year)



GRAPH
Proportion of core forest loss (%) per pattern process and land cover conversion

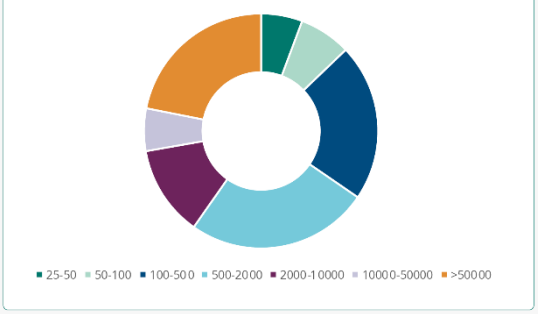


In Netherlands, nearly 60% of core forest loss is towards artificial/agricultural cover and dominated by shrinkage (around 45%), then attrition (above 10%)
Source

Forest patch distribution

Large and intact forest ecosystems support characteristic, wide-ranging, and area-sensitive species, especially those that depend on interior forest. Increased fragmentation means that the forest area in the largest patch sizes will decrease and that in the small size classes will increase.

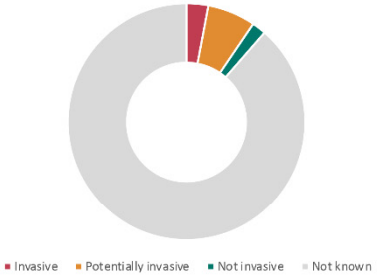
GRAPH
Distribution of the size of the forest patches, % of country forest cover



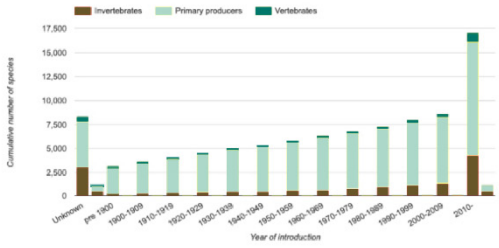
Invasive species

Invasive species are a threat to the local biodiversity and ecosystem. They often have no natural enemies in the introduced area. NOBANIS is an organization monitoring the invasives in Europe. The data below is not necessarily applicable only to forests, but can have an impact on the country's forest ecosystem.

GRAPH
Number of alien species, in Netherlands



GRAPH
Cumulative number of alien species, in the Netherlands



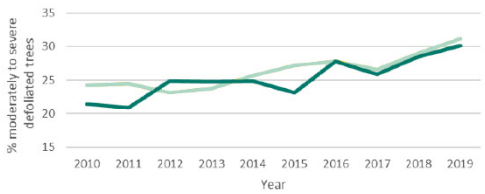
Laten staan als placemarker met juiste kleuren

Forest health indicators

The European member states record forest health indicators in a harmonised way but in various composition and at different frequencies. The main indicators are: tree crown condition, soil condition and foliar nutrient content. Not all these indicators are available for all EU27 countries. Most sources aggregate the data at the EU level as noted in the graphs below (Ask ICP FORESTS for country specific data if possible)

Tree crown condition

GRAPH
Percentage of moderately to severe defoliated trees



Defoliation increased with 40.7% for broadleaved trees and with 28.6% for conifers over the period 2010 to 2019 for the EU27 member states. (source ICP Forests1).

Soil condition

Soil acidity is an important soil property that influences concentrations of important nutrients and minerals. Low soil acidity may cause unfavorable growing conditions for forests.

GRAPH
Soil condition parameters on forest land in the Netherlands

Organic carbon g kg^{-1}	pH($CaCl_2$) pH($CaCl_2$)	Total nitrogen g kg^{-1}	Soluble phosphorus mg kg^{-1}	Extractable potassium mg kg^{-1}	CEC cmol(+) kg^{-1}	C:N ratio unitless
96.6	4.5	6.4	65.6	133.8	22.5	15.1

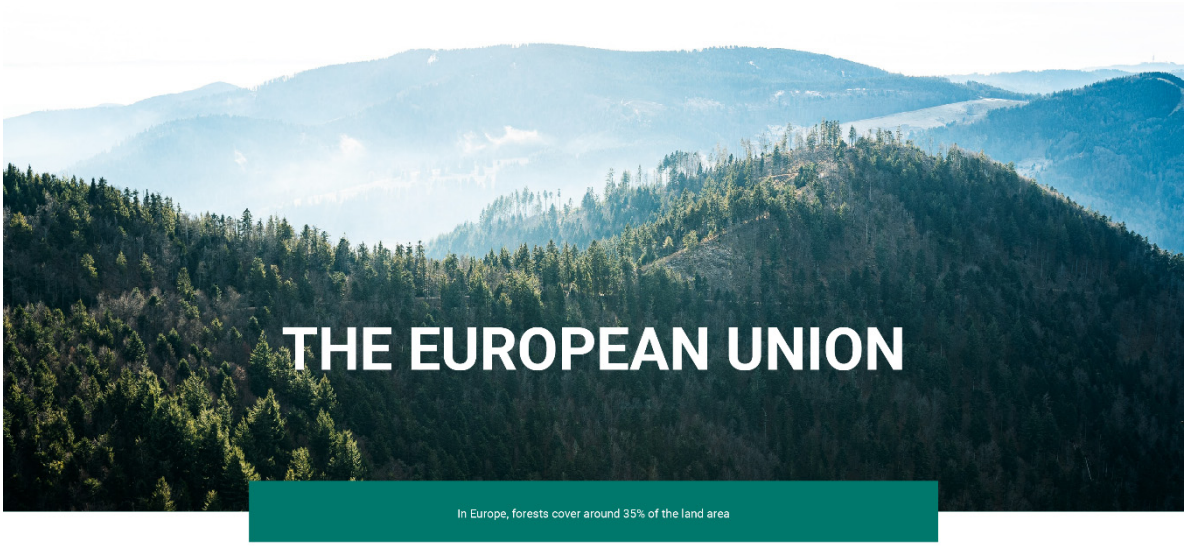
Source: Forest Europe

Resilience

As a response to climate change, increased tree mortality and decline of biodiversity, the European Green Deal, EU Biodiversity strategy for 2030, and the new EU forest strategy for 2030 call for increasing resilience of forests to natural disturbances.

There is no consensus on clear definition of resilience.

3.10.2 European Union

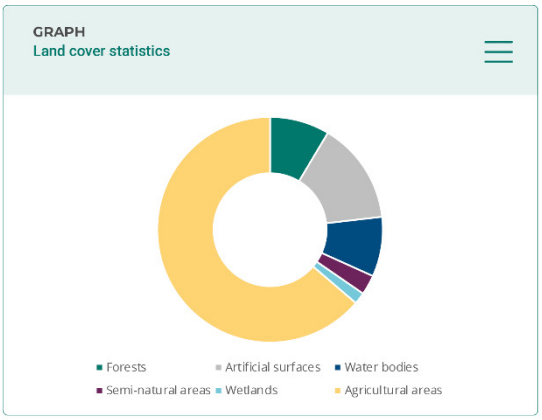


All about forests in the EU

This factsheet covers the basic statistics about Europe's forest, but also the aspects of climate and nature, biodiversity, bioeconomy, and vitality.

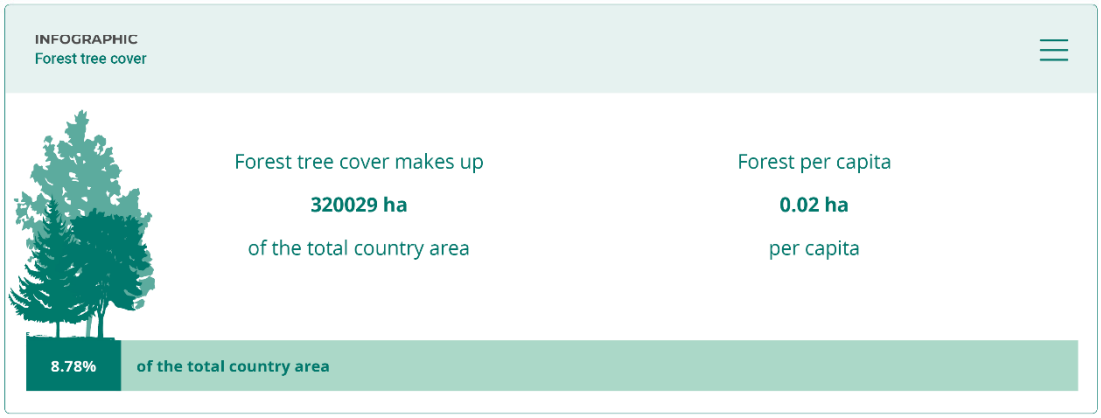
Forest tree cover map. The darker areas show where most of the forests are located.

Forest tree cover



Agricultural areas are the dominant land cover in Europe.

Measuring forest tree cover helps tracking changes, both gain and losses and supports policies related to reforestation, afforestation and ecosystem restoration. Forest per capita gives an indication of how much forest is available per person, can be an indication of the role forests play in the general culture and livelihoods of people.



Forest tree cover is basic for sustainability assessments.

Forest cover over time: Forest cover has remained stable since the year 2000.

Growing stock

Growing stock is the average volume (m^3) of forest per hectare. Increment is the increase of volume (m^3) per year.

Growing Stock

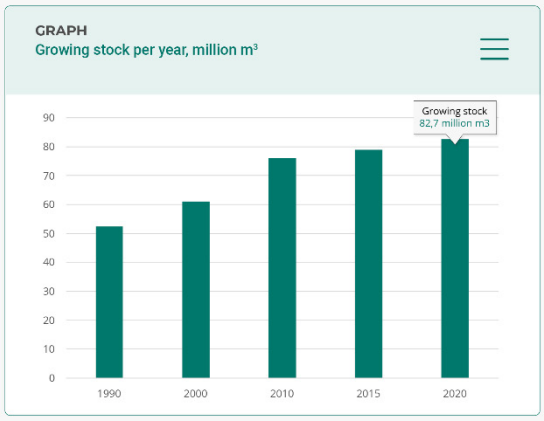
216.6 m^3/ha (NBI6)

Source: WUR

Increment

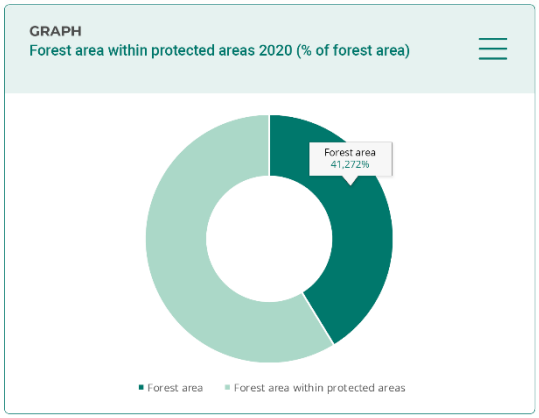
7.3 m^3/ha (NBI6)

Source: WUR

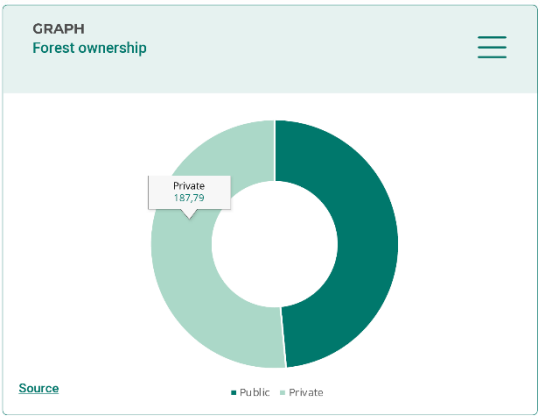


The growing stock volume has increased steadily over the last decades.

Forest area and ownership



About 3/5 of the forest is within protected areas.

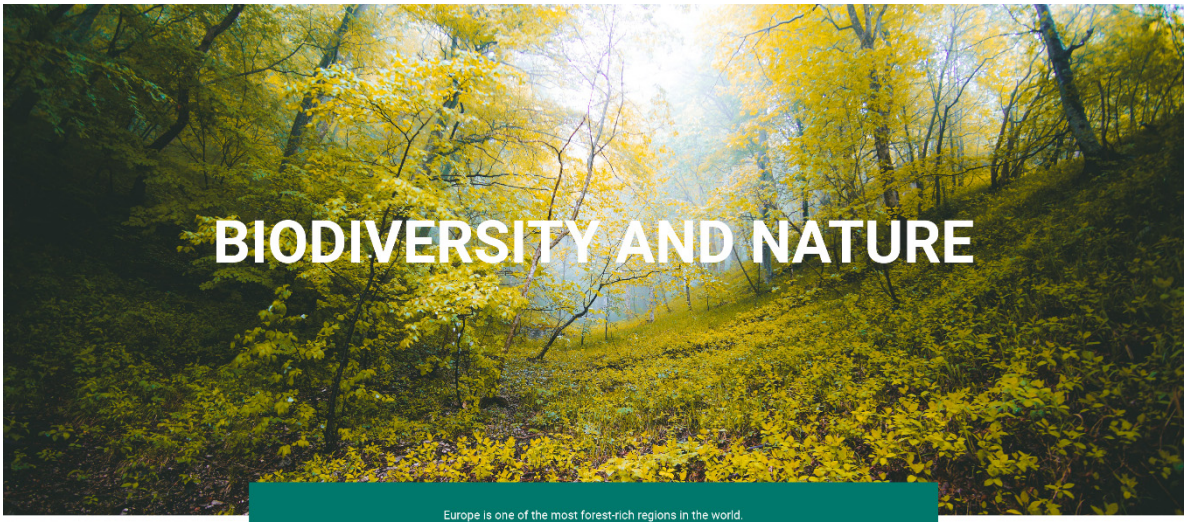


About half of the country's forest is privately owned.

Harmonised forest data

Since every country has their own criteria for measuring what classifies as forest, there has been a harmonised area established so that country statistics could be fairly compared to each other.

Harmonised living aboveground biomass	Forest area	Forest and other wooded land (FOWL) area
XX.X m^3/ha	XX	XX
Harmonised NFI statistics	Harmonised NFI statistics	Harmonised NFI statistics



BIODIVERSITY AND NATURE

Europe is one of the most forest-rich regions in the world.

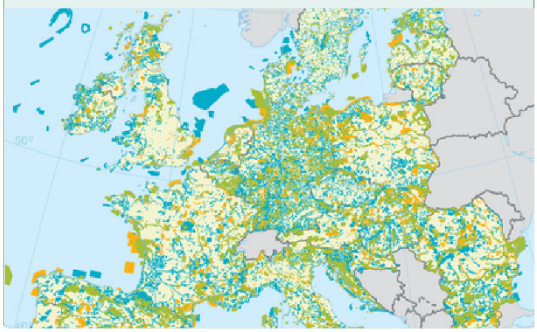
Forest biodiversity is being protected by specific areas in Europe through the Natura 2000 program, in this section you can see the areas which are protected and the conservation status of the forest habitat types. The diversity of tree species and biodiversity indicators are also described.

Europe has more forest outside Natura 2000 areas than inside Natura 2000 areas.

The east of Europe has the highest percentage of forest inside Natura 2000 (54%).

Over 65% of forests is protected for conservation of biodiversity (MCPFE Classes 1 and 2). (State of Europe's forests)

MAP
Europe's forest Natura 2000



Light green areas are protected Natura 2000 areas and dark green is forest area (where they overlap this is protected forest within Natura 2000)

GRAPH
Europe's forest Natura 2000

GRAPH
Most of the protected habitat types are coastal

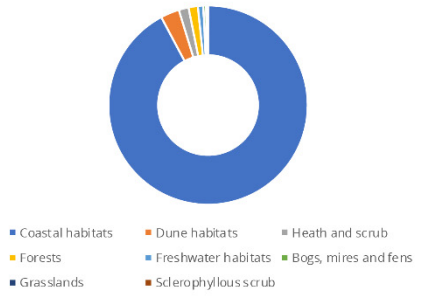


TABLE
Area of Annex I habitat types per group

Habitat	Surface area (km²)
Coastal habitats	15185
Dune habitats	500
Heath and scrub	263
Forests	248
Freshwater habitats	144
Bogs, mires and fens	72
Grasslands	48
Sclerophyllous scrub	5
Grand total	16465

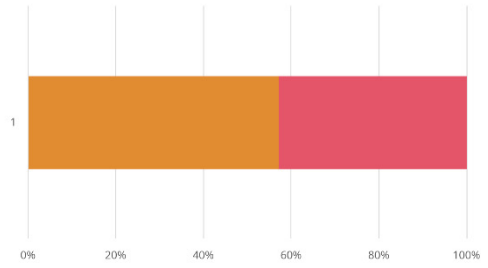
2% of the European protected habitats (Annex 1) are forests. The forest habitats that are protected are:

- Bog woodland
- Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*)
- Riparian mixed forest of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus agustifolia*, along the great rivers (*Ulmenion minoris*)
- Luzulo-Fagetum beech forests
- *Atlantic acidophilous* beech forests with Ilex and sometimes also Taxus in the shrublayer (*Quercion robori-petraeae* or *Ilici-Fagenion*)
- Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli*
- Old acidophilous oak woods with *Quercus robur* on sandy plains.

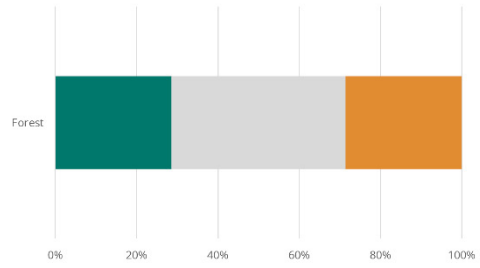
Conservation status of forest in Europe

The conservation status of these protected forests habitats are assessed as poor and bad. Almost 30% of the protected forest habitats are improving.

GRAPH
Conservation status forest



GRAPH
Trends in conservation status



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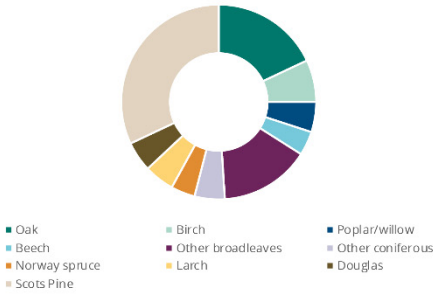

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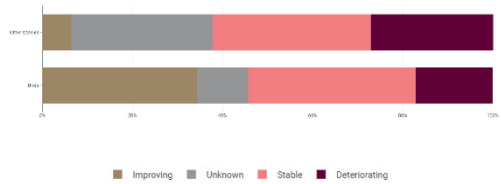
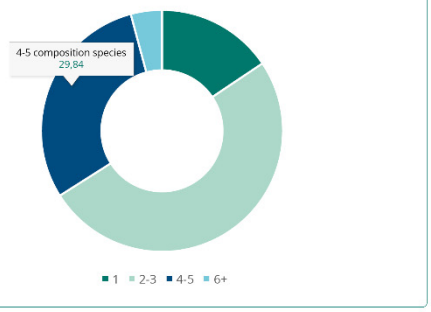


Other biodiversity indicators

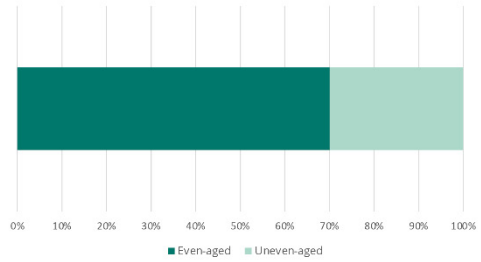
Diverse forests in terms of species and structure are important for several ecosystem services.

GRAPH
More than 75% of European forests are composed by two or more tree species.



Around 15% is composed with only one tree species. 99.2% of the forest is semi-natural in Europe.

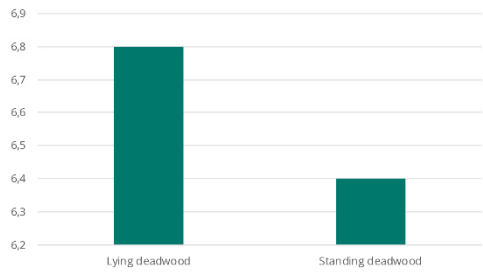
GRAPH
Most forest are even-aged stands



The forests in Europe are mostly even-aged.

Deadwood in forest provides an important source of habitat, shelter and food source for many rare and threatened species, such as insects (especially beetles), fungi and lichens, birds and bats.

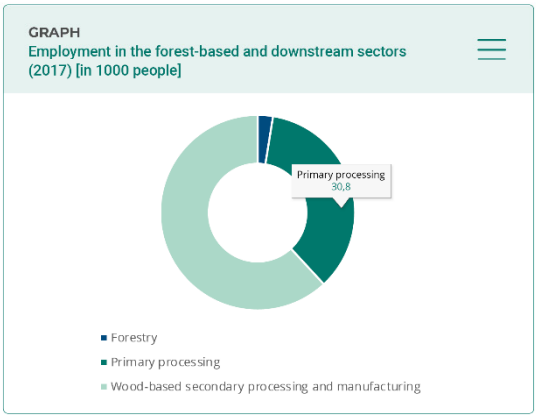
GRAPH
Deadwood in European forests m³/ha



The volume of standing deadwood (m³/ha) in Europe is higher than the average of Europe's forest. The volume of lying deadwood is a bit lower than Europe's average. An increase in both standing and lying deadwood is measured during the last national forest inventory. Source: State of Europe's forest.

Key-messages

Forest-based bioeconomy employment encompass the workforce distributed in different sectors, comprising forestry, primary processing and secondary processing and manufacturing.



The forest-based and downstream processing sectors provided employment to around 86.600 people in 2017.

Fellings as % of net annual increment

Fellings as % of net annual increment

To achieve a sustainable utilisation of forest resources it is necessary to ensure the maintenance or increase of productive functions of forests resources. The balance between annual felling and net annual increment can be used as an indicator of the wood production sustainability, as an adequate growing stock must be maintained to ensure a continuous provision of wood and non-wood products.

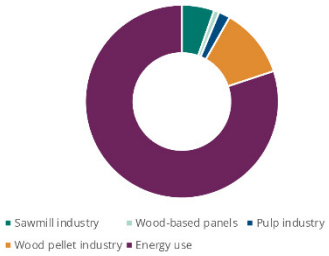
GRAPH
Fellings and increment in 1000 m³

Fellings in Netherlands remain on a sustainable level, using about 48% of the net annual increment in 2015.

Wood use for materials and energy

Whiten a range of products and services generated by forests, wood is highlighted as the main raw material for the Forest Bioeconomy sector. Wood is a versatile material used in different industries. Sawmill, panel, pulp, pellet, and energy are some of the traditional industries of the Forest sector.

GRAPH
Wood use in Europe 2015



Fellings in Netherlands remain on a sustainable level, using about 48% of the net annual increment in 2015.

Non-wood forest products

Forests provide many types of products, which include a wide variety of NWFP such as berries, mushrooms, aromatic and decorative plant material, saps and resins, nuts, honey and wild meat. Their economic and social importance is considerable but available data on NWFP are mostly incomplete and difficult to compare.

TABLE
Values of marketed NWFP in Europe

	Marketed value
Ornament plants	363.000 €
Wild meat	2664.000 €

Values of marketed NWFP in Europe are only reported for ornament plants and wild meat, according to Forest Europe, adding up to over 3 million Euros in 2015.

CLIMATE

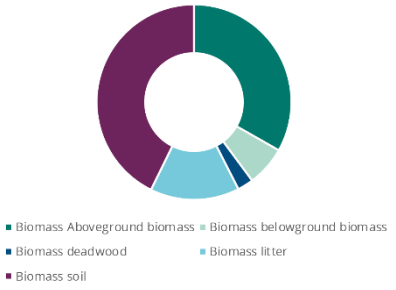
European forests absorb approximately 10% of Europe's annual greenhouse gas emissions, according to the latest State of Europe's forests report.

Forests play a vital role in regulating levels of carbon dioxide in our atmosphere. Forests accumulate and store large amounts of carbon in the trees and in the soil as they remove CO_2 from the atmosphere but may also emit greenhouse gases by harvest, decay, or disturbances. The annual net addition of CO_2 to the total stock is usually small compared to the existing forests' biomass and soils carbon stock.

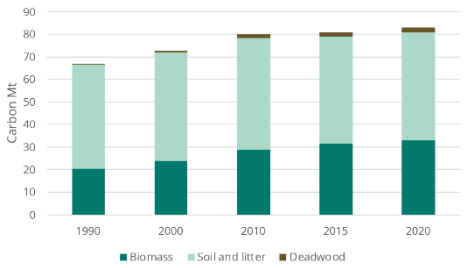
3 192 mt	180 mt	29 320 mt	83.2 mt	2 mt
emissions CO_2 equivalent in EU in 2019	emissions CO_2 equivalent in NL in 2019	carbon stored in EU27's forests in 2020	carbon stored in European forests in 2020	2 mt CO_2 eq sink in European forests in 2020

Forests take up around 1% of the total European emissions.

GRAPH
Carbon pools in European forest



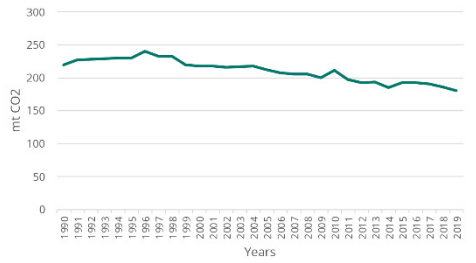
GRAPH
Carbon stock in forest 2019 - 2020 Mt



Source: state of Europe's forest

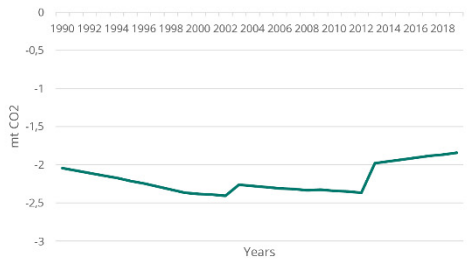
Carbon is stored in 5 different pools in forest; aboveground biomass, belowground biomass, deadwood, litter and soil. In general forests act as a carbon sink. The EU27 countries together are a net sink.

GRAPH
Emissions in Europe



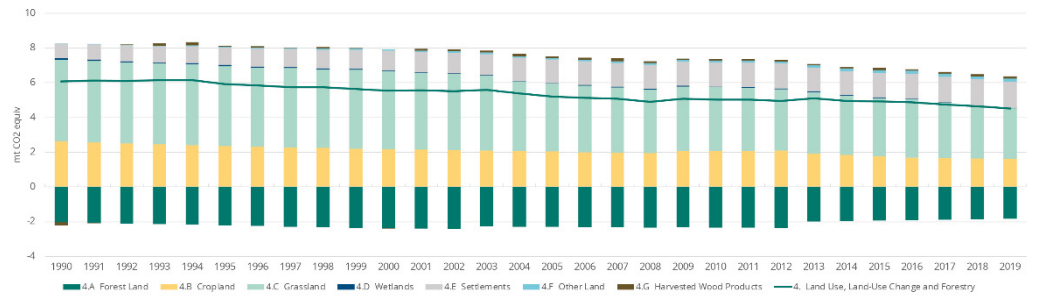
The total emissions have decreased slightly the last decades.

GRAPH
Forest land in Netherlands removals (-) (2019)



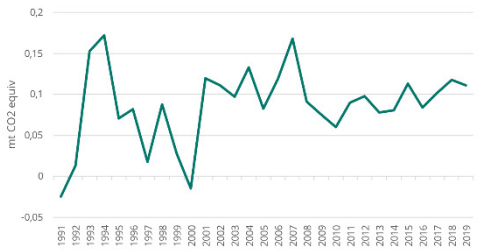
In Europe the sink in forests recovers only 1% of the total emissions in Europe.

GRAPH
European LULUCF GHG Emissions (+)/ Removals (-) (2019)



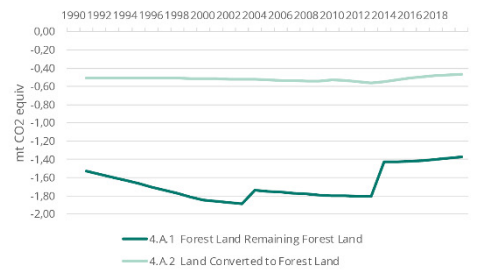
Historically, the LULUCF sector in Europe is a net source with a decline over time.

GRAPH
Harvested Wood Products Emissions (+)/Removals (-) (2019)



Since 1992 harvested wood products are a source of CO2 with exception for the year 2000. In general the EU27 harvested wood products are a sink.

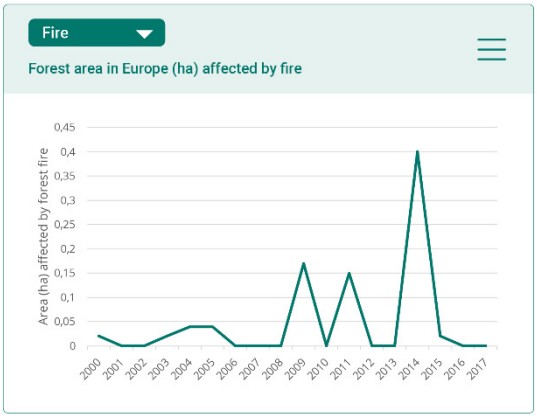
GRAPH
CO_2 mt removals (-)/emission (+) Forest land



The light line shows the removal of CO_2 by converting land to forests.
The dark line shows the removal of CO_2 by forests remaining forests.

This section shows the major pressures affecting forests and how forest health is measured with different indicators. Find out what can make the forest resilient and adapt to these pressures.

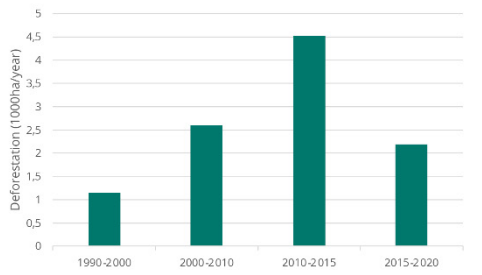
Disturbances and Pressures



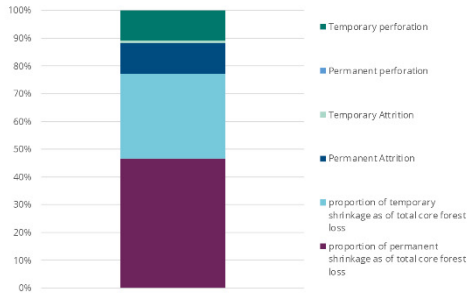
The occurrences of forest fires has increased in the last 10 years.

Deforestation

GRAPH
Deforestation (1000 ha / year)



GRAPH
Proportion of core forest loss (%) per pattern process and land cover conversion

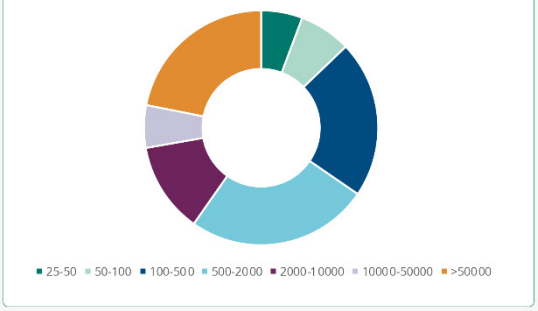


In Netherlands, nearly 60% of core forest loss is towards artificial/agricultural cover and dominated by shrinkage (around 45%), then attrition (above 10%)
Source

Forest patch distribution

Large and intact forest ecosystems support characteristic, wide-ranging, and area-sensitive species, especially those that depend on interior forest. Increased fragmentation means that the forest area in the largest patch sizes will decrease and that in the small size classes will increase.

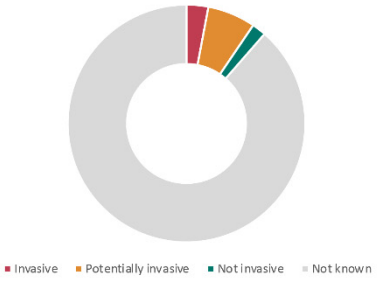
GRAPH
Distribution of the size of the forest patches, % of country forest cover



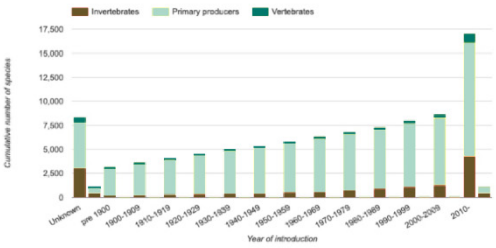
Invasive species

Invasive species are a threat to the local biodiversity and ecosystem. They often have no natural enemies in the introduced area. NOBANIS is an organization monitoring the invasives in Europe. The data below is not necessarily applicable only to forests, but can have an impact on the country's forest ecosystem.

GRAPH
Number of alien species, in Netherlands



GRAPH
Cumulative number of alien species, in Europe

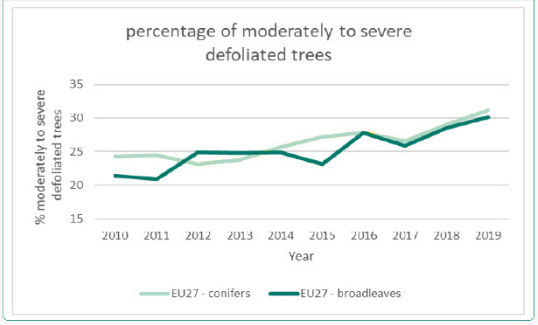


Forest health indicators

The European member states record forest health indicators in a harmonised way but in various composition and at different frequencies. The main indicators are: tree crown condition, soil condition and foliar nutrient content. Not all these indicators are available for all EU27 countries. Most sources aggregate the data at the EU level as noted in the graphs below (Ask ICP FORESTS for country specific data if possible)

Tree crown condition

GRAPH
Percentage of moderately to severe defoliated trees



Defoliation increased with 40.7% for broadleaved trees and with 28.6% for conifers over the period 2010 to 2019 for the EU27 member states. (source ICP Forests1).

Soil condition

Soil acidity is an important soil property that influences concentrations of important nutrients and minerals. Low soil acidity may cause unfavorable growing conditions for forests.

GRAPH
Soil condition parameters on forest land in Europe

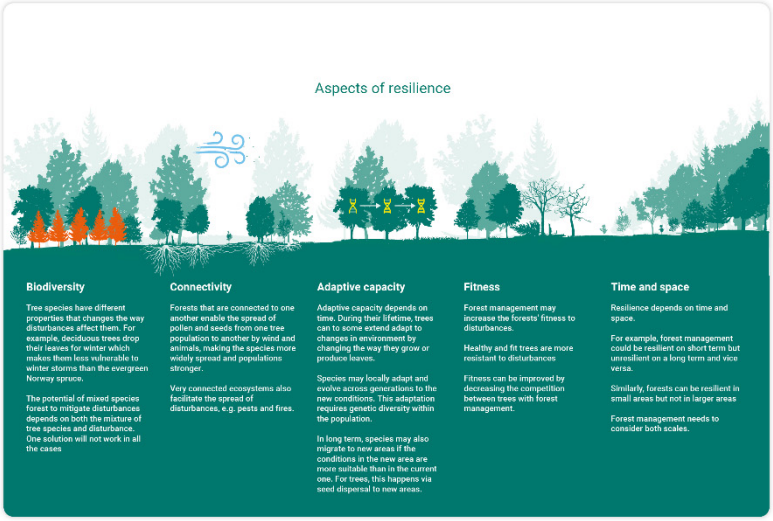
Organic carbon g kg^{-1}	pH($CaCl_2$) pH($CaCl_2$)	Total nitrogen g kg^{-1}	Soluble phosphorus mg kg^{-1}	Extractable potassium mg kg^{-1}	CEC cmol(+) kg^{-1}	C:N ratio unitless
96.6	4.5	6.4	65.6	133.8	22.5	15.1

Source Forest Europe SoEF_2020.pdf (foresteurope.org) Table 2.2-2 p 68

Resilience

As a response to climate change, increased tree mortality and decline of biodiversity, the European Green Deal, EU Biodiversity strategy for 2030, and the new EU forest strategy for 2030 call for increasing resilience of forests to natural disturbances.

There is no consensus on clear definition of resilience.



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