ISSN 1831-9424

European Commission

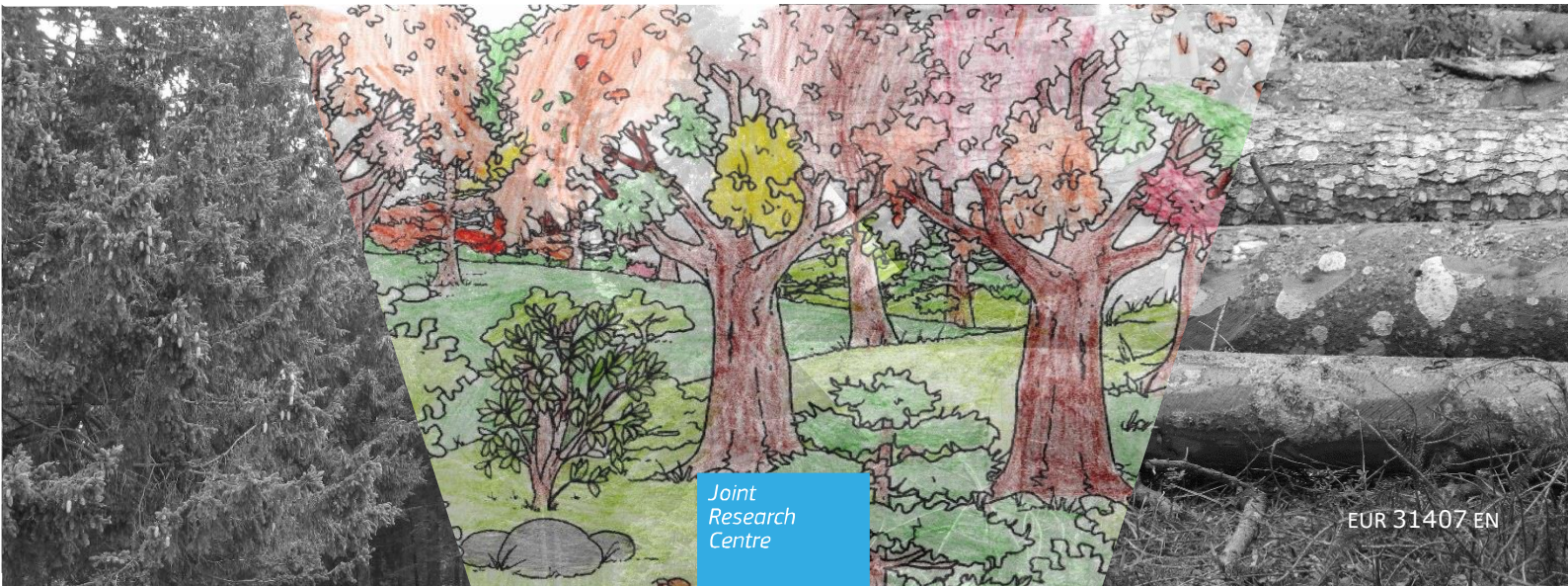
JRC TECHNICAL REPORT

Technical and scientific support to Eurostat: gap-filling of data on the stock and flow of timber and *comparison of the area of forest land and other wooded land* reported from different data sources (AA LAFOWA)

Provision of technical and scientific support to DG ESTAT in relation to EU land footprint estimates and gap-filling techniques for European forest accounts (LAFOWA) - Administrative arrangement JRC 36253 - ESTAT-2021-0372 - Task 2

Pilli, R., Blujdea, V., Rossi, S., Grassi, G.

2023



EUR 31407 EN

Contact information
Name: Giacomo Grassi

Email: giacomo.grassi@ec.europa.eu

EU Science Hub
https://joint-research-centre.ec.europa.eu

JRC 132211

EUR 31407 EN

PDF ISBN 978-92-76-98897-7 ISSN 1831-9424 doi:10.2760/69791 KJ-NA-31-407-EN-N

Luxembourg: Publications Office of the European Union, 2023

How to cite this report: Pilli, R., Blujdea, V., Rossi, S., Grassi, G., *Provision of technical and scientific support to DG ESTAT in relation to EU land footprint estimates and gap-filling techniques for European forest accounts (LAFOWA)*, Publications Office of the European Union, Luxembourg, 2023, doi:10.2760/69791, JRC132211.

Contents

Abstract

Forest area and the volume of timber stocks are essential variables describing forest resources. These information are collected within the European Forest Accounts of EUROSTAT, which include a set of accounts quantifying the stocks and flows for forest, and forestry and logging industry. The reporting on economic variables is much more complete than reporting for the stock accounts on forest area (included within the so called Tables A1) and volume of timber (Tables A2). The aim of this report, which is part of the Administrative Arrangement ESTAT-2021-0372, is to improve the completeness of table A2a, and the understanding of how existing data on forest area can be reconciled.

This report focuses on the second task of the AA ESTAT-2021-0372, named LAFOWA, and signed between DG ESTAT and DG JRC. Task 2, from one side, within the *subtask 2i, aims to update and extend the time series reported on EFA table A2a for the period of 2016 – 2020*, and, from the other side, within *subtask 2ii, aims to provide a structured and comprehensive comparison of publicly available data on the area of forest land and other wooded land* as reported from different data sources.

The first subtask follows the completion of the activities carried out within the previous AA ESTAT-2019-0300 (AA LAFO). At this purpose, updating to 2020 the estimates provided from the forest growth model applied within the AA LAFO, calibrated on the latest harvest rates reported from official statistics, we estimated, for each country, all the main components of the growing stock balance as reported within the table A2a. This exercise, from one side provided a complete set of data for the entire period 2000 - 2020 for 14 out of 27 Member States which did not report any information on this table. From the other side, we also partially updated the data of the other Member States, already estimated on the AA LAFO and further compared and update various data sources reporting detailed information on the evolution of the growing stock and harvest at EU and country level, within the period 2000 - 2020.

Within the second subtask we provided a systematic comparison between the definition of forest considered from FAO and other international institutions, and the one provided from National Forest Inventories (NFI). In most cases, these definitions are mutually consistent, and because NFI are generally used as the main data sources for reporting the forest area to international institutions, the area reported from NFI is generally well in line with the one reported from Forest Resource Assessment 2020 (FRA 2020) and from the State of Europe's Forests 2020 (SoEF 2020). On the opposite, at country level, the area reported to UNFCCC may slightly diverge from other data sources, due to different definitions applied from Member States, for reporting the forest area, in order to be in line with the IPCC rules for estimating and accounting GHG. The primary data source, however, is always given from the NFI surveys, which provide an accurate assessment of the forest area at national level.

Since NFI are not aligned in time between various countries, when assessing the diachronic evolution of the forest area reported at country level, the use of different minimum thresholds between various national surveys may determine some inconsistency. Other data sources, partially based on a remote sensing assessment, may partially overcome this limit. This is the case of the Land Use and Coverage Area frame Survey (LUCAS), promoted from EUROSTAT and of the data derived from ESA CCI/Copernicus Climate Change Service which clearly overestimate the forest area reported within the period 2000 - 2016. Analysing these data, however, we highlighted that the forest area reported from these data series, are not fully consistent with other data sources, above all if used to estimate the evolution of the forest area at country and at EU level. Despite these differences, these surveys, such as other remote sensing tools based on an harmonized assessment of the forest area at EU level, can be useful to complement specific scientific studies. To overcome these limits, often due to the technical evolution of remote sensing observation systems, the JRC promoted a specific assessment of the forest area, integrating various data collected from remote sensing with direct information reported from countries' NFI.

While the definition of forest land is generally consistent between EU Member States, various studies highlighted that the concept of forest area available for wood supply is based on different legal, environmental and/or economic parameters varying at country level. For this reason, the data reported from various countries, if not properly harmonized, are not fully comparable.

Similar issues can be also highlighted for the definition of Other Wooded Land applied at country level. In some cases, this definition may considerably diverge from the international definition proposed from FAO and EUROSTAT. Moreover, some countries do not report any definition or data concerning other

wooded lands. These data, however, when missing, could be inferred from the corresponding biogeographical area. Indeed, at country level, the average share of other wooded land compared to the area reported as forest land, shows a quite clear pattern, linked to the main biogeographical conditions assessed at EU level.

Despite these differences, the total forest area derived from various data sources at EU 27 level fall within a relatively narrow interval, ranging between about 159 mil ha, according to FAO, SoEF and C3SLC-Forest, and 155 mil ha, according to UNFCCC's data. The total forest area estimated from JRC for 2020, equal to 157 mil ha, falls within this interval, while the forest area derived from LUCAS for 2018 is equal to about 169 kha. The added value of this assessments is the integration of remote sensing observations of tree cover and systematic ground observations from NFI, which represent the two major sources of information to assess forest area and Other Wooded Land at country level.

Foreword

This document is part of the Administrative Arrangement ESTAT-2021-0372 (AA LAFOWA) signed between DG ESTAT and DG JRC. This agreement aims to improve the data availability of ESTAT database on three different areas, defined as Task 1, which focuses on land footprint estimates, Task 2, including forest accounts and statistics, and Task 3, concerning food waste accounting. This report focuses on the implementation of the second task of this AA, aiming to update and extend the time series of data concerning the stocks and flows reported on European Forest Account system, and to improve the understanding on existing data on forest area published by EU and other international organization.

Acknowledgements

This report is a result of an intensive and fruitful collaboration between the JRC and ESTAT. We wish to express our most sincere thanks to Veronika Vysna and Ekkehard Petri from DG ESTAT for their advice throughout the study, and the useful input and comments on the earlier drafts of this report.

We also thank Valerio Avitabile and our colleagues working at JRC for their useful suggestions and comments. The JRC Pubsy Service for the final revision of this document, and Erica Guerini for the technical support.

This publication is part of the project Provision of technical and scientific support to DG ESTAT in relation to LAnd footprint, European FOrest accounts and food WAste (LAFOWA), financially supported by the Directorate-General for the statistical office of the European Union (Eurostat) in the context of the Administrative Arrangement contract n° ESTAT-2021-0372.

Authors

Roberto Pilli, Viorel Blujdea, Simone Rossi, Giacomo Grassi

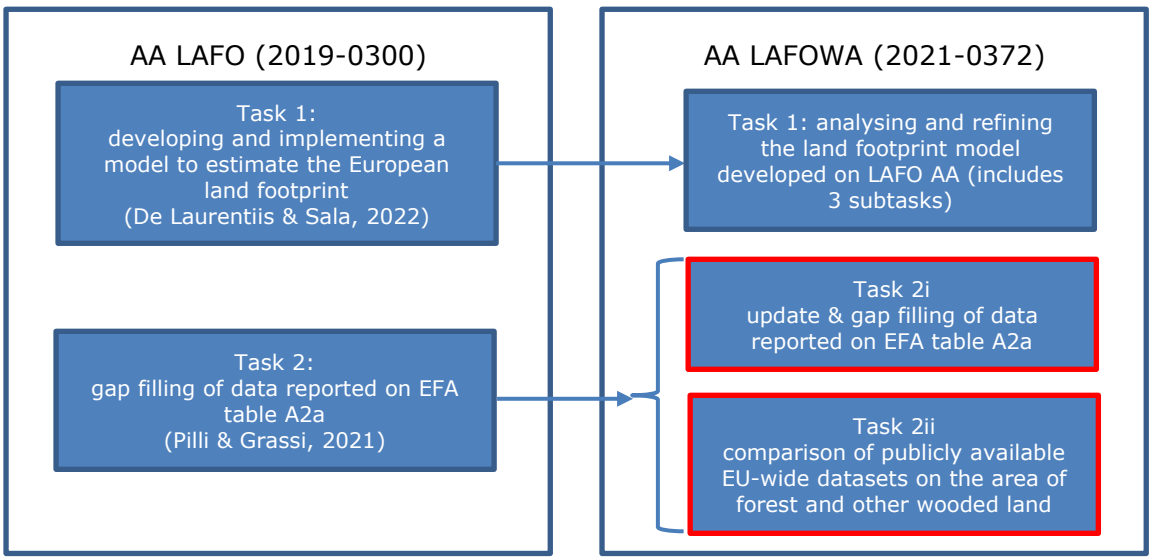
1 Introduction

This Administrative Arrangement, ESTAT-2021-0372 (hereafter identified as AA LAFOWA), composes the continuation of a previous project, AA ESTAT 2019-0300 carried out in 2021, and aims to improve the data availability of ESTAT on three different areas, defined as Task 1, which focuses on land footprint estimates, Task 2, including forest accounts and statistics, and Task 3, concerning food waste accounting.

Tasks 1 and 2 follow the completion of the activities carried out within the previous AA ESTAT-2019-0300 (AA LAFO), consisting of developing and implementing a model for the estimation of the land footprint of European consumption (De Laurentiis and Sala, 2021) and a method to gap fill existing data reported to the European Forest Accounts system of EUROSTAT (Pilli and Grassi, 2021).

This report focuses on the implementation of the second task of the AA LAFOWA, aiming to update and extend the time series of data concerning the stocks and flows reported on European Forest Account system's table A2a, and to improve the understanding of how existing data on forest area published by the EU and international organization can be reconciled.

The European Forest Accounts system (EFA[1]) is a set of accounts quantifying the stocks and flows for forest, forestry and logging industry, compatible with the System of Environmental-Economic Accounting – Central Framework and the national accounts. EFA is a voluntary data collection with up to ca. 20 EU Member States reporting for one or more of the ten EFA tables on an annual basis. The reporting on economic variables is much more complete than reporting for the stock accounts on forest area (included within the so called Tables A1) and volume of timber (Tables A2). The following diagram summarizes the relations between the various tasks concerning the AA LAFO and LAFOWA, highlighting, with red outlines, the specific tasks covered from the present report.



1.1 Detailed tasks description

Task 2 includes two subtasks, named 2i and 2ii. Task 2i aims to update and extend the time series reported on EFA table A2a, for the period 2016 – 2020 by using the same approach developed and applied - until 2015 - in the AA LAFO, further updated for new information made available by Member States, new model calibration and other relevant methodological updates. A synthesis of these methodological updates is reported on section 2.

Task 2ii aims to provide a structured and comprehensive comparison of publicly available EU-wide datasets on the area of forest and, when available, other wooded land, including data from various

[1] See https://ec.europa.eu/eurostat/cache/metadata/en/for_sfm_esms.htm

sources (e.g. remote sensing, in situ surveys, etc.) and produced by or reported to EU institutions or international organizations. Section 3 reports a comprehensive overview of differences between definitions, concepts, and data, and produce an overview of uses of each of these datasets by the European Commission and EEA.

Further details, for both these tasks, are reported as Supplementary Materials within separate worksheets.

2 Update of EFA Table A2a

Before to update the data series included within table A2a[2], all the main information made available from the international databases were revised and updated, following the same criteria applied within the AA LAFO. At this purpose, we compiled a new data base, comparing data on area, growing stock, increment and harvest, as provided from EUROSTAT, Forest Resource Assessment 2020 Country Reports (FRA 2020), FAOSTAT and State of Europe's Forests 2020 (hereafter SoEF 2020). These data were further compared with the estimates provided by the Carbon Budget Model (CBM, already applied within the AA LAFO[3]) and other data sources reported by literature or made available at country level (See the Supplementary Material EFA_JRC_Stock_Balance_2022 for further details).

A preliminary overview of the information made available within the EFA database[4] under the Table A2a (for_vol_efa) highlights that only 14 out of 27 EU Member States report at least one value within the period 2010 – 2020 and mostly after 2014 (see Table 1).

Table 1: List of EU Member States reporting at least some information (green cells) on Table A2A, within the period 2010-2020. This table reports the information made available before the 2022 EFA data collection which targeted the data for the reference year 2020.

GEO/TIME	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Belgium										
Bulgaria										
Czechia										
Denmark										
Germany										
Estonia										
Ireland										
Greece										
Spain										
France*										
Croatia										
Italy										
Cyprus										
Latvia										
Lithuania										
Luxembourg										
Hungary										
Malta										
Netherlands										
Austria										
Poland										
Portugal										
Romania										
Slovenia										
Slovakia										
Finland										
Sweden										

* Reported only for Forest Area Available for Wood Supply

[2] See https://ec.europa.eu/eurostat/databrowser/view/for_vol_efa/default/table?lang=en
[3] For details on the use of the Carbon Budget Model within this AA, please see Pilli and Grassi, 2021.
[4] See (last update October 2022): https://ec.europa.eu/eurostat/web/forestry/data/database

2.1 Methodological assumptions

Table A2a reports, on a yearly basis, the changes in the volume of the growing stock between the beginning (opening stock, OS) and the end (closing stock, CS) of each year, taking into account, on the one side, the net annual increment (NAI) attributed to the opening growing stock, and on the other side, the amount of removals (REM) and irretrievable losses (IL) subtracted within the same year. The final yearly balance between these items also includes possible statistical reclassifications (SRC) due to changes in use or status of the corresponding land use and a possible balancing item (BI). All these parameters are combined within the following equation (Eq. 1) (see Table 2 for further details):

$$CS = OS + NAI - REM - IL \pm SRC \pm BI \qquad \text{Eq. (1)}$$

Table 2: Main items reported in Table A2a.

PARAMETERS	Description	Acronym
Opening stocks (December t-1)	Timber stock at the beginning of the reference year, including both growing stock and any dead wood material that is retrievable. The Opening stock corresponds to the CS for the previous year	OS
Net increment	Net annual increment[1], as the difference between annual growth of wood and recurrent natural losses.	NAI
Removals	Annual removals from logging activities as considered within the Joint Forest Sector Questionnaire (JFSQ) definition[2].	REM
Irretrievable losses	Felling residues, felling from windthrow that cannot be removed, timber lost due to fires	IL
Statistical re-classifications	Changes in the volume of timber due to changes in use/status of the corresponding land area	SRC
Balancing item	Used to balance out discrepancies between opening and closing stocks after taking account of the flows explicitly defined in this EFA table (increases, decreases and irretrievable losses, and net changes as a result of re-classification) and observed based on the source data. See the explanation below on this parameter.	BI
Closing stocks (December t)	Timber stock at the end of the reference year, which corresponds to the OS for the next year	CS

[1] The NAI should be consistent with the Gross Annual Increment estimated by country's NFI or reported from other data sources (see Avitabile et al., 2023)

[2] According to the JFSQ, removals are defined as "*The volume of all trees, living or dead, that are felled and removed from the forest, other wooded land or other felling sites. It includes unsold roundwood stored at the forest roadside. It includes natural losses that are recovered (i.e. harvested), removals during the year of wood felled during an earlier period, removals of non-stem wood such as stumps and branches (where these are harvested) and removal of trees killed or damaged by natural causes (i.e. natural losses), e.g. fire, windblown, insects and diseases. Please note that this includes removals from all sources within the country including public, private, and informal sources. It excludes bark and other non-woody biomass and any wood that is not removed, e.g. stumps, branches and tree tops (where these are not harvested) and felling residues (harvesting waste). It is reported in cubic metres solid volume underbark (i.e. excluding bark). Where it is measured overbark (i.e. including bark), the volume has to be adjusted downwards to convert to an underbark estimate.*" (JFSQ, 2020)

Each parameter is available for Forest land (distinguished between Forest Available for Wood Supply (FAWS) and Forest Not Available for Wood Supply (FNAWS)), Other Wooded Land (including an "of which item" Other Wooded Land Available for Wood Supply) and Other Land with Tree Cover Available for Wood Supply. The present analysis only considers the Forest land, further distinguished between FAWS and FNAWS, through a simplified ex-post assessment.

The key variables determining the closing stock reported in Table A2a are NAI, REM and IL, plus, of course, the amount of timber volume attributed to the opening growing stock, as reported at the beginning of each time step of one year. The previous analysis, carried out in 2019-2020, was based on the data available until 2019, further integrated with the estimates provided, at country level, by the Carbon Budget Model calibrated against the period 2000 – 2015 (Pilli and Grassi, 2021). For these runs, the historical period 2000–2015 was modelled according to the amount of harvest removals reported by FAOSTAT - and by other ancillary data sources – for the period 2000 – 2015, while since 2016 onwards, the CBM model simulated the theoretical evolution of the forest growing stock assuming the continuation of the current management practices as detected within the period 2000–2009 (Grassi et al., 2018). For this reason, within the AA LAFO, the parameters provided, since 2016 onward, at country

level, were reported as preliminary estimates, inferred from the latest available data of GS estimated by CBM for 2015.

Within the present AA, all CBM outputs were updated to 2020, according to the latest harvest data made available by FAOSTAT to 2020. These data include, not only the amount of industrial roundwood removals reported until 2020, but, in some cases, also a review of the previous historical data series, according to new data made available by countries.

Taking in account this premise, and in line with the approach already applied within the AA LAFO, within the present AA the closing GS, namely the growing stock at the end of each year *t*, is determined as:

$$GS_t = GS_{t-1} + NAI - REM - IL \qquad \text{Eq (2)}$$

Each parameter reported on Eq. (2) can be determined, for the total forest area and for the period 2000-2020, through the following steps:

1. The **growing stock** can be estimated from the merchantable GS per ha reported by CBM for the period 2000–2020 (GS_{CBM}, based on historical harvest data), further corrected to account for possible differences/inconsistencies with the values reported under Table A2a (when available) or by FRA Country Reports (GS_{FRA}) for 2000, 2010, 2015 and 2020 (when missing, these values were replaced with data reported by SoEF 2020), through a country specific Correction Factor (CF_{GS}), equal to:

$$CF_{GS} = \frac{(GS_{FRA}^{2000} + 2*GS_{FRA}^{2010} + 3*GS_{FRA}^{2015} + 4*GS_{FRA}^{2020})}{(GS_{CBM}^{2000} + 2*GS_{CBM}^{2010} + 3*GS_{CBM}^{2015} + 4*GS_{CBM}^{2020})} \qquad \text{Eq. (3)}$$

   The resulting, *rectified* growing stock per ha (GS_R), is determined as:

$$GS_R = GS_{CBM} * CF_{GS} \qquad \text{Eq. (4)}$$

   For 1999, the total closing GS is equal to GS_R multiplied by the corresponding forest area, as derived by FRA for 2000. Since 2000 onwards, the closing GS is determined by the algebraic sum of the variables reported on Eq. (2), estimated according to the following steps.

2. The **total amount of removals** can be inferred for the entire period 2000–2020 by different data sources, including:

   (i) Total removals o.b. reported by EUROSTAT (*for_remov o.b.*), based on the JFSQ data already including bark according to additional information directly provided by countries. If these data are not available, the following sources can be considered.

   (ii) Total removals u.b. reported by EUROSTAT (*for_remov u.b.*) based on the JFSQ data. These values must be further corrected to account for the bark fraction using an average correction factor determined as the ratio between *for_remov o.b.* and *for_remov u.b,* when both are available for the same years. If neither option (i) or (ii) are feasible, the following source can be considered.

   (iii) Total removals u.b. reported by FAOSTAT, further corrected to account for the bark fraction, according to the approach described above.

3. The total amount of **irretrievable losses** can be estimated by multiplying the total amount of removals determined above by the annual fraction of forest residues *(RF_Y)* estimated by CBM for the period 2000–2020[5].

Once all the above mentioned parameters are determined, the **net annual increment** per ha can be estimated, for each time step, by adding the annual removals and the corresponding amount of irretrievable losses estimated on steps (2) and (3) to the difference between the closing and the opening GS determined for each year, as determined on step (1):

$$NAI = GS_t - GS_{t-1} + REM + IL \qquad \textit{Eq. (5)}$$

5 In this study, the annual fraction of forest residues was derived, from the CBM estimates, considering the ratio between the total amount of biomass transferred to dead organic matter (DOM) through silvicultural practices and natural disturbances - including salvage logging - and the total removals. This fraction, however, could be also determined as the fraction of merchantable biomass transferred to DOM, excluding branches and other wood components. This may be relevant to assess the Gross Annual Increment and the fellings rate at country level (see Avitabile et al., 2023).

The final total NAI to be reported in Eq. (2) is equal to the NAI per ha multiplied by the total area attributed to each year, as defined on step (1).

The gap-filling approach described above can be applied both to Member States which do not report any information in Table A2a and to the countries which already report some data. In this last case, if a country filled the table since a certain year *z*, an additional **balancing item** may be added on year z-1, to align the closing GS provided with the present approach to the opening GS directly reported by Member State on year *z*. The relative extent of this item, expressed by the ratio between the BI and the GS, depends not only by the accuracy of present estimates but also by the consistency between the GS directly reported by the country and the one reported by FRA[6].

Where no additional information is available, the total GS is proportionally distributed between FAWS and FNAWS according to the proportion of GS reported by SoEF. REM and IL are entirely attributed to FAWS, while NAI is estimated as the algebraic difference between the other items. No estimate is provided for the other land use categories of the EFA questionnaire.

The gap-filling approach was applied at country level, first defining the main parameters reported in Eq. (2), then applying each item, year by year, to table A2a, including additional balancing items – when needed – and scaling the data between FAWS and FNAWS. The first part, reported in the file *EFA_FRA_CBM_Data_analysis*, includes 26 countries' sheets (excluding Malta), reporting for each Member State:

a) Total forest area (in ha 10^3) reported by FRA Country Report for 2000, 2010, 2015 and 2020, if available (sometimes these last values are constant or based on a linear interpolation of previous data series). A linear interpolation between these values and an extrapolation to 1999 is also reported.

b) The GS (in m^3 10^3) reported by FRA Country Report for 2000, 2010, 2015 and 2020, if available. The interval, -10% to +20% referred to the same values is also reported, to assess the reliability of the final estimates. In some cases, when FRA does not report any value, the SoEF data were used instead.

c) Closing GS (in m^3 10^3) reported by country to EFA within Table A2a, if available.

d) Merchantable GS per ha (GS_{CBM}, in m^3 ha^{-1}) estimated by CBM for the period 1999-2020. For Cyprus, due to the lack of data provided by CBM, the sheet reports the GS reported by FRA, further interpolated for missing data (in this case the CF_{GS} is equal to 1).

e) Average Correction Factor (CF_{GS}) applied to GS_{CBM}, to account both for different definitions of the biomass' components considered by CBM and by Country Reports, and for possible inaccuracies of the model output.

f) Rectified GS per ha (GS_R, in m^3 ha^{-1}) estimated by multiplying the GS reported by CBM by the CF_{GS}, as estimated above.

g) Ratio between the GS of FAWS and the GS of the total forest area, as reported by SoEF 2020 (if available). A linear interpolation between these values is also reported.

h) NAI per ha (in m^3 ha^{-1} yr^{-1}) estimated according to Eq. (5).

i) Total NAI (in m^3 10^3) estimated by multiplying the NAI per ha by the total forest area reported by FRA.

j) Total annual removals (in m^3 10^3) estimated as:

   (i) Total removals o.b. reported by the for_vol table (only for countries already reporting some data within Table A2a) if available, otherwise:
   (ii) Total removals o.b. reported by the for_remov table if available, otherwise:
   (iii) Total removals u.b. reported by the for_remov table, further corrected to account for the bark fraction if available, otherwise:
   (iv) Total removals u.b. reported by FAOSTAT, further corrected to account for the bark fraction.

k) Relative share of IL, expressed as percentage of annual removals, derived by the CBM output. For Cyprus irretrievable losses were not considered.

6 According to the approach described on step 1, GS_{CBM} was aligned to GS_{FRA}, through a specific CF.

l) Total amount of IL (m^3 10^3), estimated by multiplying the total annual removals by the relative share reported above.

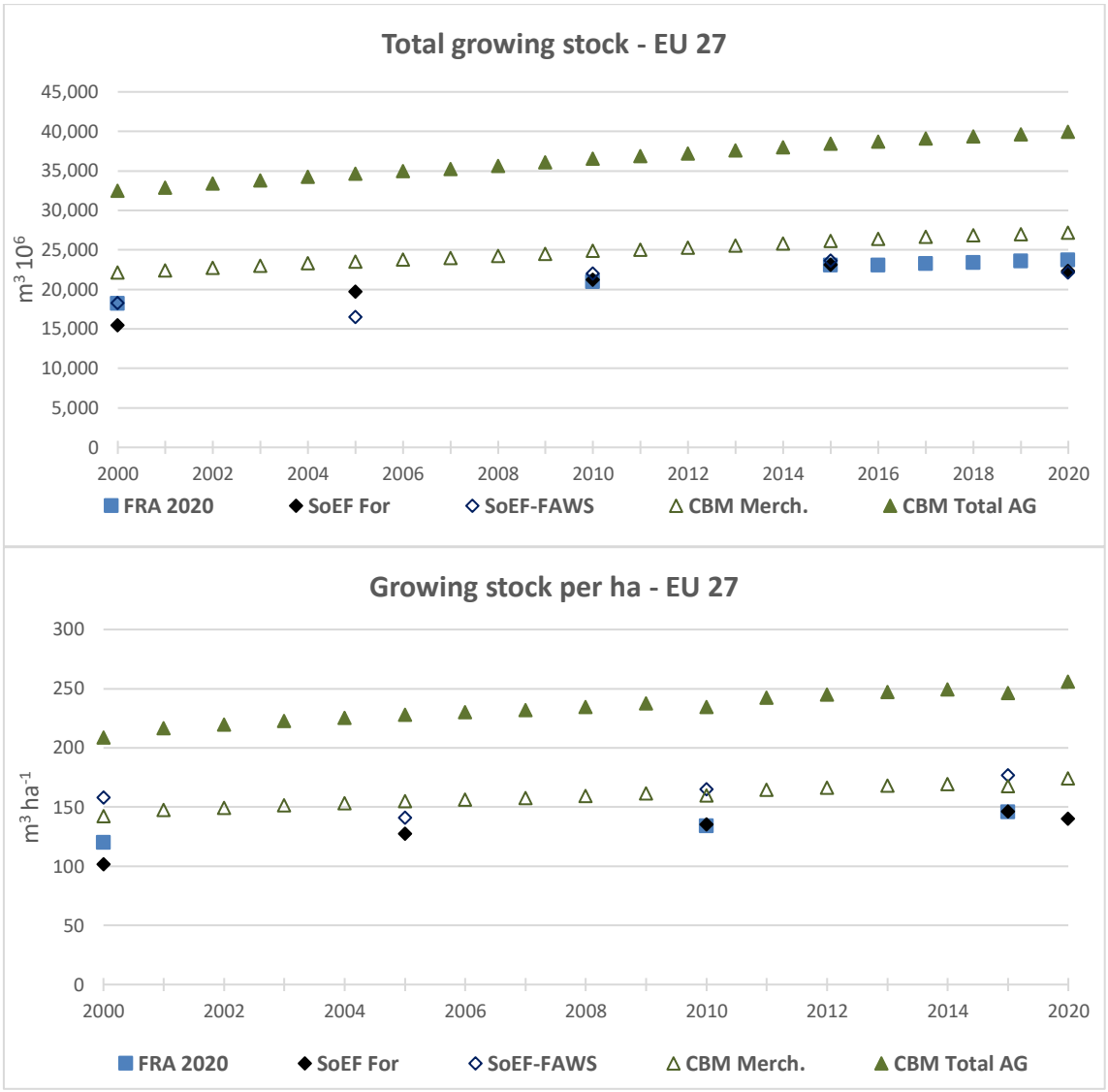
m) Total GS (in m^3 10^3) estimated from 2000 to 2020 according to Eq. (2).

The detailed application of each parameter at country level is reported in 26 country-specific worksheets (see Supplementary Material) including, for each year between 2000 and 2020, opening and closing GS, NAI, REM, IL and the other items (SRC, IL, and a BI, if relevant/needed) reported in Table A2a, as estimated according to the present methodological approach or directly reported by the Member States. No estimate can be currently provided for 2021.

2.2. EU 27 data and results

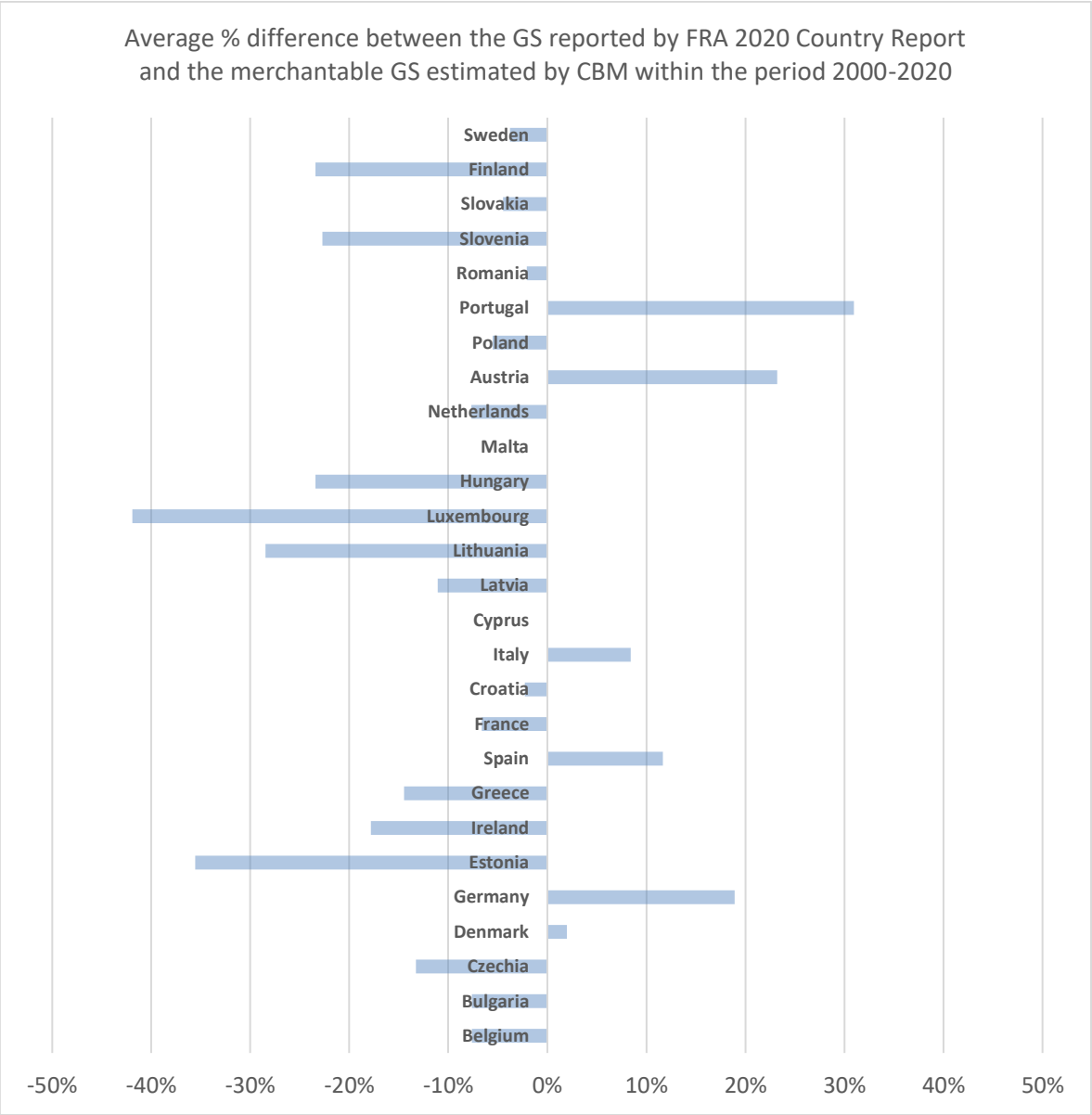
According to all data sources, the total merchantable growing stock of EU 27 was continuously increasing between 2000 and 2020, from about 18.2 and 22.1 Mm3, to about 23.7 and 27.2 Mm3, based on FRA 2020 and on CBM, respectively (Figure 1, upper panel). This trend is not only due to an increasing forest area - see next section - but also to the stock of biomass available per unit of area, increasing, on average, by about 1.2% yr-1 and 1.1% yr-1, according to FRA 2020 and CBM, respectively (Figure 1, lower panel). Data reported from SoEF 2020 confirm this trend but highlight a slightly different pattern, due to the fact that the time series reported from SoEF is not fully consistent (because some countries are missing in some years). Interestingly, when scaled per unit of area, the merchantable growing stock reported from SoEF for the FAWS, it is only increasing by about 0.2% per year within the period 2000 – 2020, against an average rate of 1.9% per year for the total forest area. This may be also due to the impact of harvest - including ordinary management practices and salvage logging - mostly concentrated within this area.

Figure 1: the upper plot reports, for EU 27, the total growing stock (in m^3 10^6) reported from FRA 2020 (for total forest area) and from SoEF 2020 (for total forest area and FAWS) and estimated by CBM (referred to the merchantable biomass and the total aboveground biomass of total forest area). The lower plot reports the growing stock per unit of area (in m^3 ha^{-1}) derived from the same data sources.



As expected, the total aboveground biomass stock estimated by CBM, including branches and other non-merchantable wood components, is systematically higher (on average +47%), than the merchantable stock provided by CBM. Such as in the previous study, this last component is, in turn, 17% higher than the merchantable biomass reported from FRA 2020 (see Pilli and Grassi, 2021 for further details). For this reason, we applied an average correction factor, to align the GS reported from FRA Country Reports to the estimates reported from CBM. As highlighted on Figure 2, the average CF mostly fall within the interval ±10% (for 11 out of 25 countries), and only in few cases (Luxembourg, Estonia and Portugal) exceeds the interval ±30%.

Figure 2: average percentage difference between the GS reported by FRA Country Reports and the merchantable GS estimated by CBM. The average refers to values reported by FRA and by CBM for 2000, 2010, 2015 and 2020, applying to both these data sources a weighting factor equal to 1, 2, 3 and 4 for 2000, 2010, 2015 and 2020, respectively.

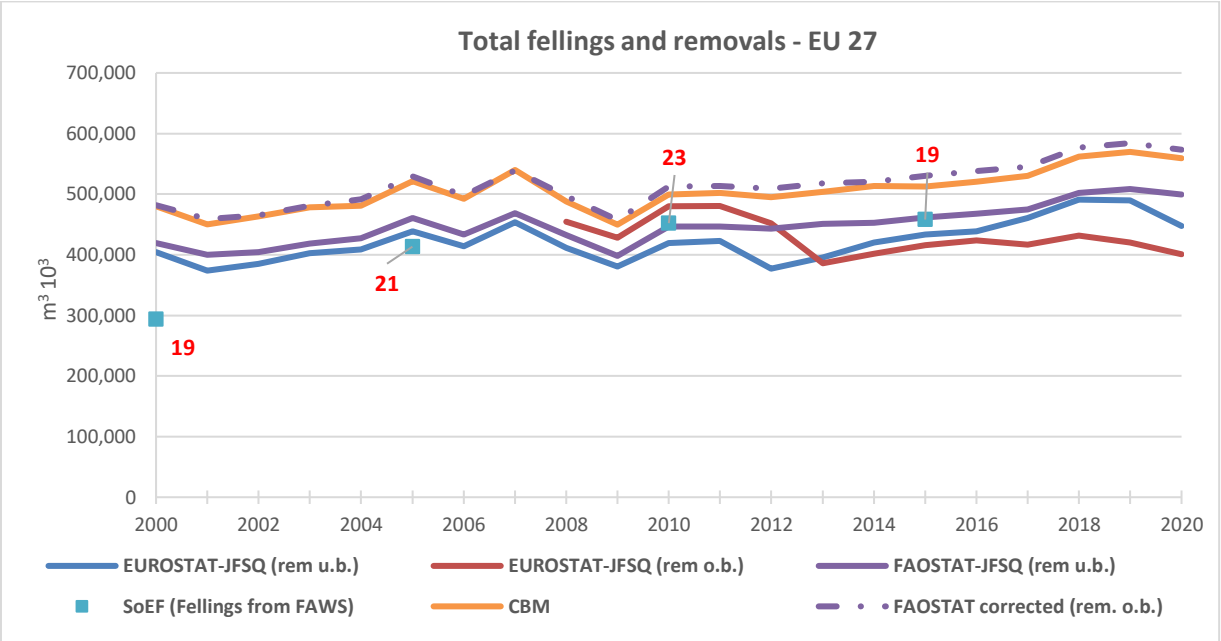


Taking into account the different data sources considered within the present study, and excluding stochastic interannual variations due to major natural disturbance events - such as in 2007 - we can highlight that, until 2012, the total harvest at EU level has been quite stable and equal on average to about 490 Mm3 yr o.b. (Figure 3). Since 2013, however, the overall harvest has continuously increased, above all after 2018, and it was equal to about 574 Mm3 o.b. in 2020. As expected, the total removals inferred from EUROSTAT (JFSQ for_remov) is considerably lower than the values reported from other data sources, because of the number of missing countries.

As highlighted within the previous report (AA LAFO), harmonizing different data sources is quite challenging (see Pilli and Grassi 2021). First, because detailed data on the fraction of bark considered, or excluded, from different data sources are generally missing. Comparing over and under bark removals reported within the JFSQ data series, we highlighted that this fraction varies between about 25% of the merchantable volume, within Mediterranean countries such as Portugal, Greece, and Spain, where forest composition includes a large share of oaks (e.g., *Quercus suber*), to about 12% for most of the other European countries. Indeed, for 16 out of 26 countries the bark fraction falls within the interval

12±3% (see Figure 4). Within the present study, the new CBM model runs were based on the removals u.b. reported from FAOSTAT, converted to over bark removals by assuming a constant average bark fraction equal to 12% for all countries.

Figure 3: comparison between total removals calculated at the EU level according to the data reported by (i) EUROSTAT, based on JFSQ (removals u.b. and removals o.b.); (ii) FAOSTAT (based on JFSQ – rem u.b), further corrected to account for the bark fraction (FAOSTAT_corrected); (iii) CBM, reported as removals o.b. The figure also highlights the total amount of fellings reported by SoEF 2020, including removals o.b. (as considered from previous data sources) plus logging residues and referred to the FAWS. This data series is only available for 19, 21, 23 and 19 countries, for 2000, 2005, 2010, and 2015 respectively. SoEF 2020 does not report the amount of fellings for the year 2020.



A second issue is clearly linked to the fraction of logging residues included within the amount of fellings reported from SoEF. Even though some countries data are missing from the SoEF data series (see again Figure 4), in many cases the overall amount of fellings reported from SoEF is not consistent (i.e., lower) with the annual removals reported from other data sources (see Supplementary Materials for details). For this reason, also estimating the share of logging residues included within the total fellings, by comparing the total fellings reported by SoEF with the total removals reported by FAOSTAT, may be challenging (Figure 5). Where available, these values can be compared with the amount of logging residues estimated from the CBM output (see Pilli and Grassi 2021 for further details).

Figure 4: percentage bark fraction estimated as the average ratio between the amount of removals over and under bark reported on the JFSQ data series (see Supplementary Materials for details)

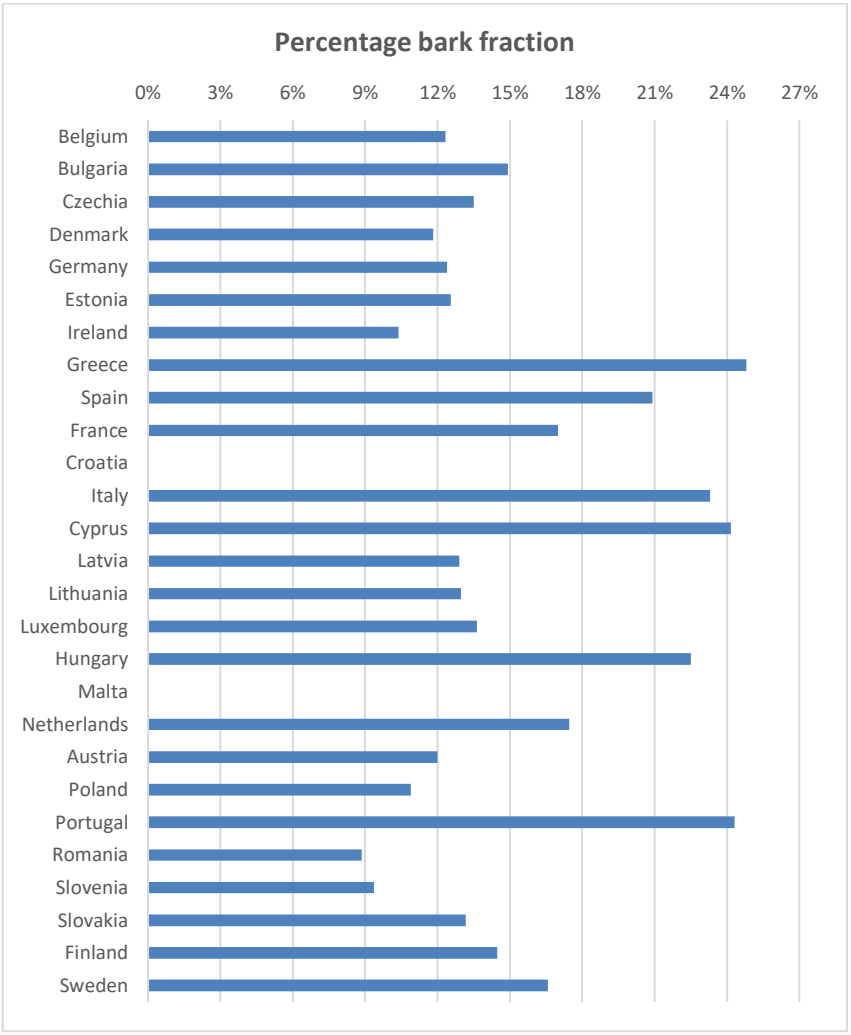
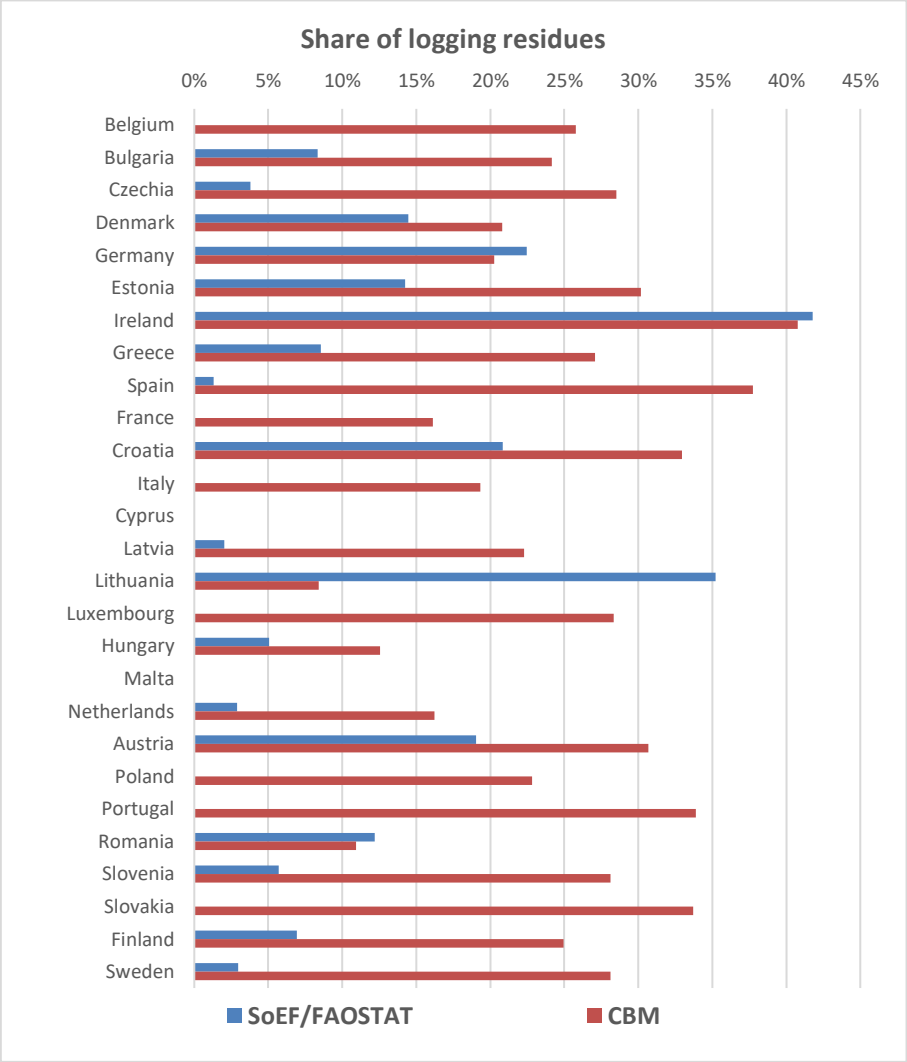


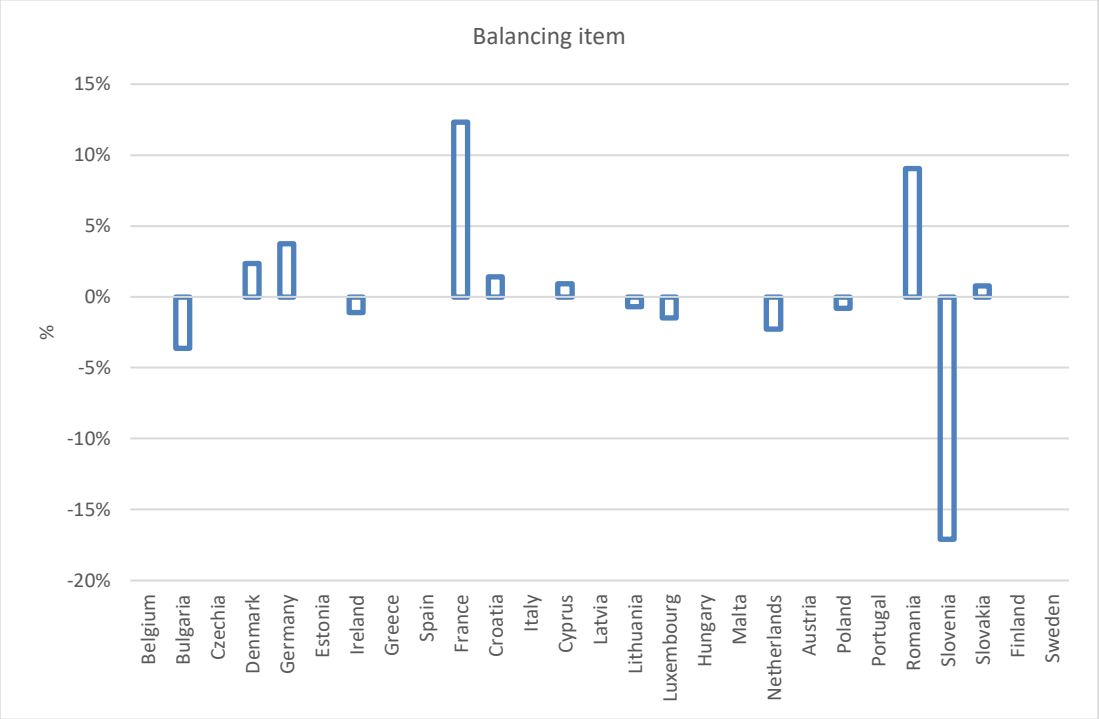
Figure 5: share of logging residues estimated as the ratio between the total fellings reported by SoEF and the total removals reported by FAOSTAT (corrected to account for bark's fraction). This approach cannot be applied if fellings ≤ removals. The figure also reports the share of logging residues and other losses due to natural disturbances estimated by CBM.



According to eq (2), the annual growing stock is also determined from the NAI, which is a key driver - together with removals and irretrievable losses - to determine the evolution of the GS. Within the present study, however, this parameter was indirectly derived from the other variables (see eq. 5). Therefore, neither the NAI estimated from CBM and reported from other data sources, directly affect these estimates. Nevertheless, for a critical comparison of the NAI reported from various data sources we refer to the in depth analysis reported from Avitabile et al., 2023.

The balancing item applied to align the present estimates to the values directly reported by Member States may indirectly measure the consistency between the data directly reported by countries and the data series derived from CBM. Such as within the previous AA, the percentage balancing item applied to each country (calculated as the ratio between BI and corresponding closing GS) generally falls within the range +4% - -2% (see Figure 6). In few cases (France, Romania and Slovenia), where the GS reported on Table A2a diverges from the data series reported by FRA, this share is larger than ±6%.

Figure 6: relative size of the balancing item (calculated as the ratio between BI and corresponding closing GS) applied to align the GS estimated within the present study to the values directly provided by countries on Table A2a, when available.



The total growing stock (Final GS) estimated in this report, further compared with the GS reported by FRA Country Reports (FRA 2020, with the corresponding range -10% to +20%) and with the closing GS reported on Table A2a (when available) is reported, for each country, as Supplementary Material within the excel worksheet EFA_JRC_Stock_Balance_2022. This file also includes a detailed comparison between the estimates provided within the present study and the values reported in 2021 within the AA LAFO. In particular, for the total forest area, the percentage difference between the closing GS reported in 2021 and the present one is generally lower than ±5% for all countries except Lithuania and Romania (Table 3). In general, these differences are due both to the new estimates derived from the new CBM model runs performed within the latest AA and to a refinment of the methodological assumptions applied to estimate the opening GS at the beginning of the time series (i.e., 2000), estimated as relative difference with the GS and forest area attributed to 1999[7]. As expected, on FAWS, and above all on FNAWS, we detected larger differences due to the specific methodological assumptions applied to these categories (see Table 4 and Table 5).

For each country, detailed additional comments regarding the estimates provided within the present study are reported as Annex 1. In particular, it is important to recall that, due to the lack of specific data on FNAWS, the removals were fully allocated to FAWS and NAI was estimated as absolute difference between the opening and the closing stock assigned to FNAWS. Both these last parameters were estimated as relative share of total GS attributed to FAWS and FNAWS according to SoEF data. For this reason, in some cases, both GS and NAI attributed to FNAWS may show interannual variations > ±20%, compared with the previous year (included, in some cases negative values). This is also due to the fact that, according to official statistics reported to SoEF, in some cases, the relative share of forest area attributed to FAWS/FNAWS varies in time. For these reason the specific estimates concerning the share of NAI attributed to FAWS/FNAWS should be considered as highly uncertain (see also Avitabile et al., 2023).

[7] In these cases, we recalculated the forest area attributed to 1999 and this also affected the opening GS attributed to 2000, and to the following data series.

Table 3: comparison between the closing GS estimated or reported by countries for the total forest area until 2021 (AA LAFO) and estimated within the present AA. The comparison is reported as percentage difference between latest and previous values. Grey cells refer to values directly reported by countries.

Forest	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Avgerage
Belgium	11%	10%	10%	9%	8%	7%	5%	4%	3%	2%	1%	1%	1%	1%	0%	0%	0%	0%	-1%	-1%	4%
Bulgaria	4%	4%	4%	4%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%
Czechia	3%	3%	3%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	1%	1%	1%	1%	1%	2%
Denmark	8%	8%	7%	6%	6%	5%	4%	4%	3%	3%	3%	2%	2%	1%	0%	-1%	-3%	-2%	-1%	-1%	3%
Germany	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-2%	-2%	-2%	-3%	-3%	0%	0%	0%	0%	0%	0%	-1%	-1%
Estonia	0%	0%	0%	0%	0%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-2%	-2%	-3%	-4%	-4%	-5%	-5%	-2%
Ireland	-3%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-5%	-5%	-5%	-5%	-4%	-3%	0%	0%	0%	0%	0%	-3%
Greece	-5%	-6%	-6%	-6%	-6%	-6%	-6%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-3%	-3%	-3%	-4%	-5%
Spain	-1%	-1%	-1%	-2%	-2%	-2%	-2%	-2%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-2%	-2%	-2%	-10%	-3%
France	-2%	-3%	-3%	-4%	-4%	-5%	-5%	-5%	-5%	-5%	-5%	0%	0%	0%	0%	0%	-1%	-1%	-1%	-2%	-3%
Croatia	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	0%	0%	0%	0%	0%	0%	0%	-1%
Italy	-4%	-2%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-2%	-2%	-2%	-3%	-3%	-3%	-4%	-4%	-5%	-2%
Cyprus	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Latvia	3%	2%	2%	1%	1%	0%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	0%	0%	0%	0%
Lithuania	-57%	-57%	-57%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	-1%	-1%	-8%
Luxembourg	0%	0%	1%	1%	2%	2%	2%	2%	3%	1%	1%	1%	1%	-1%	-1%	0%	0%	0%	0%	0%	1%
Hungary	-1%	-1%	-1%	-1%	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	2%	2%	2%	1%	1%	1%
Malta																					
Netherlands	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	0%	0%	0%	0%	1%	2%
Austria	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-3%	-3%	-3%	-3%	-3%	-3%	-2%	-2%	-2%	-1%	-3%
Poland	1%	1%	1%	1%	1%	2%	2%	2%	2%	2%	2%	2%	2%	-2%	-1%	0%	0%	0%	0%	0%	1%
Portugal	-2%	-2%	-2%	-1%	-1%	-1%	-1%	0%	0%	0%	0%	-1%	-1%	-1%	0%	0%	1%	2%	3%	3%	0%
Romania	-17%	-17%	-17%	-17%	-17%	-17%	-16%	-16%	-16%	-7%	-6%	-6%	-6%	-8%	-8%	-8%	-8%	-6%	-8%	-8%	-11%
Slovenia	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%
Slovakia	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	-1%	-2%	0%
Finland	-1%	-2%	-2%	-2%	-2%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-4%	-4%	-4%	-4%	-4%	-5%	-5%	-3%
Sweden	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%

Table 4: comparison between the closing GS estimated or reported by countries for FAWS until 2021 (AA LAFO) and estimated within the present AA. The comparison is reported as percentage difference between latest and previous values. Grey cells refer to values directly reported by countries.

FAWS	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Avgerage
Belgium	11%	10%	10%	9%	8%	7%	5%	4%	3%	2%	1%	1%	2%	2%	2%	3%	3%	2%	2%	1%	4%
Bulgaria	4%	4%	4%	4%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	1%
Czechia	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	3%	4%	4%	5%	5%	4%	4%	3%	3%
Denmark	4%	5%	5%	6%	6%	7%	6%	5%	4%	4%	3%	3%	2%	1%	0%	-1%	-2%	-1%	0%	0%	3%
Germany	3%	3%	2%	2%	2%	1%	0%	-1%	-1%	-2%	-2%	-3%	-3%	0%	0%	0%	0%	0%	0%	-1%	0%
Estonia	-2%	-2%	-1%	-1%	-1%	-1%	-1%	0%	0%	0%	0%	-1%	-2%	-3%	-4%	-6%	-7%	-7%	-8%	-9%	-3%
Ireland	-4%	-4%	-5%	-5%	-5%	-5%	-5%	-5%	-6%	-6%	-6%	-7%	-8%	-3%	7%	0%	0%	0%	0%	0%	-3%
Greece	-5%	-6%	-6%	-6%	-6%	-6%	-6%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-3%	-3%	-3%	-4%	-5%
Spain	17%	17%	17%	16%	16%	16%	16%	16%	15%	15%	15%	14%	15%	15%	15%	15%	14%	14%	12%	4%	15%
France	-2%	-3%	-3%	-4%	-4%	-5%	-5%	-5%	-5%	-5%	-5%	0%	0%	0%	0%	0%	-1%	-1%	-1%	-1%	-3%
Croatia	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-3%	-3%	-2%	-2%	0%	0%	0%	0%	0%	0%	0%	-2%
Italy	0%	1%	3%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-2%	-2%	-2%	-3%	-3%	-3%	-4%	-4%	-5%	-2%
Cyprus	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	0%
Latvia	3%	2%	2%	1%	1%	0%	0%	-1%	-1%	0%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	0%
Lithuania	-58%	-58%	-58%	0%	0%	1%	1%	1%	1%	1%	1%	2%	2%	0%	0%	0%	0%	0%	-1%	-1%	-8%
Luxembourg	0%	0%	0%	1%	1%	2%	2%	2%	3%	2%	1%	1%	1%	-1%	-1%	0%	0%	0%	0%	0%	1%
Hungary	4%	4%	4%	4%	5%	5%	5%	6%	6%	7%	6%	6%	5%	5%	6%	6%	5%	5%	5%	4%	5%
Malta																					
Netherlands	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	3%	3%	3%	1%	1%	1%	2%	2%	2%
Austria	1%	1%	1%	1%	1%	1%	1%	1%	1%	2%	2%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Poland	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	3%	-2%	-1%	0%	0%	0%	0%	0%	1%
Portugal	0%	-1%	-2%	-2%	-3%	-4%	-4%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-2%	-2%	-1%	0%	0%	-2%
Romania	-17%	-17%	-17%	-17%	-17%	-17%	-16%	-16%	-16%	-9%	-8%	-5%	-2%	-12%	-11%	-12%	-12%	-10%	-9%	-9%	-12%
Slovenia	10%	10%	10%	10%	10%	10%	9%	9%	9%	8%	8%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%
Slovakia	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	-1%	-3%	0%
Finland	-1%	-2%	-2%	-2%	-2%	-3%	-3%	-3%	-3%	-3%	-4%	-4%	-4%	-4%	-4%	-4%	-5%	-5%	-5%	-5%	-3%
Sweden	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-3%	-4%	-5%	-1%

Table 5: comparison between the closing GS estimated or reported by countries for FNAWS until 2021 (AA LAFO) and estimated within the present AA. The comparison is reported as percentage difference between latest and previous values. Grey cells refer to values directly reported by countries.

FNAWS	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Avgerage
Belgium	11%	10%	10%	9%	8%	7%	5%	4%	3%	2%	1%	-5%	-11%	-16%	-20%	-24%	-24%	-25%	-25%	-25%	-5%
Bulgaria	4%	4%	4%	4%	4%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	1%	1%
Czechia	41%	30%	21%	13%	6%	-1%	0%	1%	1%	2%	2%	-3%	-8%	-12%	-15%	-18%	-16%	-14%	-12%	-10%	0%
Denmark	133%	74%	39%	16%	-1%	-14%	-13%	-11%	-9%	-7%	-5%	-5%	-6%	-7%	-8%	-9%	-11%	-9%	-9%	-17%	6%
Germany	-85%	-76%	-67%	-58%	-49%	-41%	-33%	-27%	-19%	-12%	-5%	-6%	-8%	0%	0%	0%	0%	0%	0%	4%	-24%
Estonia	23%	17%	12%	8%	5%	2%	-1%	-4%	-6%	-8%	-11%	-5%	2%	8%	15%	22%	22%	24%	25%	27%	9%
Ireland	4%	3%	3%	3%	3%	3%	4%	5%	6%	7%	8%	18%	28%	-10%	-34%	0%	0%	0%	0%	0%	3%
Greece	-5%	-6%	-6%	-6%	-6%	-6%	-6%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-3%	-3%	-3%	-4%	-5%
Spain	-65%	-65%	-65%	-65%	-65%	-65%	-65%	-66%	-66%	-66%	-66%	-66%	-66%	-66%	-65%	-65%	-62%	-58%	-55%	-60%	-64%
France	-2%	-3%	-3%	-4%	-4%	-5%	-5%	-5%	-5%	-5%	-5%	0%	0%	0%	0%	0%	-1%	-1%	-1%	-23%	-4%
Croatia	-2%	-2%	-2%	-2%	-2%	-2%	0%	2%	4%	5%	7%	6%	5%	0%	0%	0%	0%	0%	0%	0%	1%
Italy	-34%	-34%	-34%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-2%	-2%	-2%	-3%	-3%	-3%	-4%	-4%	-5%	-7%
Cyprus	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Latvia	3%	2%	2%	1%	1%	0%	-1%	-2%	-3%	-4%	-5%	-3%	-1%	1%	3%	5%	6%	7%	8%	9%	1%
Lithuania	-47%	-47%	-46%	0%	0%	1%	1%	1%	1%	1%	1%	-3%	-8%	0%	0%	0%	0%	0%	-1%	-1%	-7%
Luxembourg	25%	26%	26%	27%	28%	28%	28%	29%	29%	-23%	-7%	-6%	8%	7%	24%	0%	0%	-1%	-1%	-1%	12%
Hungary	-44%	-43%	-43%	-42%	-41%	-40%	-39%	-39%	-38%	-38%	-38%	-36%	-34%	-32%	-29%	-27%	-25%	-22%	-20%	-18%	-34%
Malta																					
Netherlands	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	1%	0%	-1%	-2%	-5%	-5%	-5%	-4%	-4%	0%
Austria	-46%	-45%	-44%	-43%	-43%	-42%	-42%	-41%	-41%	-41%	-41%	-39%	-37%	-34%	-32%	-30%	-28%	-25%	-23%	-21%	-37%
Poland	-7%	-7%	-7%	-7%	-7%	-7%	-7%	-6%	-6%	-6%	-6%	-6%	-6%	-11%	-9%	0%	0%	0%	0%	-1%	-5%
Portugal	-11%	-6%	-1%	4%	9%	13%	13%	13%	13%	12%	12%	12%	12%	12%	12%	13%	13%	14%	16%	16%	10%
Romania	-17%	-17%	-17%	-17%	-17%	-17%	-16%	-16%	-16%	1%	2%	-9%	-18%	5%	5%	6%	6%	10%	-3%	-3%	-7%
Slovenia	9%	9%	9%	9%	9%	9%	16%	24%	34%	45%	59%	0%	0%	0%	0%	0%	0%	0%	0%	0%	12%
Slovakia	0%	0%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	0%	0%	0%	0%	0%	0%	-2%	1%
Finland	-1%	-1%	-2%	-2%	-2%	-3%	-2%	-1%	-1%	0%	0%	1%	1%	1%	1%	2%	1%	1%	1%	1%	0%
Sweden	6%	6%	6%	6%	6%	6%	6%	5%	5%	4%	4%	5%	6%	6%	7%	8%	12%	16%	21%	25%	8%

3 Area analysis

3.1 Concepts and definitions

Despite the EUROSTAT definition of forest is fully aligned to FRA 2000 definition[8], many countries do not report to EUROSTAT any information on their forest area or other forest land use subcategories, such as the forest area available for wood supply or other wooded land.

According to the definition given by FAO in 1958 “forests are all lands bearing a vegetative association dominated by trees of any size, exploited or not, capable of producing wood or other products, or exerting an influence on the climate or on the water regime, or providing shelter for life-stock and wildlife” (FAO, 1960). Based on this definition, forests are therefore meant as “areas”, which fulfil certain criteria (Loetsch & Haller, 1973). The first word’s assessments of forest resources, carried out by FAO between 1946 and the 60s, left the definition of these criteria to the specific national circumstances, just highlighting the differences in meanings assigned to specific terms, such as forest, but also “yield” or “increment”, in different regions and countries (FAO, 1949, 1963). Since the 80s, however, FAO’s resource assessments started to specify the minimum criteria for defining “forests”, based on:

- a minimum 10% of canopy cover density
- a minimum tree height equal to 7 m
- a minimum area of 10 ha

These criteria were partially revised within the Forest Resource Assessment 1990 (FAO, 1995), where forest is defined as a land:

“with tree crown cover (stand density) of more than about 20% of the area. Continuous forest with trees usually growing more than about 7m in height and able to produce wood. This includes both closed forest formulations where trees of various storeys and undergrowth cover a high proportion of the ground and open forest formulations with a continuous grass layer in which tree synusia cover at least 10% of the ground.”

The same report also provides a first definition of Other Wooded Land (hereafter, OWL), defined as

“Land which has some forestry characteristics but is not forest as defined above. It includes: open woodland and scrub, shrub and brushland, whether or not used for pasture or range. It excludes land occupied by “Trees outside the forest.”

All these criteria were further refined within the Global Forest Resource Assessment 2000 (FRA, 2000) where the term forest, including both natural forests and plantations, is referred to:

“lands with a tree canopy cover of more than 10 percent and area of more than 0.5 ha. Forests are 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 m. Young stands that have not yet but are expected to reach a crown density of 10 percent and tree height of 5 m are included under forest, as are temporarily unstocked areas. The term includes forests used for purposes of production, protection, multiple-use or conservation (i.e. forest in national parks, nature reserves and other protected areas), as well as forest stands on agricultural lands (e.g. windbreaks and shelterbelts of trees with a width of more than 20 m), and rubberwood plantations and cork oak stands. The term specifically excludes stands of trees established primarily for agricultural production, for example fruit tree plantations. It also excludes trees planted in agroforestry systems.”

Within the same assessment, also the concept of OWL was revised, and defined as:

“land that has either a crown cover (or equivalent stocking level) of 5 to10 percent of trees able to reach a height of 5 m at maturity; or a crown cover (or equivalent stocking level) of more than 10 percent of trees not able to reach a height of 5 m at maturity; or with shrub or bush cover of more than 10 percent.”

[8] https://ec.europa.eu/eurostat/ramon/nomenclatures/index.cfm?TargetUrl=DSP_GLOSSARY_NOM_DTL_VIEW&StrNom=CODED2&StrLanguageCode=EN&IntKey=16474035&RdoSearch=BEGIN&TxtSearch=Forest&CboTheme=&IntCurrentPage=1

Most of reports due to international agencies and processes, such as the Global Forest Resource Assessment 2020 to FAO and the State of Europe's Forests 2020 (see Ministerial Process's Forest Europe, 2020), are currently aligned with these criteria, basically defining three thresholds, based on the combination of a minimum area, spanning between 0.05 and 1 ha, a minimum canopy cover, between 10% and 30%, and a minimum -potential - height of trees equal to 2 or 5 m (Figure 7).

Figure 7: forest definitions adopted from major international environmental and forestry organizations, as reported from Chazdon et. al., 2016

Box 1 Forest definitions adopted by major international environmental and forestry organizations

United Nations Food and Agriculture Organization (FAO; 2000) Land with tree crown cover (or equivalent stocking level) of more than 10 % and area of more than 0.5 ha. The trees should be able to reach a minimum height of 5 m at maturity in situ. May consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground; or open forest formations with a continuous vegetation cover in which tree crown cover exceeds 10 %. Young natural stands and all plantations established for forestry purposes which have yet to reach a crown density of 10 % or tree height of 5 m are included under forest, as are 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

United Nations Framework Convention on Climate Change (UNFCCC; 2002) A minimum area of land of 0.05–1.0 ha with tree crown cover (or equivalent stocking level) of more than 10–30 % with trees with the potential to reach a minimum height of 2–5 m at maturity in situ. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown cover of 10–30 % or tree height of 2–5 m are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest

United Nations Convention on Biological Diversity (UN-CBD; 2010) A land area of more than 0.5 ha, with a tree canopy cover of more than 10 %, which is not primarily under agriculture or other specific non-forest land use. In the case of young forest or regions where tree growth is climatically suppressed, the trees should be capable of reaching a height of 5 m in situ, and of meeting the canopy cover requirement

United Nations Convention to Combat Desertification (UN-CCD; 2000) Dense canopy with multi-layered structure including large trees in the upper story;

International Union of Forest Research Organizations (IUFRO; 2002) A land area with a minimum 10 % tree crown coverage (or equivalent stocking level), or formerly having such tree cover and that is being naturally or artificially regenerated or that is being afforested

When applied at national level, the same criteria may assume different thresholds according to the specific characteristics, or needs, of each geographical area. These differences can also be linked to different management objectives from which the concept of forest is defined: i.e. simply as a source of timber products - adding a minimum threshold to quantify the productivity of each forest stand - or as a repository for maximizing the carbon storage, or a source of multiple ecosystem and socio-ecological services (Chazdon et al., 2016)

Even if, within the last decade, most of the European countries aligned their national definition to the FAO criteria – eventually adding a minimum width for linear forested lands - still, in some cases, the national definition may diverge from the international ones (Tompoo et al., 2010). At EU level, 14 and 17 countries consider, within their definition of forest land, a minimum area and tree crown cover, respectively, in line with the FAO definition. Only six countries do not apply the same threshold consider by FAO to define the minimum trees' potential height. (Table 6 and Appendix I).

If not properly corrected, for example using ancillary data provided from remote sensing, these differences on the forest definition may introduce some inconsistencies when comparing data provided from various countries. In other cases, different national and international thresholds, specifically applied for international reporting, may coexist within the same country, such as, for example, in case of Finland (Tomppo et al., 2010). Where only the latest national forest inventories were aligned to the international thresholds, a diachronic comparison between the data reported from different NFIs should be considered with some caution. Despite these differences, the ongoing effort carried out within the last decade to harmonize different definitions and thresholds considerably improved the comparability between different data sources as made available at country level (see for example, Tompoo et al., 2010; Vidal et al., 2016; Gschwantner et al., 2019).

Compared to the forest definition, the definition of OWLs is generally more variable. Indeed, only 9 out of 27 Member States apply the same thresholds suggested from FAO, generally adding other criteria such as a minimum area, mostly equal to 0.5 ha, and a minimum width. Some countries, however,

defined OWL according to the species' composition (i.e., Spain, Slovakia or Austria) or they did not consider at all this land use category (i.e, Germany or Portugal). Overall, for this reason, data on OWL are often missing or not comparable between Member States.

Table 6: main thresholds applied at country and international level (by FAO) to define the concept of forest and Other Wooded Land (OWL) according to a minimum threshold attributed to (i) area (defined in ha), (ii) percentage of tree canopy cover, (iii) tree height (defined in m) and (iv) width of the forested land (in m).

Country	Forest definition				OWL definition			
Threshold	Area	% cover	Height	Width	Area	% cover	Height	Width
FAO-SoEF	0.5	10	5	n.d.	n.d.	5-10%	5	n.d.
Belgium	0.1	10%	5		-	-	-	-
Bulgaria	0.1	10%	5		-	-	-	-
Czech Rep	0.5	10%	5	20	0.5	5-10%	5	20
Denmark	0.5	10%	5	20	0.5	5-10%	5	20
Germany	0.1	50%	-	10	-	-	-	-
Estonia	0.5	10%	5		0.5	5-10%	5	
Ireland	0.1	20%	5	20	groups of trees that do not meet the criteria of the forest definition			
Greece	0.5	10%	5	30	land which has some forest characteristics but is not forest			
Spain	0.5	10%	3	20	(1)	5% for open spaces with little or no vegetation		
France	0.5	10%	5	20	0.5-0.05	10%		20
Croatia	0.1	10%	2	-	-	-	-	-
Italy	0.5	10%	5	20	0.5	5-10%	5	
Cyprus	0.5	10%	5		0.5	5-10%	5	
Latvia	0.1	20%	5	20	-	-	-	-
Lithuania	0.1	30%	5		-	-	-	-
Luxembourg	0.5	10%	5		0.5	5-10%	5	
Hungary	0.5	10%	5	20	0.5	5-10%	-	-
Malta	1		2 - 5		-	-	-	-
Netherlands	0.5	20% (10%*)	5	30 (20*)	-	-	-	-
Austria	0.05	30%	-	10	0.05	shrub, bushes, *P. mugo* & *A. viridis*		10
Poland	0.1				-	-	-	-
Portugal	1	10%	5	20	-	-	-	-
Romania	0.5	10%	5	20	0.5	5-10%	5	20
Slovenia	0.25	(2)	5		0.25	not used for agriculture for the last 20 yr		
Slovakia	0.3	20%	5			alpine vegetation zone with Pinus mugo		
Finland	0.5	10%	5	20	0.5	5-10%	5	20
Sweden	0.5	10%	5		-	5%	5	

*Only applied for FAO_FRA reporting

(1) open and dense forest stands, areas covered by shrubs and/or herbaceous vegetation

(2) 75% for afforested lands

Since wood production is still generally considered as the most important service provided from forest lands - even if synergic with other forest functions (Pilli & Pase, 2018) - once clearly assessed the definition of forest, it is also essential to quantify the share of forest area available for wood supply. For these reasons, reporting on FAWS has been included in the Sustainable Development Goals (SDGs) of the UN 2030 Agenda for Sustainable Development (Sachs, 2012) and in the criteria and indicators for sustainable forest management of the 2015 and 2020 Reports of SoEF (Forest Europe, 2015 and 2020).

The concepts of "productive" and "unproductive" forests were already included - even if not clearly defined - within the first world assessments of forest resources promoted by FAO (FAO 1949). Such as the definition of forests, these concepts were generally interpreted in different ways at national level. A first attempt to harmonize the concept of forest area available for wood supply was proposed in 1996, defining FAWS as (UNECE/FAO, 2001):

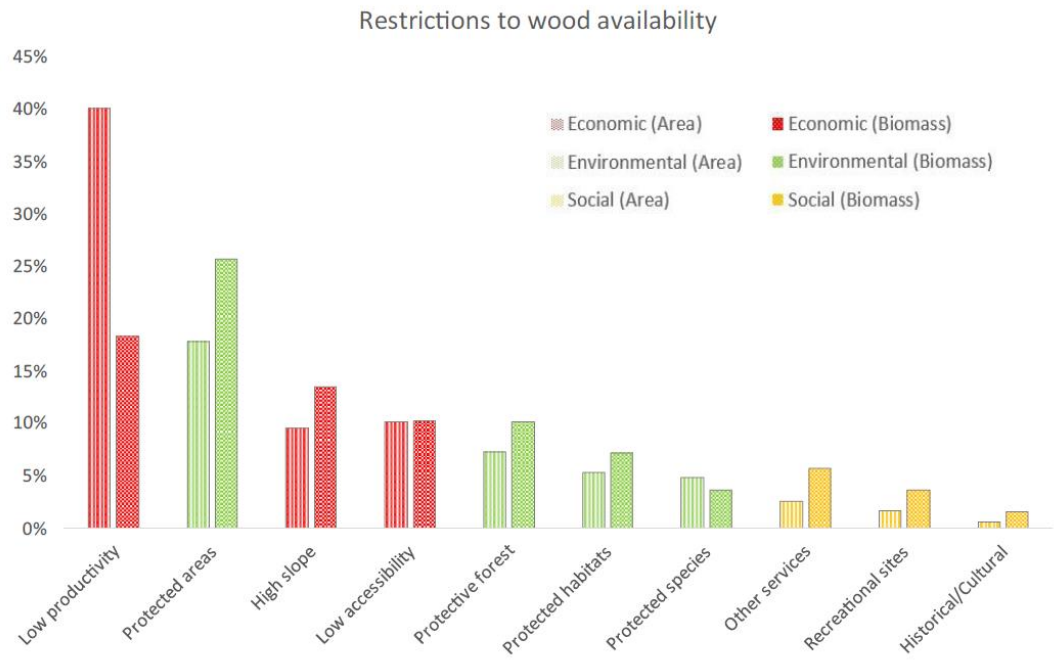
"Forest where any legal, economic, or specific environmental restrictions do not have a significant impact on the supply of wood".

In the same contest, the forest area not available for wood supply was defined as:

"Forest where any legal, economic or specific environmental restrictions prevent any significant supply of wood."

As highlighted by Alberdi et al. (2016), despite these definitions the estimates reported at national levels by European countries – for example on SoEF – are not fully comparable, because national definition of FAWS - and of the companion concept of FNAWS – may be based on different legal (e.g., excluding forests providing a protective service for urban areas), environmental (e.g., excluding protected ecosystems) and/or economic (e.g. excluding inaccessible areas) parameters (Figure 8). Moreover, even considering the same parameters, these criteria may change in time (i.e., instead of the legal status of the forest area, FAWS could include all forest lands subject to some silvicultural activity) and can be quantified according to different thresholds (i.e. a maximum distance from forest roads, for FAWS) at country level. Therefore, the estimations provided by the pan-European reporting do not facilitate comparisons between national figures (see Alberdi et al., 2020 for further details).

Figure 8: percentage contribution of each restriction to the forest available for wood supply in terms of area (left bars with light colours) and biomass (right bars with dark colours). The restrictions are divided in three main categories: economic (red), environmental (green) and social (orange) restrictions. Source: Avitabile et al., 2020.



For these reasons, the concept of FAWS was further revised, establishing a harmonized definition, based on the one used within the Temperate and Boreal Forest Resource Assessment 2000, and also used within the latest State of Europeans' Forests (Forest Europe, 2020). According to this definition, FAWS is defined as (Forest Europe, 2015):

"Forests where any environmental, social or economic restrictions do not have a significant impact on the current or potential supply of wood. These restrictions can be established by legal rules, managerial/owner's decisions or because of other reasons:

- Environmental restrictions should consider: protected areas, protected habitats or species, and also those protective forests meeting the above requirements. Age or diameter class restriction should not be taken into account (except in the case of protected ancient forest).

- Social restrictions include restrictions to protect aesthetic, historical, cultural, spiritual, or recreational values as well as areas where the owner has made the decision to cease wood harvesting in order to focus on other goods and services (e.g leisure, landscape, aesthetic value).

- The economic restrictions are considered as those affecting the economic value of wood utilization (profitability). These include accessibility (such as distance to nearest road), slope and soil condition."

To harmonize national statistics on FAWS, during the period 2017 – 2019 the JRC supported a specific study (Gschwantner et al., 2022), involving 27 NFI organizations under the coordination of the European National Forest Inventory Network (ENFIN). The purpose of this study was to assess the main restrictions to wood availability and quantify the forest area and biomass stock available for wood supply. These data were integrated with the FAWS statistics provided by SoEF and summarized within a reference database of FAWS data for Europe, which provides an overview of the wood resources available in the European forests in 2020 (Avitabile et al., 2018). The output of this analysis is a preliminary map9 of the total forest area and FAWS in Europe, at 100 m spatial resolution, specifically estimated by JRC (hereafter referred as JRC estimates, Avitabile et al., 2023).

This study is particularly important, because it provides for the integration between a top-down approach – i.e., regional or global forest maps derived from remote sensing – and a bottom-up, based on national data derived from NFI measurements (Avitabile et al., 2020). This is also useful to recall potential differences and limits of these data sources. Remote sensing data are mostly based on a "land cover" approach, linked to the application of different definition of forest lands, while NFI always include also direct field measurements, linked to a concept of land use. Even if, modern NFIs successfully integrate, within a multi-level approach, remote sensing analysis with direct field measurements (i.e., Gasparini et al., 2022), it is important to notice that, when comparing different data sources, both provided from remote sensing and from NFI, these differences may produce some inconsistency.

This is also the case of different data derived from a remote sensing assessment of the forest area. Comparing four different biomass maps referred to the same year (2010), Avitabile et al., (2020) highlighted the total forest area of 37 European countries varies from 123 Mha to 186 Mha, while, for the same year, the reference statistics, which includes multiple years, report a total forest area equal to about 183 Mha.

A similar example is given from the Land Use and Coverage Area frame Survey (LUCAS), an in-situ sampling survey carried out by ESTAT. While CORINE Land Cover (CLC) collects data on land cover (i.e. the bio-physical coverage of the land) through the classification of satellite images and orthophotos, LUCAS identifies changes in both land use (i.e., the socio-economic use of land) and land cover, through remote sensing and direct field observations of more than 330,000 points surveyed in the EU MS (see Ballin et al., 2018). LUCAS surveys started in 2006 and were carried out every three years. A new LUCAS module, named COPERNICUS, was introduced in 2018, when the category "wooded land" was distinguished from "shrub lands" (with or without sparse trees cover). For further details on the COPERNICUS methodological assumptions see d'Andrimont et al., 2021. Even if theoretically consistent with FAO parameters, since the definition of woodland considered in LUCAS is based on the canopy cover observed at 20 m around the LUCAS point, the total wooded land assessed by this survey may diverge from the one reported from other data sources (see next paragraph)[10].

8 This map was developed by using an "approach by exclusion", which is to map the forest that is not available due to various constraints (FNAWS) and subtract this area from the existing forest area. Then, FNAWS areas was map using the following restrictions: high slope, high altitude, protected areas, protected species, low accessibility (distance to roads), and unproductive forests. Due to the large differences in natural environment and forestry practices between regions in Europe, the thresholds for each restriction (e.g., maximum slope) were calibrated at country scale. The Copernicus HRL Forest Type map 2015 was used as a base map of forest areas.
For further details see: https://forest.jrc.ec.europa.eu/en/activities/forestbioeconomy/fawsmapping/

[10] As noted from some studies, a point within such a small local concentration may have a much higher canopy cover (40-100%) due to the smaller observation size, while a point located next in an open space might have a 0% coverage of trees (Buck et al., 2015).

Another satellite-derived dataset is the ESA CCI/Copernicus Climate Change Service (C3S) Land Cover Product, which provides global land cover maps from 1992 until the present day (with one year delay) at 300m spatial resolution through the classification and harmonization of data from different satellite sensors. The 1992-2015 product was developed in the framework of the European Space Agency (ESA) Climate Change Initiative (CCI). Starting with the 2016 map onwards, the dataset was included within the Copernicus Climate Change Service maintaining the same processing chain. Land surface is described using a 22 land cover classes legend based on the FAO Land Cover Classification System (LCCS). In this work, the LCCS classes were remapped as proxies of the IPCC Land Use categories through a conversion table (C3S, 2021). The final forest area derived from this assessment (hereafter defined as C3SLC) is reported as an example of forest area derived from a remote sensing approach. Other examples are reported in Avitabile et al., 2020.

3.2 Comparison of publicly available data

A preliminary overview of the information made available within the EFA database highlights that only 16 out of 27 Member States report at least one value within the table *for_area_efa*, which includes data on the area of wooded lands, as provided from Member States through specific EFA questionnaires (see Table 7).

Table 7: EU Member States reporting data on forest land, FAWS/FNAWS or OWL (green cells) on the table *for_area_efa*, within the period 2006-2020 (no information is reported before 2006). Last update: 19/08/2022

Country	2006			2007			2008			2009			2010			2011			2012			2013			2014			2015			2016			2017			2018			2019			2020		
Category	Forest land	FAWS/FnASW	OWC	Forest land	FAWS/FnASW	OWC	Forest land	FAWS/FnASW	OWC	Forest land	FAWS/FnASW	OWC	Forest land	FAWS/FnASW	OWC	Forest land	FAWS/FnASW	OWC	Forest land	FAWS/FnASW	OWC	Forest land	FAWS/FnASW	OWC	Forest land	FAWS/FnASW	OWC	Forest land	FAWS/FnASW	OWC	Forest land	FAWS/FnASW	OWC	Forest land	FAWS/FnASW	OWC	Forest land	FAWS/FnASW	OWC	Forest land	FAWS/FnASW	OWC
Belgium																																											
Bulgaria																																											
Czechia	:			:			:			:			:			:			:			:			:			:			:			:			:					
Denmark	:			:			:			:			:			:			:			:			:			:			:											
Germany	:			:			:			:			:			:			:			:																				
Estonia	:			:			:			:			:			:			:			:			:			:			:			:			:					
Ireland	:			:			:			:			:			:			:			:																				
Greece	:			:			:			:			:			:			:			:			:			:			:			:			:					
Spain	:			:			:			:			:			:			:			:			:			:			:			:			:					
France	:			:			:			:			:			:																										
Croatia	:			:			:			:			:			:			:			:																				
Italy	:			:			:			:			:			:			:			:			:			:			:			:			:					
Cyprus	:			:			:			:			:			:			:			:																				
Latvia	:			:			:			:			:			:			:			:			:			:			:			:			:					
Lithuan.	:			:			:			:			:			:			:			:															:			:		
Luxemb.	:			:			:			:																																	
Hungary	:			:			:			:			:			:			:			:			:			:			:			:			:			:		
Malta	:			:			:			:																																	
Netherlands	:			:			:			:																																	
Austria	:			:			:			:																																	
Poland	:			:			:			:																																	
Portugal	:			:			:			:																																	
Romania	:			:			:			:																																	
Slovenia	:			:			:			:																																	
Slovakia	:			:			:			:																																	
Finland	:			:			:			:			:			:			:			:			:			:			:			:			:					
Sweden	:			:			:			:			:			:			:			:			:			:			:			:			:					

Apart from the area covered from forest land as defined in FAO FRA 2015 (FAO, 2012), this table also includes specific data on the area covered from FAWS and FNAWS (currently reported from 15 countries) and OWL (only available for 11 countries), further distinguished between OWL available and not available for wood supply (this latter classification is not taken into account within the present analysis). Other data on forest area and OWL are made available on the table *for_area*, directly reporting the data provided to FAO and Forest Europe by all EU 27 Member States for 1990, 2000, 2010, and for the period 2015-2020. The table *for_area*, based on FAO definitions of forest and OWL, is generally complete for all Member States and can be further compared with the following data sources:

1. Data on forest land and OWL reported on *for_area_efa*
2. Data on forest land, FAWS and OWL reported by SoEF 2020
3. NFI data, mostly on the total forest area, directly reported by Member States or other data made available at country level (i.e., within the National Forestry Accounting Plans[11])
4. The total forest area reported to the UNFCCC within the countries' CRF tables (Submission 2022)
5. The area of wooded land estimated from LUCAS for 2009, 2012, 2015 and 2018, as reported on the table *LAN_LCV_OVW* made available from EUROSTAT[12]
6. The area of the IPCC category Forest Land from the ESA CCI/Copernicus Climate Change Service (C3SLC).

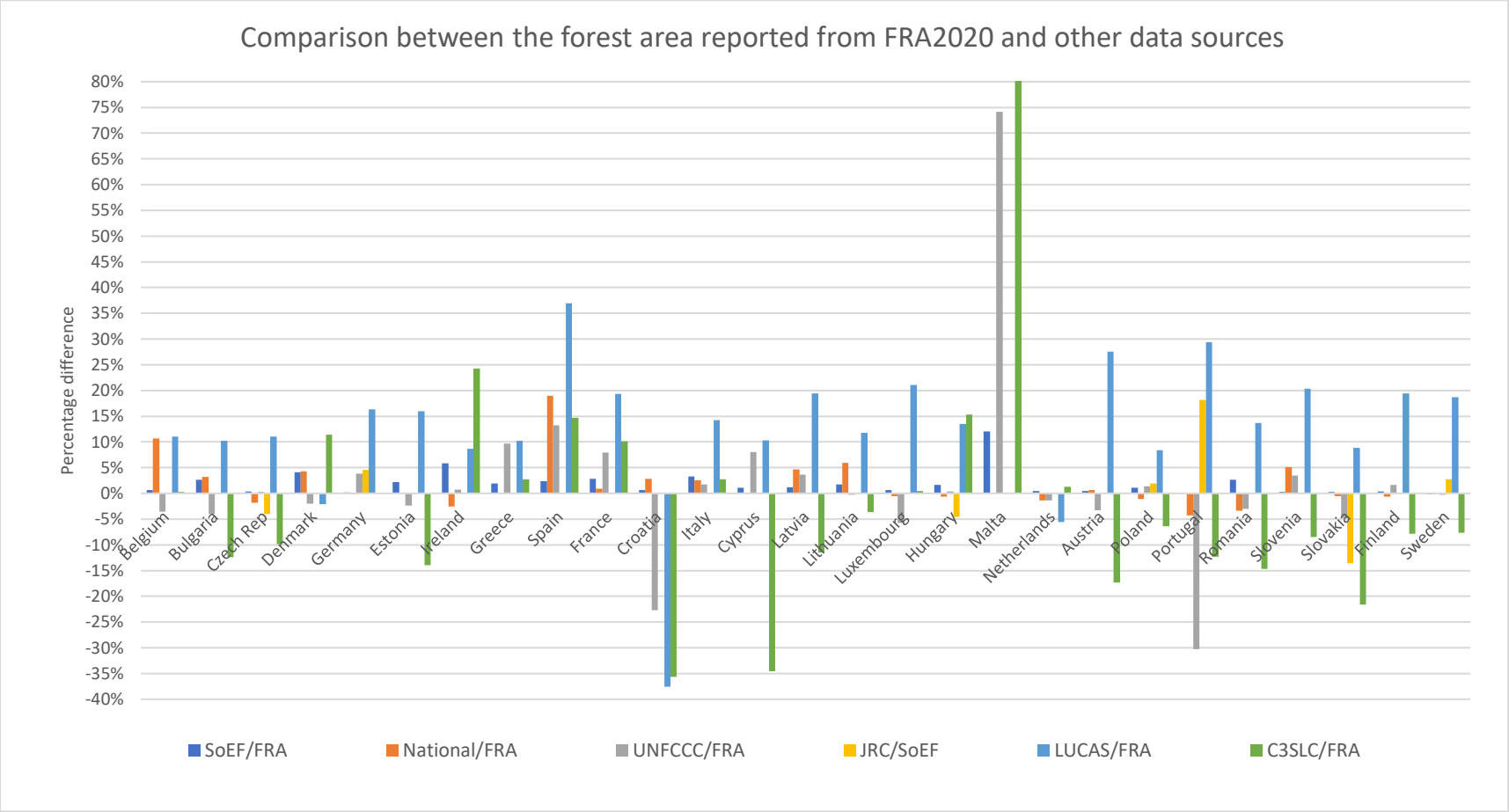
The total forest area and the area of FAWS as estimated by JRC for 2020 can be also compared with the corresponding data reported from SoEF for 2020 (indeed, in some cases, FAO do not report data for 2020).

Figure 7 reports the average percentage difference on the forest area reported from these data sources within the period 2000 -2020.

[11] The National Forestry Accounting Plans, submitted to the EC by all Member States in 2019 and 2020 as part of the requirements linked to the EU Regulation 2018/841, provide a wealth of information on forest area and other key parameters such as growing stock, increment and harvest at country level (see Korosuo et al., 2021).

[12] https://ec.europa.eu/eurostat/web/lucas/data/database

Figure 9: comparison between the forest area reported from the FRA 2020 Country Reports (i.e., the same available on table for_area_efa) and (i) the forest area reported by SoEF 2020, (ii) national data sources (NFI, NFAP, ecc.), (iii) the forest land category reported from UNFCCC (CRF Tables, submission 2022), (iv) the area derived from the ESA CCI/Copernicus Climate Change Service (C3SLC), and (v) the forest area estimated by JRC for 2020. These latter data are compared against the corresponding area reported from SoEF 2020 for the same year. The figure reports the percentage difference is estimated as average for the entire time series where data are made available.



Both the forest area directly collected from EFA (for the 16 countries reporting some data on the table *for_area_efa*), and the area reported by SoEF 2020 are well aligned with the area reported from FAO, with an average difference between these data sources equal to -1.4% and +1.9%, for EFA and SoEF, respectively. For EFA, the maximum difference with FAO data is spotted for Bulgaria, Ireland and Denmark (around -6%) and Slovenia (+4%). For SoEF, the maximum difference with FAO data is spotted for Malta (+12%, not considered by EFA), Ireland (+6%) and Denmark (+4%). Interestingly, for these two latest countries the differences are opposite and symmetric to those observed on EFA.

Data inferred from NFI, NFAPs and other statistics made available at national level, generally do not report a complete time series, but only one or few points in time (see Supplementary Materials for details). Some of these data, above all if inferred from NFI, should be considered as the primary data source providing the information reported on international statistics. As highlighted above, in some cases the forest definition applied at country level is not fully aligned with the international one. This may explain some of the differences between national data sources and FAO data (e.g. in case of Spain, where the forest area reported from the NFAP is 19% lower than the area reported from FAO). On average, however, also these data are well in line with the forest area reported from FAO, with an average difference equal to +1.7%.

Due to a broader definition of forest land category and forest management areas, as considered by the IPCC guidelines (UNFCCCC, 2006), in some cases (i.e., Spain, Croatia, Malta, Portugal) the forest area reported under UNFCCC is considerably different from the area reported from other data sources.

As expected, due to the specific methodological assumptions, the overall forest area estimated by JRC for 2020, is well in line with the area reported from SoEF (and, consequently, also from FAO), with the only exceptions of Portugal (+18%) and Slovakia (-14%). For further details on these aspects we refer to the ancillary information reported by Avitabile et al. 2023.

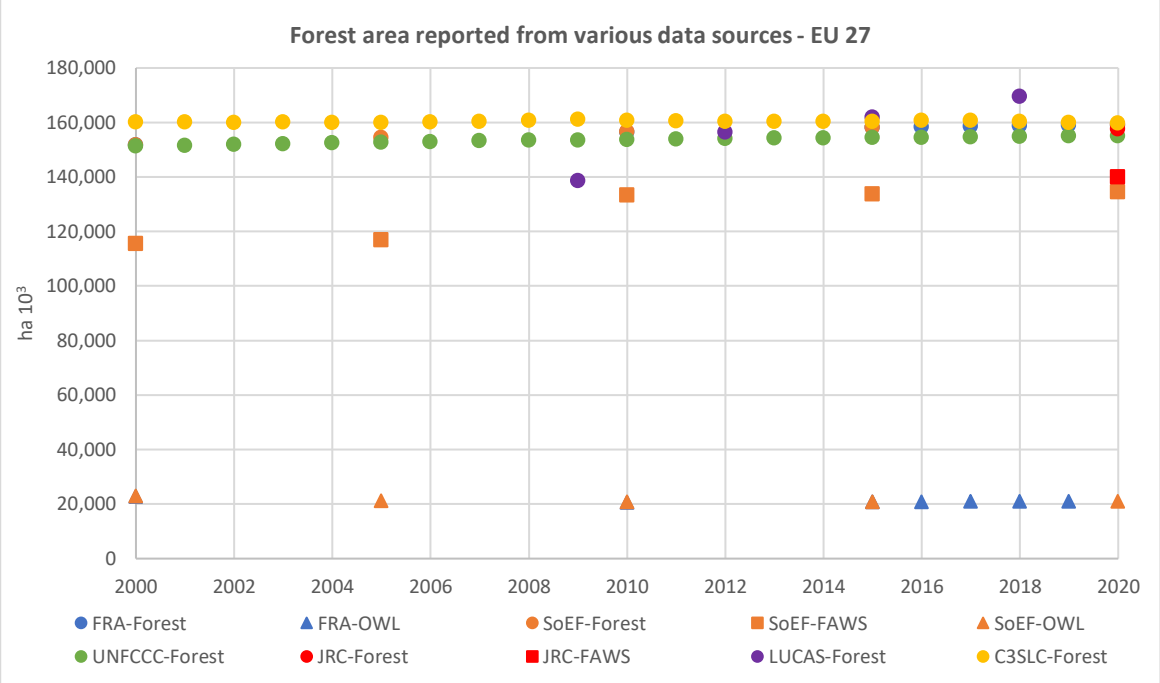
Larger differences are spotted on the area reported from LUCAS. Indeed, for most of the countries, LUCAS category of wooded land overestimates, on average by 12%, the forest area reported from FAO. This may be due both to the inclusion of OWL within the same category - indeed, OWL and wooded lands were formally distinguished only from the latest LUCAS survey - but also to a systematic overestimate of the forest land cover, due to the specific methodological approach used by LUCAS, mostly based on a remote sensing analysis (Buck et al., 2015).

Further details are reported as Supplementary Material on the excel spreadsheet EFA_JRC_Area_Analysis_2022.

Despite some differences at country level, the total forest area derived from these data sources at EU 27 level fall within a relatively narrow interval, ranging between about 159 mil ha, according to FAO, SoEF and C3SLC-Forest, and 155 mil ha, according to UNFCCC's data (Figure 10). The total forest area estimated from JRC for 2020, equal to 157 mil ha, falls within this interval, while the total wooded land estimated from LUCAS shows a quite different pattern, apparently underestimating the forest area in 2009 - also because some countries are missing from the data series[13]- and overestimating the area in 2018. Above all this last value, equal to about 170 mil ha, is not aligned with the other data sources. Discrepancies, at least within the overall historical trend, are also evident when considering the data derived from ESA CCI/Copernicus Climate Change Service which clearly overestimate the forest area reported within the period 2000 - 2016. This is often due to the technical evolution of remote sensing observation systems, which make it difficult to assess the land use change from data derived from such a long time period (see for example Ceccherini et al., 2021).

[13] In 2009 Bulgaria, Cyprus, Malta, Romania are missing.

Figure 10: evolution between 2000 and 2020 of the total area attributed to forest land and OWL for EU 27, according to FRA 2020 Country Reports, SoEF 2020 (also including the area reported as FAWS), UNFCCC, LUCAS, C3SLC and as estimated from JRC for 2020 (also for FAWS).

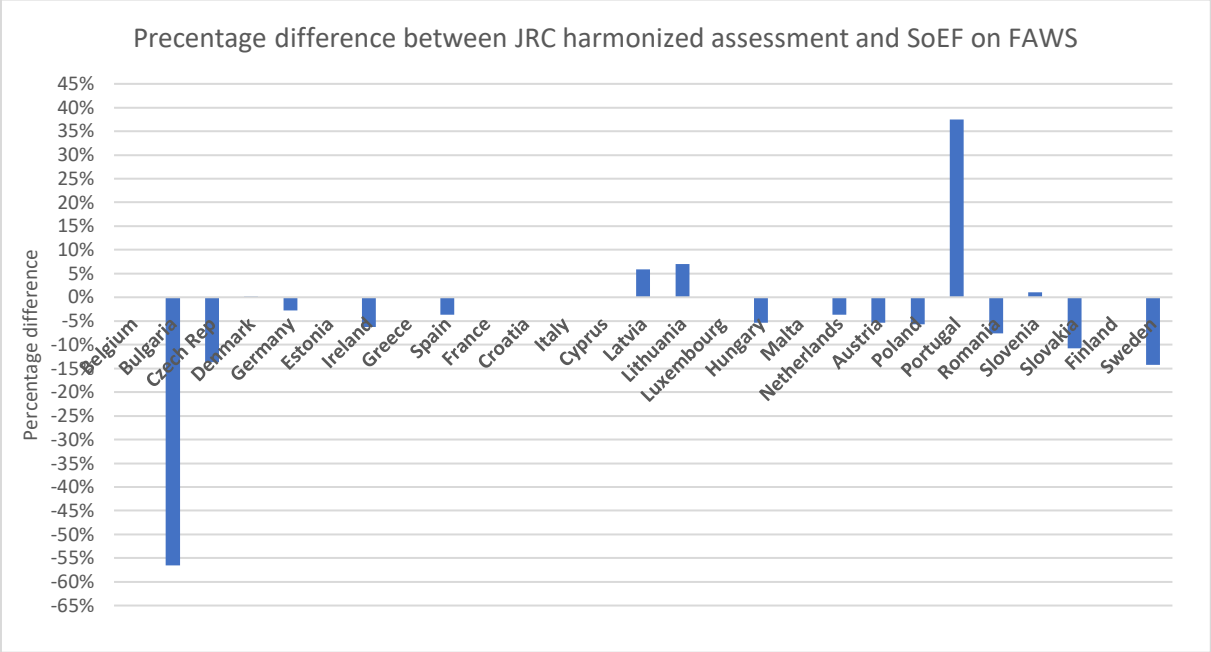


Analyzing the consistency of the data on FAWS/FNAWS and on OWL is more challenging, both because only few databases report this information and because, when reported, these data may be referred to different definitions. Despite that, the data reported from SoEF are generally in line with FAO both for FAWS/FNAWS and for OWL, at country and at EU level (Figure 10). This is probably due to the common primary data source, often based on NFI, used from these libraries.

The specific analysis performed from the JRC on FAWS, integrating the statistics provided by SoEF 2020 with the information reported from NFI organizations, highlights the potential impact of different definitions and concepts considered at country level on the assessment of the forest area available for wood supply (see for example Bulgaria[14] and Portugal in Figure 11).

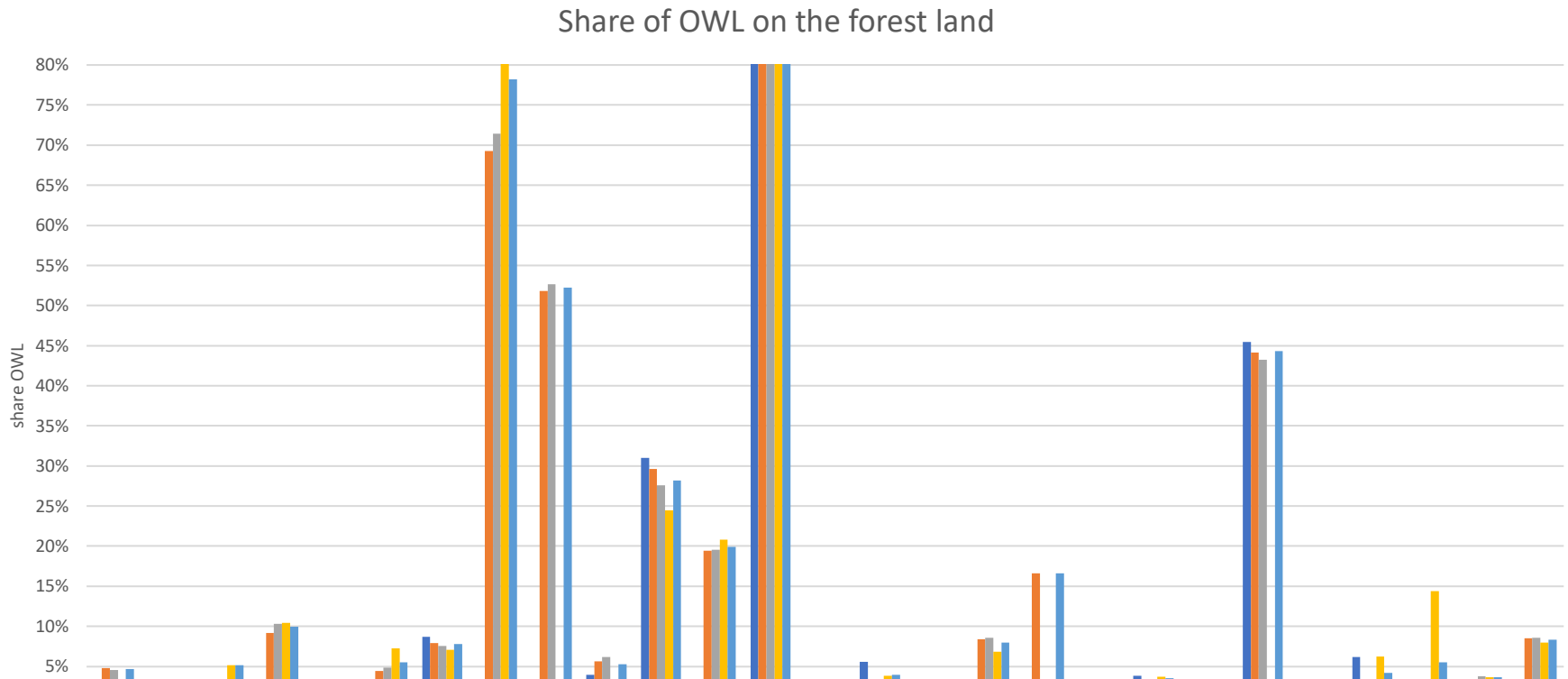
[14] For Bulgaria these differences may be due additional information, based on cadastral data, used to complement NFI data.

Figure 11: percentage difference between the area of FAWS estimated by JRC for 2020 and the area reported from SoEF 2020 for the same year.



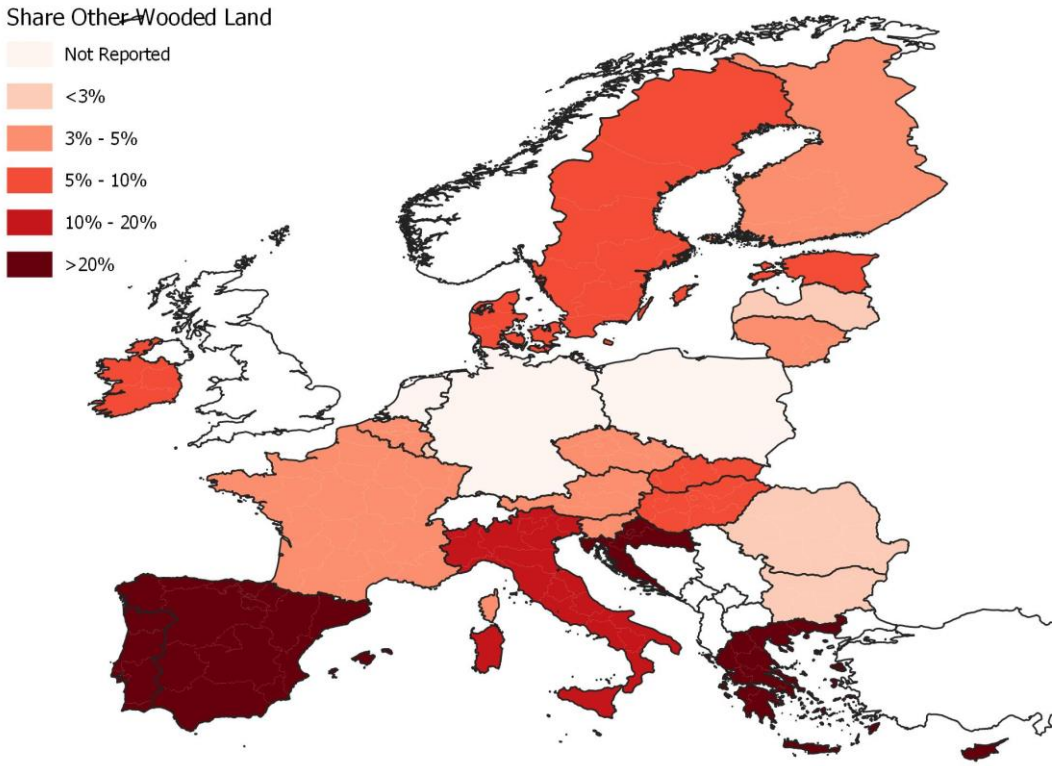
Finally, we can compare the average area attributed to OWL from various data sources with the corresponding forest area. As reported on Figure 12, different data sources are generally quite consistent at country level and we can easily highlight that, due to the specific environmental conditions, Mediterranean countries generally report a higher share of OWL than central and northern European countries (Figure 13).

Figure 12: comparison between average area attributed to OWL from various data sources with the corresponding forest area.



	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	HR	IT	CY	LV	LT	LU	HU	MT	NL	AT	PL	PT	RO	SI	SK	FI	SE
EFA		0.6%					8.7%			4.0%	31.0%		123.5%		5.6%	1.9%				3.8%		45.5%	0.2%	6.2%			
FRA 2020	4.8%	0.9%		9.1%		4.4%	7.9%	69.2%	51.8%	5.6%	29.6%	19.4%	106.1%	3.3%	3.1%	3.0%	8.4%	16.6%		3.3%		44.2%	1.7%	2.1%	1.1%	3.4%	8.5%
SoEF 2020	4.6%	1.1%		10.3%		4.9%	7.6%	71.4%	52.6%	6.2%	27.6%	19.5%	123.8%	3.4%	3.4%	2.9%	8.6%			3.3%		43.2%	3.3%	2.3%	1.1%	3.8%	8.6%
NFI/Other			5.2%	10.4%		7.3%	7.1%	93.9%			24.5%	20.8%	123.7%		3.8%	3.2%	6.9%			3.7%			0.7%	6.2%	14.4%	3.7%	8.0%
AVG	4.7%	0.9%	5.2%	10.0%		5.5%	7.8%	78.2%	52.2%	5.3%	28.2%	19.9%	119.3%	3.4%	4.0%	2.8%	7.9%	16.6%		3.6%		44.3%	1.5%	4.2%	5.5%	3.6%	8.3%

Figure 13: the map reports the average share of Other Wooded Land estimated at country level using information reported from EFA, FRA 2020, SoEF 2020 and other national data sources.



3.2.1 Gap-filling approach

Starting form this premise, a geospatial analysis of the data reported from different data sources can highlight that (see Figure 14):

1. In Mediterranean countries, due to the specific climatic conditions, forested areas which fulfill the minimum tree cover and height's thresholds, coexist with sparce, low density trees (Scarascia Mugnozza et al., 2000). These areas, including shrubs like the 'macchia' and the 'garrigue', are generally classified as "Other Wooded Lands", and determine a higher share of OWL compared with the typical forest area. This is the case of Portugal, Spain, Malta, Greece and Cyprus where the share of OWL is always > 20%. Italy, due to the particular geographical pattern, also including Alpine and Continental climatic regions, reports, at national level, a relatively lower share (between 10% and 20%), however, the specific data reported at regional level, clearly highlight an higher share on the Mediterranean regions[15] (Gasparini et al., 2022). At the same way, even if including various climatic regions, we may also add Croatia to this group of countries, due to the characteristics of the Mediterranean and sub-Mediterranean maquies and shrubs, typical of this country (Croatia, 2018)

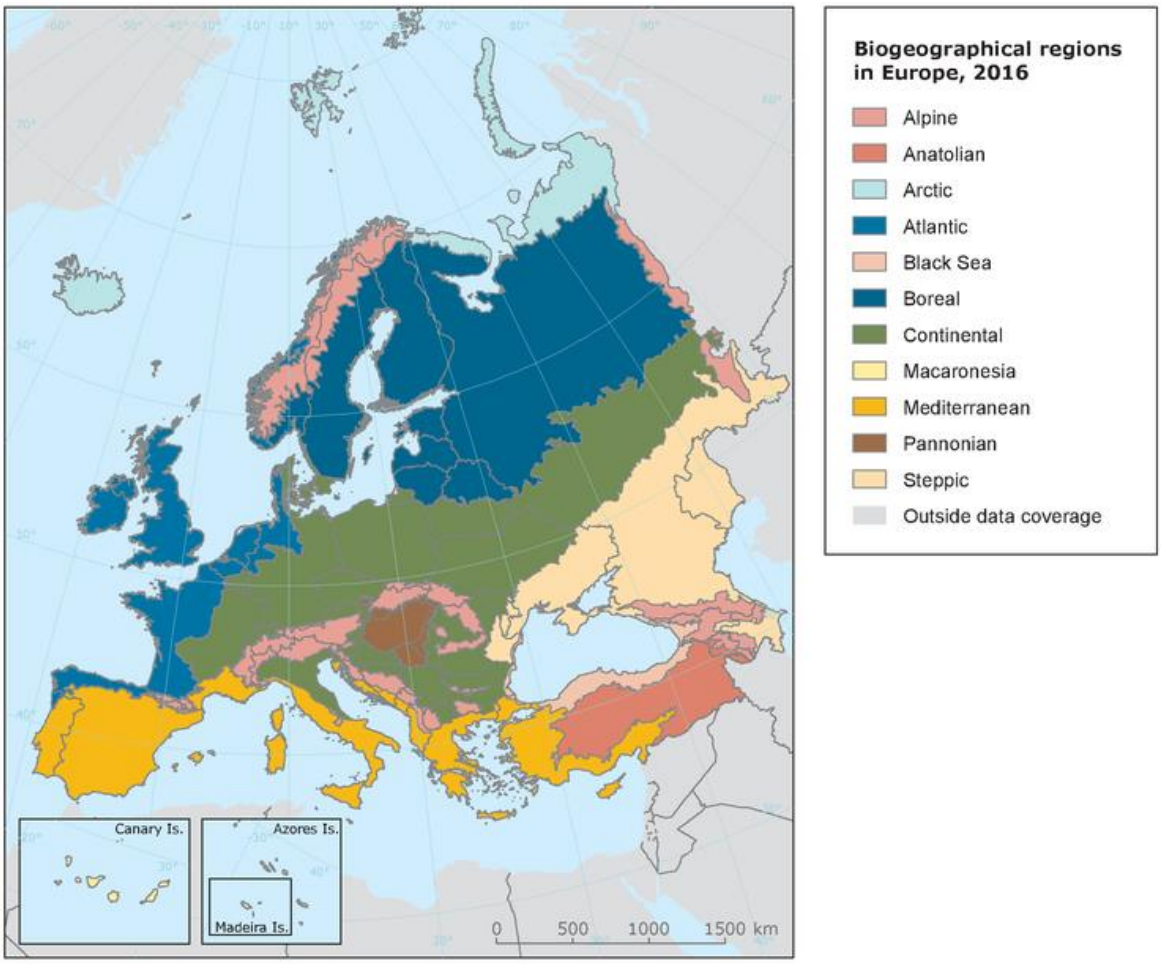
2. Continental and Alpine European regions, including, from one side Belgium, most of France and Luxembourg, and from the other side, Austria, Czech Republic, Slovakia and Slovenia report a lower share of OWL, ranging between 3% and 5%[16]. Here, climatic conditions, support both a full tree cover development – mostly based on coniferous spices for Alpine regions - and a more intensive use of agricultural lands. For these reasons, marginal lands, where the minimum forests' thresholds are not

[15] For example, according to the latest Italian NFI, in Sardinia and Sicily the share of OWL is equal, respectively, to 107% and 35% of the forest land reported at regional level (Gasparini et al., 2022).
[16] Luxembourg reports an average share of OWL equal to 2.8%.

fully satisfied, are quite limited. Within this group of countries, we may also include Hungary and Romania, which report, respectively, a slightly higher (7.9%) and lower (1.5%) share of OWL. Both these countries, however, also include different biogeographical regions (such as the Pannonian one).

3. Ireland, Denmark, Sweden and Estonia, where Atlantic and Boreal climatic conditions may limit forest development, report an average share of OWL between 5% and 10%, generally higher than the one reported on temperate regions. Within the same group we may also include Finland and other Baltic countries, even if reporting a lower share of OWL. Indeed, in some cases, this may be due to specific definitions of OWL considered at national level (see Annex 2).

Figure 14: biogeographical regions in Europe, as reported from EEA, 2017. URL: https://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-2



Taking into account this geographical pattern – probably consistent also with the "agricultural landscape" and related land use management practices -, we may also attribute a theoretical share of Other Wooded Lands to the three remaining countries - the Netherlands, Germany and Poland - which do not report any information on this category. Since all these countries fall within the Continental biogeographical region, we may assume that the share of OWL is in line with the one reported from conterminous countries, ranging between 3% and 5%. The same approach could also be use to fill the gaps of other Member States which do not report information on OWL on the table *for_area_efa.*

4 Discussions and conclusions

Because of their multifunctional services, forest spaces landscape, and their conterminous other wooded lands, play a key role within EU 27 from a climatic, economic, natural and social perspective (Pilli and Pase, 2018). A complete and realistic assessment of the extension of this area and of the resources here available, is therefore essential for preserving and enforcing these services.

The first objective of the present study, corresponding to subtask 2i of the AA LAFOWA, was to fill the gaps on the various components of the growing stock's balance assessed within the EFA table A2a, due to missing data from some Member States. At this purpose, applying the same approach used within the previous AA LAFO, and updating to 2020 the estimates provided from a specific forest growth model, calibrated on the latest harvest rates reported from official statistics, we estimated, for each country, all the main components of the growing stock balance as reported within the table A2a. This exercise, from one side provided a complete set of data for the entire period 2000 - 2020 for 14 out of 27 Member States which did not report any information on this table. From the other side, we also partially filled the data series of the other Member States - when missing - and further compared and update various data sources reporting information on growing stock, increment and harvest. In this sense, this task aims to complement and update the analysis provided within the AA LAFO, increasing the transparency and completeness of public available data (see Pilli and Grassi 2021).

The second objective of the task 2 focused on the analysis of various data sources reporting information on the area covered from forest and other wooded land. A systematic comparison between the definition of forest land as considered, from one side, from FAO and other international institutions and, from the other side, from National Forest Inventories, highlighted that, in most cases, the definitions considered at EU Member State level are consistent with the international one, above all within the most recent NFI. In some cases, however, when assessing the diachronic evolution of the forest area reported at country level, the use of different minimum thresholds between various surveys may determine some inconsistency. Since NFI are generally used as the main data sources for reporting the forest area to international institutions, the area reported from NFI is generally well in line with the one reported from FRA 2020 and SoEF, both at EU and at country level. On the opposite, in some cases, the area reported to UNFCCC may slightly diverge from other data sources. This is, for example, the case of Croatia, which also considers as forest land, within the IPCC reporting, 440 kha covered from maquies and shrubs (otherwise classified as OWL, see Croatia, 2018). Portugal includes as forests, under the IPCC, agri-forest systems where the tree cover exceeded 10% (Portugal, 2020). Finally Spain considers, under IPCC, a minimum tree cover of 20% (instead of 10%) and a minimum area equal to 1 ha (Spain, 2021).

These differences are mostly due to different definitions used, at country level, for reporting the forest area to various institutions. The primary data source, however, is generally always given from the NFI surveys - or in some cases, such as Czech Republic and Croatia, from Forest Management Plans - based on direct field measurements, performed on permanent or semi-permanent plots, eventually integrated from a preliminary screening based on a remote sensing assessment of the forest area (Tompoo et al., 2010). The main advantage of this approach is an accurate assessment of the forest area at national level, but this may not exclude possible inconsistencies when comparing the data reported from various countries. This is also due to the fact that NFI are typically discontinuous measurements of the state of forests, not aligned in time between various countries and performed every 5 (or more) years. While some countries, such as Sweden or Finland, have a consolidated, continuous NFI cycle providing a regular monitoring system of the evolution of the forest area, other countries, such as Italy, Germany or Greece, have a discontinuous monitoring system, with NFI cycles performed every 10 or more years.

To partially overcome these limits, since 2006 EUROSTAT promoted an harmonized assessment of land use and land cover across EU countries through a standardized approach based on a two phases survey (d'Andrimont et al., 2021). In the first phase, a frame of more than 1 million geo-referenced points is systematically selected and stratified from a 2 square km grid built all over the EU territory. In the second phase, a sub-sample of these points is assessed through direct field surveys or photo interpretation (Ballin et al., 2018). Analyzing these data, as reported from table LAN_LCV_OVW made available from EUROSTAT for 2009, 2012, 2015 and 2018, we highlighted that the area estimated from LUCAS data is generally not consistent with other data sources. Also the 2018 assessment, LUCAS Copernicus, explicitly distinguishing wooded lands from shrub lands, generally overestimated the forest area both at country and at EU level. Even if theoretically consistent with FAO parameters, since the definition of

woodland considered in LUCAS is based on the canopy cover observed at 20 m around the LUCAS point, the total wooded land assessed by this survey may diverge from the one reported from other data sources. Despite these differences, this data source, such as other remote sensing assessments of the forest area, can be useful to complement specific scientific studies[17] providing an harmonized assessment of the forest area at EU level. However, these data sources, if not properly combined with direct field measurements (i.e NFIs), cannot be directly use for analysing the evolution of the forest area or the forest land use change at country or at EU level. Indeed, due to the evolution of remote sensing tools, the absolute and relative accuracy of these data varies in time and need to be further assessed (see for example Ceccherini et al., 2022)[18]. This is also quite evident from the analysis of the data series named C3LSC. Here, while the data referred to 2020 are quite in line with other data sources, the overall trend shows a constant forest area, which is not consistent with the data collected at country level. To overcome these limits, often due to the technical evolution of remote sensing observation systems, the JRC promoted a specific assessment, integrating various data collected from remote sensing with direct information reported from countries' NFI. The forest area estimated from this study, such as the FAWS, specifically referred to 2020, is, from one side, well in line with other data sources made available at national and international level (i.e. SoEF 2020) and, from the other side, successfully integrate the spatial detailed derived from remote sensing data (for further information see Avitabile et al., 2023). The added value of this approach is the integration of remote sensing observations of tree cover with systematic ground observations from NFI, which represent the two major sources of information to assess the forest area at country level (see Ceccherini et al., 2022).

While the definition of forest land is generally consistent between EU Member States, various studies highlighted that the concept of forest area available for wood supply - as a sub-category of the total forest area - is based on different legal, environmental and/or economic parameters varying at country level (Alberdi et al., 2016 and 2020). For this reason, the data reported from various countries, if not properly harmonized, are not fully comparable (Avitabile et al., 2020).

Similar differences can be also highlighted for the definition of OWL applied at country level. In some cases, this definition may considerably diverge from the international definition proposed from FAO. Moreover, three EU Member States do not report any definition or data concerning this category. These data, however, when missing, could be inferred from the corresponding biogeographical area. Indeed, at country level, the average share of other wooded land compared to the area reported as forest land, shows a quite clear pattern, linked to the main biogeographical conditions. The same approach could be used also to fill the gaps within the table *for_area_efa*, where actually most of the countries do not report any information on OWL.

[17] See for example, Lugato et al., 2017

[18] Assessing the uncertainty of LUCAS surveys is out of the scope of the present report. For further details on LUCAS we refer to https://ec.europa.eu/eurostat/web/lucas (November 2022)

References

Alberdi, I., Bender, S., Riedel, T., Avitable, V., Boriaud, O., Bosela, M., ... & Hernández, L. (2020). Assessing forest availability for wood supply in Europe. Forest policy and economics, 111, 102032.

Alberdi, I., Michalak, R., Fischer, C., Gasparini, P., Brändli, U. B., Tomter, S. M., ... & Vidal, C. (2016). Towards harmonized assessment of European forest availability for wood supply in Europe. Forest Policy and Economics, 70, 20-29.

Avitabile V., Pilli R., Camia A. (2020). *The biomass of European forests*, EUR 30462 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-26100-1, doi:10.2760/758855, JRC122635.

Avitabile V., Pilli R., Migliavacca M., Camia A., Mubareka, S. (2023). Forest Biomass Production. In Mubareka, Migliavacca and Sanchez Lopez (eds) Biomass production, supply, uses and flows in the European Union. Publications Office of the European Union, Luxembourg, 2023

Avitabile, V., & Camia, A. (2018). An assessment of forest biomass maps in Europe using harmonized national statistics and inventory plots. Forest ecology and management, 409, 489-498.

Ballin, M., Barcaroli, G., Masselli, M., Scarnò, M. (2018). Redesign sample for Land Use/Cover Area frame Survey (LUCAS) 2018. EUROSTAT, Statistical Working Papers, doi: 10.2785/132365

Buck, O., Haub, C., Woditsch, S., et al., (2015). Task 1.9 -Analysis of the LUCAS nomenclature and proposal for adaptation of the nomenclature in view of its use by the Copernicus land monitoring services. European Environment Agency, Copenhagen.

Ceccherini, G., Duveiller, G., Grassi, G., Lemoine, G., Avitabile, V., Pilli, R., & Cescatti, A. (2022). Potentials and limitations of NFIs and remote sensing in the assessment of harvest rates: a reply to Breidenbach et al. *Annals of Forest Science*, *79*(1), 1-7.

Ceccherini, G., Duveiller, G., Grassi, G., Lemoine, G., Avitabile, V., Pilli, R., & Cescatti, A. (2021). Reply to Wernick, IK et al.; Palahí, M. et al. *Nature*, *592*(7856), E18-E23.

Chazdon, R. L., Brancalion, P. H., Laestadius, L., Bennett-Curry, A., Buckingham, K., Kumar, C., ... & Wilson, S. J. (2016). When is a forest a forest? Forest concepts and definitions in the era of forest and landscape restoration. *Ambio*, *45*(5), 538-550.

CRF, Common Reporting Format table, Submission 2022. URL (November 2022): https://unfccc.int/ghg-inventories-annex-i-parties/2022

Croatia (2018). National Forestry Accounting Plan for the Republic of Croatia. Republic of Croatia. Ministry of Environment and Energy. Ministry of Agriculture, Zagreb, 2018.

C3S (2021). Product User Guide and Specification- ICDR Land Cover 2016-2020. Copernicus Climate Change Service

d'Andrimont, R., Verhegghen, A., Meroni, M., Lemoine, G., Strobl, P., Eiselt, B., ... & van der Velde, M. (2021). LUCAS Copernicus 2018: Earth Observation relevant in-situ data on land cover throughout the European Union. Earth System Science Data Discussions, 2020, 1-19.

De Laurentiis, V. and Sala, S. (2022). Land Footprint Estimates, European Commission, 2021, JRC128115. URL (November 2022): http://data.jrc.ec.europa.eu/collection/id-00357

FAO (1949). Yearbook of Forest Products Statistics. Annuaire statistique des produits forestiers.. 1948. Food and Agricolture Organization of the United Nations, Washington D.C. (USA), 205 pp

FAO (1960). World Forest Inventory. Inventaire Forestier Mondial. Inventario Forestal Mundial. 1958. Food and Agricolture Organization of the United Nations, Rome (Italy), 137 pp.

FAO (1963). World Forest Inventory. Inventaire Forestier Mondial. Inventario Forestal Mundial. Unasylva - Vol. 2, No. 4

FAO (1995). Forest Resources Assessment 1990. Global Synthesis. FAO Forestry Paper 124, Rome (Italy), Available at (November 2022): https://www.fao.org/3/v5695e/V5695E00.htm

FAO (2000). Global Forest Resources Assessment 2000. Main Report. FAO Forestry Paper 140, Rome (Italy), Available at (November 2022): https://www.fao.org/3/Y1997E/y1997e00.htm#Contents

Forest Europe (2015). Relevant terms and definitions used for the improved Pan-European indicators for sustainable forest management. URL (November 2022): https://foresteurope.org/wp-content/uploads/2017/02/3AG_UPI_Updated_Terms_Definitions.pdf

Forest Europe (2015). State of Europe's Forests 2015. URL: https://foresteurope.org/state-europes-forests-2015-report/

Forest Europe (2020). State of Europe's Forests 2020. URL (November 2022): https://foresteurope.org/wp-content/uploads/2016/08/SoEF_2020.pdf

Gasparini, P., Di Cosmo, L., Floris, A., & De Laurentis, D. (2022). Italian National Forest Inventory—Methods and Results of the Third Survey. Springer Cham, https://doi.org/10.1007/978-3-030-98678-0

Gschwantner, T., Riedel, T., Henning, L., Adolt, L., Di Cosmo, L., Freudenschuss, A., Gasparini, P., Kohn, I., Kučera, M., Marin, G., Máslo, J., Mionskowski, M., Neagu, S., Nilsson, M., Pesty, B., Pikula, T., Schadauer, K., Sroga, R., Talarczyk, A., Westerlund, B. (2022). Final Report. Specific Contract no. 21. Use of National Forest Inventories data to harmonise and improve the current knowledge on forest increment in Europe. In the context of the: Framework contract for the provision of forest data and services in support to the JRC activities and applications on forest resources". Contract Number 934340. JRC, ENFIN, May 2022.

Global Forest Resource Assessment – Country Reports (2020). URL: http://www.fao.org/forest-resources-assessment/fra-2020/country-reports/en/

Grassi, G., Pilli, R., House, J., Federici, S., & Kurz, W. A. (2018). Science-based approach for credible accounting of mitigation in managed forests. Carbon balance and management, 13(1), 1-16. URL: https://cbmjournal.biomedcentral.com/articles/10.1186/s13021-018-0096-2

Gschwantner, T., Alberdi, I., Balázs, A., Bauwens, S., Bender, S., Borota, D., ... & Freudenschuß, A. (2019). Harmonisation of stem volume estimates in European National Forest Inventories. Annals of forest science, 76(1), 24. https://doi.org/10.1007/s13595-019-0800-8

JFSQ (2020). Joint Forest Sector Questionnaire Definitions. EC DG Eurostat, FAO, ITTO, UNECE. URL (December 2022): https://unece.org/forestry-timber/documents/2021/04/informal-documents/jfsq-2020-definitions

Korosuo, A., Vizzarri, M., Pilli, R., Fiorese, G., Colditz, R., Abad Viñas, R., Rossi, S. and Grassi, G. (2021). Forest reference levels under Regulation (EU) 2018/841 for the period 2021-2025, EUR 30403 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-32258-0, doi:10.2760/0521, JRC121803 URL: (November 2022): https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/forest-reference-levels-under-regulation-eu-2018841-period-2021-2025

Loetsch, F. & Haller, K.E. (1973). Forest Inventory, Volume 1 Statistics of Forest Inventory and Information from Aerial Photographs. Second Edition, BLV Verlagsgesellschaft München Bern Wien, pp. 1-17.

Lugato, E., Paniagua, L., Jones, A., de Vries, W., & Leip, A. (2017). Complementing the topsoil information of the Land Use/Land Cover Area Frame Survey (LUCAS) with modelled N2O emissions. *PloS one*, *12*(4), e0176111.

Pilli, R., & Pase, A. (2018). Forest functions and space: a geohistorical perspective of European forests. *iForest-Biogeosciences and Forestry*, *11*(1), 79.

Pilli, R., Grassi, G. (2021). Provision of technical and scientific support to DG ESTAT in relation to EU land footprint estimates and gap-filling techniques for European forest accounts (LAFO), EUR 30581 EN, Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-29684-3, doi:10.2760/73306, JRC123404

Portugal (2020). National Forestry Accounting Plan Portugal 2021-2025. Agência Portuguesa do Ambiente. Republica Portuguesa.

Sachs, J. D. (2012). From millennium development goals to sustainable development goals. *Lancet*, *379*(9832), 2206–2211.

Scarascia-Mugnozza, G., Oswald, H., Piussi, P., & Radoglou, K. (2000). Forests of the Mediterranean region: gaps in knowledge and research needs. *Forest Ecology and management*, *132*(1), 97-109.

Spain (2021). Informe de Inventario Nacional Gases de Efecto Invernadero. Edición 2021 (1990-2019) España, Marzo 2021.

Tomppo, E., Gschwantner, T., Lawrence, M., McRoberts, R. E., Gabler, K., Schadauer, K., ... & Cienciala, E. (2010). National forest inventories. *Pathways for Common Reporting. European Science Foundation*, *1*, 541-553.

UN, UNFCCC (2006). Report of the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol on its first session, held at Montreal from 28 November to 10 December 2005. Addendum: Part Two: Action taken by the Conference of the Parties serving as the meeting of the Parties to the Kyoto Protocol at its first session. FCCC/KP/CMP/2005/8/Add.3, 2006

UNECE/FAO, 2001. Global Forest Resources Assessment (2000). Main report. FAO Forestry Paper 140. FAO, Rome, Italy (479 p).

Vidal, C., Alberdi, I., Redmond, J., Vestman, M., Lanz, A., & Schadauer, K. (2016). The role of European National Forest Inventories for international forestry reporting. *Annals of Forest Science*, *73*(4), 793-806

List of abbreviations and definitions

BI→ Balancing item

C3LSC → Forest Land from the ESA CCI/Copernicus Climate Change Service

CBM → Carbon Budget Model

CF → Correction factor

CLC → Corine Land Cover

CS → Closing stock

DOM → Dead Organic Matter

EFA → European Forest Account system

FAWS → Forest available for wood supply

FNAWS → Forest not available for wood supply

FRA → Forest Resource Assessment

GS → Growing stock

IL → Irretrievable losses

JFSQ → Joint Forest Sector Questionnaire Definitions

LUCAS → Land Use and Coverage Area frame Survey

NAI → Net annual increment

NFAP → National Forestry Accounting Plan

NFI → National Forest Inventory

o.b. → over bark

OS → Opening stock

OWL → Other Wooded Land

REM → Removals

SoEF → State of Europe's Forests

SRC → Statistical reclassification

u.b. → under bark

UNFCCC → United Nations Framewok Convention on Climate Change

List of figures

List of tables

Supplementary Materials and Annexes

Supplementary Material 1. Worksheet *EFA_JRC_Stock_Balance_2022*

This excel worksheet includes:

- a first part focusing on the comparison between different data sources, further distinguished between forest area (sheet *Area_Comp*), growing stock (sheet *Growing_Stock_Comp*), harvest (sheet *Harvest_Comparison*) and increment (sheet *NAI_Comparison*)
- a second section includes 26 sheets reporting, for each Member States (excluding Malta) the main parameters needed to apply the gap-filling approach as described above

Both these sections are preceded by further details reported on specific sheets.

Supplementary Material 2. *Country_stock_balance_2022*

Twenty-seven worksheets, one for each Member States (excluding Malta), reporting the detailed application of the gap-filling approach from 2000 to 2020. Further details are reported on each specific sheet.

Supplementary Material 3. EFA_JRC_Area_Analysis_2022

This worksheet includes, for each Member State, a collection of various data sources reporting data on the forest area, the forest area available for wood supply and the area of Other Wooded Land. All data are further compared, at country and at EU level, within a specific sheet named Area_*Comparison*.

All these worksheets are publically available on the Joint Research Centre Data Catalogue at the following URL https://data.jrc.ec.europa.eu/dataset?collection=CBM

Annex 1. Country-specific notes on the values estimated by JRC for gap-fill table A2a

Please note that the following comments are specifically referred to the estimates provided within the present report, and they do not refer to the values directly provided by countries. In general, for all countries, as highlighted on section 2.2, we recall that, due to the lack of specific data on FNAWS, REM were fully allocated to FAWS and NAI was estimated as absolute difference between Opening stock and Closing stock. Both these last parameters were estimated as relative share of total GS attributed to FAWS and FNAWS according to SoEF data. For this reason, in some cases, both GS and NAI attributed to FNAWS may show interannual variations > ±20%, or, in case of NAI, some negative values (in 19 out of 1639 records). Apart from simple algebraic assumptions, this can be also due to the fact that, according to official statistics reported to SoEF, the relative share of forest area attributed to FAWS/FNAWS may vary in time (i.e. the area classified as FNAWS may decrease). For these reasons, the estimates attributed to FNAWS should be considered as highly uncertain.

Bulgaria:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations.

A balancing item was added in 2005 to align JRC estimates with the data series provided by country.

Czech Republic:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations, mostly due to salvage logging after natural disturbances. In some cases, this may also affect the estimates provided on NAI, which were partially derived from other items.

Denmark:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations. In some cases, this may also affect the estimates provided on NAI, which were partially derived from other items.

A balancing item was added in 2018 to align JRC estimates with the data series provided by country.

Please note that the Opening stock estimated for 2000 is about 10% lower than the GS reported on FRA Country Report.

Germany:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations, mostly due to salvage logging after natural disturbances. In some cases, this may also affect the estimates provided on NAI, which were partially derived from other items.

A balancing item was added in 2013 to align JRC estimates with the data series provided by country

Estonia:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations. In some cases, this may also affect the estimates provided on NAI, which were partially derived from other items.

Ireland:

Please note that in case of Ireland, inter-annual variations on the GS and NAI are also due to the increasing forest area reported by country (increasing, on average, by 1.3%/yr until 2011, and by 0.8%/yr between 2012 and 2020)

A balancing item was added in 2013 to align JRC estimates with the data series provided by country

Greece:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations. In some cases, this may also affect the estimates provided on NAI, which were partially derived from other items.

Spain:

Please note that, according to data reported from official statistics, the forest area increases by about +0.8%/yr between 2000 and 2010, and then it is quite constant (+0.01%/yr between 2010 and 2020). This determines a discontinuity on the data series reported for NAI, that is indirectly derived from the other items. For similar reasons, since 2015 onward, the time series estimated for GS is about 15% higher than the GS reported on FRA Country Report.

France:

France directly reports data only for FAWS between 2012 and 2019 (this covers about 95% of the total forest area). All data referred to total forest area and FnAWS within this period were derived from the relative share of opening GS estimated for 2011, for total forest area and FNWAS respectively, in relation to FAWS. Within the same period, removals and irretrievable losses reported for FAWS were only attributed to total forest area. NAI was proportionally distributed to total forest area and FNAWS. A balancing item was also added to total forest area and FnAWS to ensure the consistency of final values within the period 2011-2019.

Please note that the total removals reported from France (referred to FAWS) between the period 2012-2019 are considerably different from the total removals reported from other data sources (i.e. <32%). Within the same period, France reports, on average, about 10 mil m^3 yr^{-1}, as removals attributed to the area classified as OWL, equal to about 0.6 mil ha in 2013, according to FRA. This amount, however, seems to be largely overestimated, attributing to the category OWL an average production equal to about 17 m^3 ha^{-1} yr^{-1} - largely higher then the production attributed to FAWS.

Before 2012, due to the lack of specific data on FNAWS, REM were fully allocated to FAWS and NAI was estimated as the absolute difference between Opening stock and Closing stock. Both these last parameters were estimated as relative share of the total GS attributed to FAWS and FNAWS according to SoEF. For this reason, the NAI attributed to FNAWS and FAWS may show interannual variations > ±20% and both the GS and NAI show a clear stepping-point in 2012.

Croatia:

A balancing item was added in 2013 to align JRC estimates with the data series provided by country.

Italy:

Please note that due to some discrepancies on the total removals reported from different data sources, in some cases, removals have strong (i.e. > ±20%) interannual variations.This may also affect the estimates provided on NAI, which were partially derived from other items

Cyprus:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations. In some cases, this may also affect the estimates provided on NAI, which were partially derived from other items.

A balancing item was added in 2005 to align JRC estimates with the data series provided by country.

Latvia:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations. In some cases, this may also affect the estimates provided on NAI, which were partially derived from other items.

Lithuania:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations. In some cases, this may also affect the estimates provided on NAI, which were partially derived from other items

A balancing item was added in 2013 to align JRC estimates with the data series provided by country.

Lithuania directly reports data for GS between 2014 and 2016, but only reports NAI and removals for 2014. The missing items for 2015 and 2016 are reported as statistical reclassifications (therefore no further value was added to NAI, REM and IL). For the period 2017-2020, the share of GS between FAWS and FNAWS was estimated according to the share reported by country for 2016.

Luxembourg:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations. In some cases, this may also affect the estimates provided on NAI, which were partially derived from other items.

A balancing item was added in 2009 to align JRC estimates with the data series provided by country.

Netherlands:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations. In some cases, this may also affect the estimates provided on NAI, which were partially derived from other items.

NL directly report data between 2016 and 2018, but the country does not report any information on the share of GS and other items between FAWS and FnAWS, therefore these data were estimated according to the share derived by SoEF 2020. This increases the inter-annual variability and the uncertainty of JRC estimates.

A balancing item was added in 2015 to align JRC estimates with the data series provided by country.

Austria:

Please note that, according to data reported from official statistics, the amount of removals in 2009 was considerable different (> ±20%) then the removals reported on the previous year. This is mostly due to the effect of salvage logging after natural disturbance events.

Poland:

Please note that the GS reported by FRA Country Report for 2000 is considerably lower (<37%) than the GS reported in 2010. As a consequence, the GS estimated by JRC for 2000 is not aligned (i.e. Δ=11.9%) with the value reported on FRA Country Report for PL.

A balancing item was added in 2013 to align JRC estimates with the data series provided by country.

Portugal:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations. In some cases, this may also affect the estimates provided on NAI, which were partially derived from other items.

Romania:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations. In some cases, this may also affect the estimates provided on NAI, which were partially derived from other items.

Please note that the GS reported by FRA Country Report for 2015 is considerably higher than the GS reported in 2000 (+65%) and 2010 (+61%). As a consequence, the GS estimated by JRC between 2000 and 2010 is not aligned with the values reported by FRA Country Report.

Slovenia:

A balancing item was added in 2011 to align JRC estimates with the data series provided by country

Slovakia:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations, probably due to salvage logging after natural disturbances. This may also affect the estimates provided on NAI, which were partially derived from other items.

A balancing item was added in 2013 to align JRC estimates with the data series provided by country

Finland:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations. In some cases, this may also affect the estimates provided on NAI, which were partially derived from other items.

Sweden:

Please note that, according to data reported from official statistics, in some cases, removals have strong (i.e. > ±20%) interannual variations. In some cases, this may also affect the estimates provided on NAI, which were partially derived from other items.

Annex 2. Detailed definition of Forest and Other Wooded Lands as considered by countries

Belgium

Source: Rondeux J., Sanchez C., Latte N. National Forest Inventory Reports- Chapter 2. Belgium (Walloon Region). In Tompoo et al., (eds). National Forest Inventories, 2010.

Forest: for Walloon region, it is defined as a forested area of at least 0.10 ha, with a minimum 10% of crown cover and a minimum height of trees of 5 m

Other Wooded Land: n.d.

Bulgaria

Source: Stoeva L., Markoff I., Zhiyanski M. National Forestry Accounting Plan of Bulgaria, including Forest Reference Levels for the period 2021-2025. Republic of Bulgaria, Ministry of Environment and water

Forest: according to the Bulgarian Forest Act (last amendment 18.12.2015, SG №100), forests are defined as "Area over 0.1 ha, covered with forest tree species higher than 5 meters and tree crown cover over 10% or with trees which can reach these parameters in natural environment". Areas of natural forest regeneration outside urban areas with a size of more than 0.1 ha also represent "forest". City parks with trees, forest shelter belts, and single row trees do not fall under the category "forests. Forests also include:

- area which is in a process of recovering and is still under the parameters, but it is expected to reach forest crown cover over 10% and tree height 5 meters
- area, 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.

Other Wooded Land: n.a.

Czech Republic

Source: Kučera M., Adot, R.. eds. Národní inventarizace lesu v Ceské republice – výsledky druhého cyklu 2011–2015 [online]. Vydání první. Brandýs nad Labem: Ústav pro hospodárskou úpravu lesu Brandýs nad Labem, 2019 [cit. datum citování]. ISBN 978-80-88184-24-9. Dostupné z: http://nil.uhul.cz/downloads/kniha_nil2_web.pdf

Forest: represent plots of land with an area of more than 0.5 ha with a total canopy of trees reaching 10% and with a height of at least 5 m. The category does not include stands with a width of less than 20 m (linear stands) and stands or plots of land with predominantly agricultural or urban use. Furthermore, the forest category does not include water bodies (tuns, ponds, etc.) with an area of exceeding 400 m^2, streams and bodies of water of a linear character (blind river arms, etc.) with a width riverbed exceeding 8 m and paved roads (asphalt, concrete, stone, etc.) with a width of strip crossing 4 m. However, the forest category includes land that is only temporarily deforested (bare cuttings, disaster clearings, areas after preparation of soil for restoration, fire areas, etc.), i.e. grounds, for which there is an assumption of future achievement of the required 10% tree canopy with a minimum 5 m high.

Other Wooded Land: includes land outside the forest category, with an area exceeding 0.5 ha and for which at least one of the conditions applies: 1) the canopy of a tree with a height of at least 5 m does not reach 10%, but it does at least 5%, 2) tree canopy with a height of at least 5 m does not reach 5%, whereby the sum of the tree canopy (height of at least 5 m, trees may not be present at all) and a bush with a height of at least 0.5 m reaches at least 10%. The OWL category also does not include water bodies (tunes, ponds, etc.) with an area exceeding 400 m^2, streams and water bodies of a linear character (blind river arms, etc.) with a bed width exceeding 8 m and paved roads (asphalt, concrete, stone, etc.) with a lane width exceeding 4 m. This category excludes stands with a width of less than 20 m (linear stands) and plots of land or stands with predominantly agricultural or urban use. Fulfillment

of the height and canopy parameters of the stand is required at the time of saving (difference to access in the forest category).

Denmark

Source: Nord-Larsen, T., Johannsen, V. K., Riis-Nielsen, T., Thomsen, I. M., Bentsen, N. S., Gundersen, P., & Jørgensen, B. B. (2018). Skove og plantager 2017: Forest statistics 2017. Institut for Geovidenskab og Naturforvaltning, Københavns Universitet[19]

Forest: area larger than 0.5 hectares, wider than 20 meters with trees taller than 5 meters and having a crown cover of more than 10 per cent. or with trees potentially capable of reaching these values at the site of growth. The definition includes temporarily unvegetated areas and auxiliary areas necessary for forestry, but not areas dominated by agricultural or urban use, including summer house areas. Other wooded area:

Other Wooded Land: areas with the same area requirements as for the forest definition, but with a crown cover of 5-10% of trees taller than 5 meters or trees which, at the place of growth, are potentially capable of reaching these values; or areas with a crown cover greater than 10 per cent. of tree or shrub species that are not able to reach a height of more than 5 meters in the place of growth.

Germany

Source: Federal Ministry of Food and Agriculture – Third National Forest Inventory, Terminology. URL: https://www.bundeswaldinventur.de/en/service/terminology

Forest: The definition of forest according to the National Forest Inventory is based on that of the Federal Forest Act (Federal Ministry of Food, Agriculture and Consumer Protection: Survey instructions for the Third National Forest Inventory (2011–2012). 2nd revised version, May 2011). Within the meaning of the NFI, forest is any area of ground covered by forest vegetation, irrespective of the information in the cadastral survey or similar records. The term 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 recreational 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. Areas with forest cover in open pastureland or in built-up areas of under 1,000 square metres, coppices under 10 metres wide and the cultivation of Christmas trees and ornamental brushwood as well as parkland attached to country houses are not forest within the meaning of the NFI. Watercourses up to 5 metres wide do not break the continuity of a forest area.

Other Wooded Land: n.a.

Estonia

Source: Estonia. National Forest Accounting Plan 2021 – 2025[20].

Adermann V.. National Forest Inventory Reports- Chapter 10. Estonia. In Tompoo et al., (eds). National Forest Inventories, 2010.

Forest: the Estonian Forest Act distinguishes forest and forest land. Forest is an ecosystem that consists of forest land that is covered by vegetation and where living fauna is present. Forest land on the other hand, is defined as land that meets at least one of the following requirements:

- is registered in land cadastre as forest land;

19 As made available from: https://forest.eea.europa.eu/datacatalogue?source=%7B%22track_total_hits%22%3Atrue%2C%22query%22%3A%7B%22bool%22%3A%7B%22must%22%3A%5B%7B%22term%22%3A%7B%22COUNTRY%22%3A%22Denmark%22%7D%7D%5D%7D%7D%2C%22display_type%22%3A%22list%22%2C%22size%22%3A50%2C%22sort%22%3A%5B%7B%22YEAR_PUBLISHED%22%3A%7B%22order%22%3A%22desc%22%7D%7D%5D%2C%22highlight%22%3A%7B%22fields%22%3A%7B%22*%22%3A%7B%7D%7D%7D%7D

20 Ancillary information are also reported at https://andmed.stat.ee/en/stat/keskkond__loodusvarad-ja-nende-kasutamine__metsavaru

- has an area of 0.1 hectares, growing woody plants with a minimum height of 1.3 meters and a minimum tree crown cover of at least 30%.

Since 2005, the data measured and recorded by the NFI includes land that satisfies the UNECE/FAO and FRA 2005 definition for forest land, even if this area is not necessarily qualify as forest land according to the Estonian Forest Act. In this case forest is defined as a minimum area of 0.5 ha and 10% crown cover, with minimum height of trees of 5 m at maturity in situ (including temporary unstocked areas).

Other Wooded Land: area min 0.5 ha and 5–10% crown cover with minimum height of trees of 5 m at maturity in situ or the combined cover of shrubs and trees >10% (reference definition applied in parallel with national definition of land use classes since 2006).

Ireland

Source: Department of Agriculture, Food & the Marine. Forest Statistics. Ireland 2020.

O'Donovan C, Redmond J. National Forest Inventory Reports- Chapter 18. Ireland. In Tompoo et al., (eds). National Forest Inventories, 2010.

Forest: The National Forest Inventory defines forests as land with a minimum area of 0.1 ha under stands of trees 5 m or higher, having a minimum width of 20 m and a canopy cover of 20% or more within the forest boundary; or trees able to reach these thresholds in situ. The forest definition relates to land use rather than land cover, with the result that open space within a forest boundary either permanently or temporarily unstocked with trees, along with felled areas that are awaiting regeneration, are included as forest.

Other Wooded Land: groups of trees that do not meet the criteria of the forest definition, as defined from photo-interpretation, not verified in the field.

Greece

Source: Ministry of Environment & Energy/ National Centre for the Environment and Sustainable Development, with the contribution of YLORIKI Co. National Forest Accounting Plan of Greece.

Meliadis I., Zagkas T., Tsitsoni T., National Forest Inventory Reports- Chapter 15. Greece. In Tompoo et al., (eds). National Forest Inventories, 2010.

Forest: is defined according to the following thresholds:

- *25% minimum tree crown.*
- *0.3 hectares minimum land area.*
- *2 meters tree height, or the potential to achieve it.*

Other Wooded Land: land which has some forest characteristics but is not forest as defined above. It includes open woodland and shrub, shrub and brushland, whether or not used for pasture or range

Spain

Source: Ministry of Environment. Secretariat-general for the environment. Directorate-general for nature conservation. Spanish Forest Strategy 1998

Alberdi I., et al., National Forest Inventory Reports- Chapter 34. Spain. In Tompoo et al., (eds). National Forest Inventories, 2010.

Gschwantner et al., 2021 Use of National Forest Inventories data to harmonise and improve the current knowledge on forest increment in Europe – Final Report. Specific Contract n. 20. JRC, ENFIN

Forest: according to the Forest Land Act of 8 June 1957 forest land is understood to mean land on which species of tree, thicket, grasses or scrub (matorral) grow, whether spontaneously or as a result of sowing or planting, provided they are not characteristic agricultural species or have been subject to agriculture. This definition of forest land is, however, not univocal as some regional governments have defined it differently. Within the NFI, forest is defined according to the following thresholds:

- *10% minimum tree crown.*
- *0.5 hectares of minimum land area or 20 m of minimum width.*
- *3 meters tree height, or the potential to achieve it.*

Other Wooded Land: includes open and dense forest stands, areas covered by shrubs and/or herbaceous vegetation and open spaces with little or no vegetation and crown cover <5%.

France

Source: National Forestry Accounting Plan of France including the Forest Reference Level (FRL) for the 2021-2025 and 2026-2030 periods. English version, December 2019, amended in June 2020.

Robert N., et al., National Forest Inventory Reports- Chapter 12. France. In Tompoo et al., (eds). National Forest Inventories, 2010.

Forest: A forest may consist either of closed forest stands where trees of various storeys and undergrowth cover a high proportion of the ground, or open forest stands. Young natural stands and all plantations comprising woody species that are likely to reach 5 metres in height on maturity but whose crown does not yet cover 10% of the area are included in the "Forest" category. Similarly, areas that are normally part of forest land but have been temporarily cleared because of human intervention or natural causes and which are expected to become forest again within 5 years of clearing are also included in the "Forest" category. However, trees stands that meet the defined thresholds but are not mainly used for forestry (orchards, urban parks, gardens, etc.) are excluded from the "Forest" category.

Other Wooded Land: a definition for Other Wooded Land similar to the Temperate and Boreal Forest Resources Assessments or COST Action E43 is not available. However, some additional data, used for FAO reporting, are available for computing an estimate of these wooded lands:

- Tiny woods: stands wider than 20 m, with an area greater than 0.05 ha but less than 0.5 ha, and a crown cover by forest trees greater than 10%
- Heath: non-cultivated vegetation with width greater than 20 m, area greater than 0.05 ha, and crown cover by forest trees less than 10%

Croatia

Source: Vedriš M., Čavlovič J., Božič M. National Forest Inventory Reports- Chapter 6. Croatia. In Tompoo et al., (eds). National Forest Inventories, 2010.

Republic of Croatia. Ministry of Environment and Energy. Ministry of Agriculture. National Forestry Accounting Plan for the Republic of Croatia. 2019

Forest: According to Regulation (Annex II) in Croatia for category Managed forests definition is as follows: forest land spanning more than 0.1 hectares with trees higher than 2 meters and canopy cover more than 10 percent, or trees able to reach these thresholds.

Other Wooded Land: according to Vedriš et al. (2010), within the NFI, there is no category that matches the category 'Other wooded land' as defined by FRA.

Italy

Source: Gasparini P., Tosi V., Di Cosmo L.. National Forest Inventory Reports- Chapter 19. Italy. In Tompoo et al., (eds). National Forest Inventories, 2010.

Forest: 0.5 ha of minimum area and at least 10% crown cover, with minimum height of trees of 5 m at maturity in situ

Other Wooded Land: 0.5 ha of minimum area and 5–10% tree crown cover (minimum height of trees of 5 m at maturity in situ) or at least 10% shrub coverage

Cyprus

Source: Loizou L. National Forest Inventory Reports- Chapter 33. Slovenia. In Tompoo et al., (eds). National Forest Inventories, 2010.

Forest: area spanning more than 0.5 ha with trees higher than 5 m and a crown cover of more than 10%, or trees able to reach these thresholds in situ. Land predominantly under agricultural or urban use area not included.

Other Wooded Land: area spanning more than 0.5 ha with trees higher than 5 m and a crown cover of 5–10%, or trees able to reach these thresholds in situ or with a combined cover of shrubs, bushes and trees above 10%. Land predominantly under agricultural or urban use not classified as forest.

Latvia

Source: Lazdiņš, A. et al.. Latvia's national forest accounting plan and proposed forest reference level

2021-2025. LSFRI Silava, 2019

Forest: forest is defined according to the following thresholds:

- *20% of minimum basal area at maturity stage.*
- *0.1 hectares of minimum land area or 20 m of minimum width for protective belts and other bands of trees.*
- *5 m of minimum tree height at maturity (or the potential to achieve it).*

Other Wooded Land: n.d.

Lithuania

Source: National Forestry Accounting Plan by Lithuania, 2020

Forest: area of land, covered with trees or temporary without tree cover, with 30 % crown cover and 5 m height at maturity stage in natural site, not smaller than 0.1 ha.

Other Wooded Land: n.d.

Luxembourg

Source: La forêt luxembourgeoise en chiffres. Rêsultats de l'inventaire forestier national au Grand_Duché de Luxembourg 200-2011. Ministere du Developpment durable et Infrastructures. Department de l'Environment. Administration de la Nature et des Forêts. Université de Liege. Gembloux Agro-Bio Tech.

Forest: area of land with a tree cover >10%, spanning at least 0.5 ha, with a minimum height of trees of 5 m at maturity.

Other Wooded Land: area spanning more than 0.5 ha with trees higher than 5 m and a crown cover of 5–10%, or trees able to reach these thresholds in situ or with a combined cover of shrubs and trees above 10%.

Hungary

Source: Kolozs L., Szepesi A. National Forest Inventory Reports- Chapter 16. Hungary. In Tompoo et al., (eds). National Forest Inventories, 2010.

National Forest Accounting Plan of Hungary under regulation (EU) 2018/841, 2019

Hungarian National Forest Inventory website - Glossary of terms. URL: https://nfi.nfk.gov.hu/glossary_of_terms

Forest: according to the Hungarian National Inventory Report (2020), the definition of Forests in Hungary is "land spanning at least 0.5 hectares with forest trees (actually or potentially) higher than five meters at maturity and a canopy cover at maturity of (actually or potentially) more than 30 percent. It does not include land that is predominantly under agricultural or urban land use." In contrast, „Forest land" "includes areas covered by trees, as well as roads and other areas that are under forest management but are not covered by trees". According to the definition considered within the latest NFIs (cycle I and cycle II), and in line with the FAO/COST Action E43 definition, forest is defined as land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover more than10 percent, or trees able to reach these thresholds in situ. Less than 20 m wide forest belts are excluded from the term even if they meet all of the other requirements.

Other Wooded Land: according to the FAO/COST Action E43 definition, other wooded land means land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover between 5-10 percent, or trees able to reach these thresholds in situ, or land spanning more than 0.5 hectares with

the combined canopy cover of trees and shrubs over 10%. Based on these two definitions, the Hungarian forest inventory keeps separate records of other wooded lands covered with trees only (OWL1) and shrub covered lands (OWL2). Please note that to calculate the value of other wooded land (OWL), as the term is used internationally, these two values need to be added.

Malta

Source: FRA 2020 Country Report

Forest: area covering a minimum of 1 ha with trees having a potential to reach a minimum height of 2 - 5m at maturity in situ, managed under Natura 2000 management plans.

Other Wooded Land: n.d.

The Netherlands

Source: Schelhaas et al., 2022. Zevende Nederlandese Bosinventarisatie. Wageningen University & Research

FRA 2020 Country Report

Forest: In the series of forest inventories, at least since the Fourth Forest Statistics, the following definition of 'forest' has been used: “A site with woody vegetation of at least 0.5 ha, at least 30 meters wide and with a minimum canopy cover of 20 percent. The trees must be able to reach a minimum height of 5 meters on site”. Areas where there are temporarily no trees, such as young stands and recent clear-cutting, are considered forest, as are areas that belong to the forest company, such as forest roads, nurseries and wood piles. Enclosed roads, bodies of water and grass strips narrower than 6 m must be counted. This definition is also used for the LULUCF reports. Both in the final MFV report and in the NBI-6 report a slightly different definition is given, whereby the minimum crown cover is 10% and the minimum width is 20 m. This definition comes from the FAO and is used for the reports of the Forest Resource Assessments (FRA).

Other Wooded Land: in the Netherlands no distinction is made between the categories ‘forest’ and ‘other wooded land’.

Austria

Source: FRA 2020 Country Report

Forest: according the Austrian Forest Act 1975, forest is defined as a land with tree species (without land with shrub and bushes) spanning more than 0.05 hectares (minimum width: 10 meter) and a canopy cover of more than 30 percent.

Other Wooded Land: land with shrub and bushes spanning more than 0.05 hectares (minimum width: 10 meter), including areas with *Pinus mugo* and *Alnus viridis*.

Poland

Source: FRA 2020 Country Report

Ministry of Climate, 2019. National Forestry Accounting Plan of Poland

Forest: the definition of forest used in reporting to the Climate Convention is the same considered in the Forest Act of 1991, which specifies that a forest is a compact area of at least 0.10 ha, covered with, or temporarily deprived of, forest vegetation (forest crops) - trees and shrubs and forest undergrowth which:

- is intended for forestry production, or
- constitutes a nature reserve or a part of a national park, or
- has been entered into the register of monuments,
- is associated with forest management.

According to the Polish definitions, the minimum area of forest is at least 0.1 ha. Up to now there is no data evaluating the share of forest patches greater than 0.1 ha and less than 0.5 ha.

Other Wooded Land: not considered

Portugal

Source: Agẽncia Portuguesa do Ambiente. Republica Prtuguesa, 2020. National Forestry Accounting Plan Portugal 2021-2025

Forest: Portugal's forest definition is based on the following parameters:

- Minimum land area: 1 ha
- Minimum tree cover: 10%
- Minimum tree height: 5 m
- Minimum width: 20 m

According to the national definition, agri-forest systems (mostly of cork-oak and holm-oak) are considered as forests whenever the tree cover exceeded 10%. Where the tree cover is below 10%, the areas are classified according to the dominant land-cover, most commonly as cropland, pastures or shrublands. Some woody perennial crops like olive groves, vineyards and fruit production orchards are included as cropland, even if the characteristics of the vegetation would reach the forest thresholds mentioned above.

Other Wooded Land: n.a.

Romania

Source: Inventarul Forestier National - Vegetaţia forestieră – Definiţii. URL (access 04/10/2022): https://translate.google.com/?hl=it&sl=auto&tl=it&text=Vegeta%C5%A3ia%20forestier%C4%83%20%E2%80%93%20Defini%C5%A3ii&op=translate

Forest: is defined as a land spanning more than 0.5 ha, with at least 10% crown cover, a minimum height of trees of 5 m at maturity in situ and a minimum width of 20 m for linear stands.

Other Wooded Land: stands > 0.5 ha, with a width > 20 m, and consistency/coverage between 5-10% for tree species which are able to reach 5 m at maturity, or consistency/coverage > 10% for tree species which are not able to reach 5 m. It does not include the lands which are predominantly used for agricultural crops.

Slovenia

Source: Kušar G., Kovac M., Simoncic P., National Forest Inventory Reports- Chapter 33. Slovenia. In Tompoo et al., (eds). National Forest Inventories, 2010.

Forest: is defined as a plot of land overgrown with forest trees in the form of stands, which can:

- reach a height of at least 5 m and sized to at least 0.25 ha

- A plot of agricultural land in transition to forest land sized to at least 0.25 ha that has not been used for agriculture for the last 20 years and is overgrown with forest trees which can reach a height of at least 5 m and their crown cover should be at least 75%

- Riverside forest corridors and windbreaks sized to at least 0.25 ha, if their widths are at least one tree-height

Other Wooded Land: refers to all stands sized to at least 0.25 ha that cannot be identified as forest within the meaning of this law but have been overgrown with forest trees or other forest vegetation and have not been used for agriculture for the last 20 years. The term other wooded land also comprises game pens and the forest corridors under power lines sized to at least 0.25 ha.

Slovakia

Source: Moravčic M., Čaboun V., Priwitzer T. National Forest Inventory Reports- Chapter 32. Slovak Republic. In Tompoo et al., (eds). National Forest Inventories, 2010.

FRA Country Report 2020.

Forest: is defined as a land spanning more than 0.3 ha, with trees taller than 5 m and a canopy cover of more than 20%, or trees able to reach these thresholds in situ.

Other Wooded Land: Alpine vegetation zone with *Pinus mugo*.

Finland

Source: Tomppo., E, Kovac M., Simoncic P., National Forest Inventory Reports- Chapter 33. Slovenia. In Tompoo et al., (eds). National Forest Inventories, 2010.

Forest: is defined as an area with a minimum 10% crown cover, a minimum height of trees of 5 m at maturity in situ, a minimum size 0.5 ha, and a minimum width for linear formation of 20 m.

Other Wooded Land: includes a reference definition, applied in parallel with national definition of poorly productive forest land since 1998, and it is based on the following criteria: 5% crown cover with a minimum height of trees of 5 m at maturity in situ, or combined crown cover of trees and shrubs 10%. The minimum size is 0.5 ha and minimum width for linear formation is equal to 20 m

Sweden

Source: Axelsson et al., National Forest Inventory Reports- Chapter 35. Sweden. In Tompoo et al., (eds). National Forest Inventories, 2010.

Forest: is defined as a land with - or potential of - at least 10% crown cover and minimum height of trees of 5 m and a minimum area of 0.5 ha

Other Wooded Land: Land, but not forest land, with, or with potential of forest with at least 5% crown cover and minimum height of trees of 5 m

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct centres. You can find the address of the centre nearest you online (european-union.europa.eu/contact-eu/meet-us_en).

On the phone or in writing

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

— by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),

— at the following standard number: +32 22999696,

— via the following form: european-union.europa.eu/contact-eu/write-us_en.

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website (european-union.europa.eu).

EU publications

You can view or order EU publications at op.europa.eu/en/publications. Multiple copies of free publications can be obtained by contacting Europe Direct or your local documentation centre (european-union.europa.eu/contact-eu/meet-us_en).

EU law and related documents

For access to legal information from the EU, including all EU law since 1951 in all the official language versions, go to EUR-Lex (eur-lex.europa.eu).

Open data from the EU

The portal data.europa.eu provides access to open datasets from the EU institutions, bodies and agencies. These can be downloaded and reused for free, for both commercial and non-commercial purposes. The portal also provides access to a wealth of datasets from European countries.

Open data from the EU

The portal data.europa.eu provides access to open datasets from the EU institutions, bodies and agencies. These can be downloaded and reused for free, for both commercial and non-commercial purposes. The

The European Commission's science and knowledge service

Joint Research Centre

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

EU Science Hub
joint-research-centre.ec.europa.eu

@EU_ScienceHub

EU Science Hub - Joint Research Centre

EU Science, Research and Innovation

EU Science Hub

EU Science

Publications Office
of the European Union