



# Guidance on developing and reporting Forest Reference Levels in accordance with Regulation (EU) 2018/841

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# Guidance on developing and reporting Forest Reference Levels in accordance with Regulation (EU) 2018/841



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## OVERVIEW

This technical guidance document has been prepared for DG Climate Action, to support the EU Member States in complying with the 'LULUCF Regulation', *Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU (Text with EEA relevance)*<sup>1</sup>. In particular, the aim of this document is to provide guidance for the Member States on the establishment of Forest Reference Levels (FRLs) and National Forestry Accounting Plans (NFAPs) as required by the LULUCF Regulation.

The LULUCF Regulation requires the Member States to submit their NFAPs, including a proposed FRL, to the Commission by 31 December 2018 for the period from 2021 to 2025, and by 30 June 2023 for the period from 2026 to 2030. While the guidance provided in this document is not binding on the Member States, it seeks to help the Member States to interpret the LULUCF Regulation, and provides examples of possible technical approaches for preparing the FRLs and NFAPs. However, there may exist a number of other approaches to set the FRL in line with the LULUCF Regulation.

The structure of this technical guidance document is illustrated in Figure 1. The document is organized into three sections, accompanied by three Annexes. Section 1 provides an introductory summary of the state of the forest-related accounting rules, and gives an overview of the key differences between the FRL approach under the LULUCF Regulation and the previous approach under the Kyoto Protocol (KP). Section 2 details a step-wise methodology for the construction of robust and transparent FRLs by Member States. The steps in the methodology have been developed by a group of thematic experts, based on discussions with DG Climate Action and Joint Research Centre of the European Commission (JRC), as well as in workshops with experts from the Member States. These steps seek to portray a wide array of different solutions for developing the FRL to take into account the large variation in the natural conditions and forest sector characteristics across the EU Member States. Section 3 provides a detailed analysis of the criteria and guidance for determining the FRL, as set out in Annex IV.A of the LULUCF Regulation, and a suggested table of contents for the submission of the NFAPs, taking into account the requirements as set out in Annex IV.B of the LULUCF Regulation.

In the annexes to this technical guidance document, we provide a checklist for the proposed step-wise approach, as well as an illustrative handbook of the different steps for the development of the FRL. In addition, we provide suggestions and examples of tables that the Member States may consider to use in their reporting of the NFAPs.

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<sup>1</sup> Available online at: <http://europa.eu/lcQ33UG>

Section 1	Section 2	Section 3	Annexes
<ul style="list-style-type: none"><li>• Overview of the principles for GHG accounting in LULUCF sector, the current state of reporting, and an overview of the legislative text</li></ul>	<ul style="list-style-type: none"><li>• Guidance to possible approaches to develop the FRLs, and advice on how to ensure transparent reporting</li><li>• Hands-on examples on different calculation steps and possible methods</li></ul>	<ul style="list-style-type: none"><li>• Detailed analysis of the criteria for the FRL set out in the Annex IV of the Regulation</li><li>• Example table of contents for the submission of the NFAP, in accordance with the requirements of the Annex IV of the Regulation.</li></ul>	<ul style="list-style-type: none"><li>• Annex I: Checklist for the proposed step-wise approach</li><li>• Annex II: Handbook for establishing FRLs</li><li>• Annex III: Filled in examples of reporting tables as suggested in section 2</li><li>• Annex IV: Overview of Member States' reporting under KP</li></ul>

Figure 1. Structure of this technical guidance document.

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## GLOSSARY

This glossary covers the terminology used in this technical guidance document. The terms that are specifically defined in the LULUCF Regulation (Regulation (EU) 2018/841) are marked with an asterisk (\*), and those previously defined in the Decision No 529/2013/EU with a plus-sign (+). Direct quotes of definitions as stated in the LULUCF Regulation or the Decision are typed in *"blue italics"*.

**Accounting.** Rule-based assessment of the impact on GHG emissions and removals that take place under a compliance period. The impact is accounted through comparison of actual GHG emissions and removals from GHGI categories during a compliance period with the counterfactual value, following the accounting rules set for the given category.

**Actual management practices (AMP).** The dataset describing the FMP, including the specification of when and how each FMP and the associated management activity actually were implemented during the RP.

**Afforested land\*.** *"Land use reported as cropland, grassland, wetlands, settlements or other land, converted to forest land."* (Article 2(1)) Note that the process under the LULUCF Regulation is different from that under the KP, and also that the definition of the afforested land in the context of the LULUCF Regulation differs from the definition of afforestation in the IPCC Guidelines for National Greenhouse Gas Inventories (2006). Nevertheless, the accounting of afforested (and deforested) land is understood to refer to human-induced emissions or removals from land use change: the LULUCF Regulation states that the *"Member States shall account for emissions and removals resulting from afforested land and deforested land, as being the total emissions and total removals for each of the years."* (Article 6(1)), and emissions and removals are defined as anthropogenic processes.

**Background level.** *"Average emissions caused by natural disturbances in the period from 2001 to 2020, excluding statistical outliers."* (Article 10(1)).

**Biomass available for wood supply (BAWS).** The potential biomass subject to operational criteria as defined for the FMP. For example, if a FMP is to clearcut spruce forests between 80 and 120 years, BAWS would be all spruce forests in between 80 and 120 years. Please also see Grassi et al. (2017) for more details about this term.

**Carbon pool\*.** *"The whole or part of a biogeochemical feature or system within the territory of a Member State and within which carbon, any precursor to a greenhouse gas containing carbon or any greenhouse gas containing carbon is stored."* (Art 3(1)). Note that in order to avoid double-counting of traded wood, 'production approach' is to be used. This means that the imported HWP shall not be accounted for by the importing Member State. (Annex V).

**Carbon stock\*.** *"The mass of carbon stored in a carbon pool."* (Article 3(1)).

**Compliance period (CP).** The period 2021–2030, to which the LULUCF Regulation sets out the commitments of the Member States for LULUCF, and the rules for the accounting of emissions and removals from LULUCF and for checking the compliance of Member States with those commitments (Article 1). Note that for accounting purposes, the CP is split in the LULUCF Regulation into two periods: 2021 to 2025, and to 2026 to 2030. While the overall accounting rules set out in the LULUCF Regulation are the same for the whole CP, there are some differences in the requirements of wetlands for the first and second CP. After each 5-year period, the Commission will carry out a comprehensive review of the data (Article 14(2)) and determine compliance with the "no debit" commitment of each Member State as set out in Article 4.

**Deforested land\***. *“Land use reported as forest land converted to cropland, grassland, wetlands, settlements or other land.”* (Article 2(1)).

**Dynamic age-related forest characteristics.** The LULUCF Regulation refers to *“dynamic age-related forest characteristics”* (Article 8(5)). In this technical guidance document, age-related characteristics are understood to refer to the state of ‘maturity’ of the forest, which can be characterized e.g. with mean age of a stand, its biomass density, and age or diameter class distribution. “Dynamic” is understood to refer to the development of these characteristics over time, such as the movement of a stand from one age or diameter class to another over time.

**Emissions\***. *“Anthropogenic emissions of greenhouse gases into the atmosphere by sources.”* This is an opposite process to ‘Removals’.

**Forest\***. *“An area of land defined by minimum values for area size, tree crown cover or an equivalent stocking level, and potential tree height at maturity at the place of growth of the trees as specified for each Member State in Annex II [of the LULUCF Regulation]. It includes areas with trees, including groups of growing, young natural trees, or plantations that have yet to reach the minimum values for tree crown cover or equivalent stocking level or minimum tree height as specified in Annex II, including any area that normally forms part of the forest area but on which there are temporarily no trees as a result of human intervention, such as harvesting, or as a result of natural causes, but which area can be expected to revert to forest.”* (Article 3(1)).

**Forest management\***. *“Any activity resulting from a system of practices applicable to a forest that influences the ecological, economic or social functions of the forest.”*

**Forest management practice(s) (FMP).** The LULUCF Regulation text is not explicit about the definition of ‘forest management practice’. In Article 8(5), the term is in singular form (*“practice”*), while Annex IV.B asks to describe *“practices”*. Please see section 2 of this document for possible interpretations of this term. In the context of this technical guidance document, a FMP refers to a set of management activities being carried out at different phases of the stand development. FMP can thus be seen as a set of activities carried out and aimed at fulfilling specific functions assigned to a forest (production, protection, etc.), including, e.g., the regeneration modality, the species planted, the schedule and intensity of thinning and final cut. In the context of this document, also “no management” is considered as a possible FMP option.

**Forest reference level (FRL)\*.** *“An estimate, expressed in tonnes of CO<sub>2</sub> equivalent per year, of the average annual net emissions or removals resulting from managed forest land within the territory of a Member State in the periods from 2021 to 2025 and from 2026 to 2030, based on the criteria set out in this Regulation [2018/841].”* (Article 3(1)) In accounting terms, the FRL is the counterfactual value of emissions and removals that would occur in managed forest land in the absence of any future change in management practices compared to the reference period.

**Half-life value\*.** *“The number of years it takes for the quantity of carbon stored in a category of harvested wood products to decrease to one half of its initial value.”* (Article 3(1)).

**Harvested wood product (HWP)\*.** *“Any product of wood harvesting that has left a site where wood is harvested.”* (Article 3(1)). Note that in the accounting for HWP as detailed in Article 9, the emissions and removals resulting from changes in the carbon pool of HWP are to be reflected according to the Annex V approach for the following HWP products: paper, wood panels, sawn wood (see Article 9(1)).

**Instantaneous oxidation\***. *"An accounting method that assumes that the release into the atmosphere of the entire quantity of carbon stored in harvested wood products occurs at the time of harvest."* (Article 3(1)).

**Legacy effect**. Effect or impact of an action or a disturbance that occurs only after some time. This is typical in forestry, where different management decisions or disturbances during the course of the forest rotation time affect the future state of the forests for decades or even hundreds of years after the actual occurrence.

**LULUCF Regulation**. The full name of the Regulation is *"Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU (Text with EEA relevance)"*. The LULUCF Regulation is available online at: <http://europa.eu/lcQ33UG>.

**Managed cropland\***. *"Land use reported as: cropland remaining cropland; grassland, wetland, settlement or other land, converted to cropland, or; cropland converted to wetland, settlement or other land."* (Article 2(1)a).

**Managed forest land (MFL)\***. *"Land use reported as forest land remaining forest land."* (Article 2(2)a).

**Managed grassland\***. *"Land use reported as: grassland remaining grassland; cropland, wetland, settlement or other land, converted to grassland, or; grassland converted to wetland, settlement or other land."* (Article 2(1)a).

**Managed wetland\***. *"As of 2026: land use reported as: wetland remaining wetland; settlement or other land, converted to wetland, or; wetland converted to settlement or other land"* (Article 2(1)b). Note that a Member State may include emissions and removals from managed wetland during the period from 2021 to 2025, but it is not a requirement in the LULUCF Regulation (Article 2(2)).

**Modelled management practices (MMP)**. The dataset including the quantified FMPs that will be used to by the model to project the FRL.

**Natural disturbances\***. *"Any non-anthropogenic events or circumstances that cause significant emissions in forests and the occurrence of which is beyond the control of the relevant Member State, and the effects of which the Member State is objectively unable to significantly limit, even after their occurrence, on emissions."* (Article 3(1)).

**Precursor to a greenhouse gas\***. *"A chemical compound that participates in the chemical reactions that produce any of the greenhouse gases listed in Article 3(4)"* (of the Decision 529/2013/EU).

**Production approach**. In the accounting for HWP, the HWP is accounted for in the producing country, and *"the imported [HWP], irrespective of their origin, shall not be accounted for by the importing Member State."* (Annex V).

**Reference period (RP)**. The period from 2000 to 2009.

**Removals\***. *"Anthropogenic removals of greenhouse gases from the atmosphere by sinks."* This is an opposite process to 'Emissions'.

**Reporting**. In GHG accounting context, reporting refers to emission and removal estimates prepared annually by the countries. The reporting provides the information needed for accounting the impact of human activities on the atmospheric GHG concentration. Note that in this document, we use 'reporting' also in a more general

sense to refer to documentation and submissions of data or estimates prepared by the countries.

**Salvage logging**<sup>+</sup>. *“Any harvesting activity consisting of recovering timber that can still be used, at least in part, from lands affected by natural disturbances.”*

**Sink**<sup>\*</sup>. *“Any process, activity or mechanism that removes a greenhouse gas, an aerosol, or a precursor to a greenhouse gas from the atmosphere.”* (Article 3.1). This is an opposite process to a ‘source’.

**Solid and energy use of forest biomass**. The LULUCF Regulation refers to *“solid and energy use of forest biomass”*, but does not provide a specific definition. In absence of other definitions, it is advisable to consider ‘solid use’ as the use of forest biomass to other than energy purposes. For ‘energy use’, it is advisable to follow FAO definition for ‘wood energy’: *“All energy derived from primary and secondary solid, liquid and gaseous biofuels derived from forests, woodlands and trees. Wood energy represents the energy produced after combustion of woodfuels, such as fuelwood, charcoal, pellets, briquettes, etc., corresponding to the net calorific value (NCV) of the fuel.”* (FAO term portal 2018) Note, however, that following the ‘production approach’ to avoid double-counting of traded wood, imported HWP shall not be accounted for by the importing Member State. (Annex V)

**Source**<sup>\*</sup>. *“Any process, activity or mechanism that releases a greenhouse gas, an aerosol or a precursor to a greenhouse gas into the atmosphere.”* (Article 3.1). This is an opposite process to a ‘sink’.

**State of the forest**. Set of data and information that describe the forest, such as total area of Managed Forest Land; as well as stratum-specific variables, e.g. area, increment, biomass, age-related information.

**Stratum, strata**. In the context of this technical guidance document, a stratum (in plural: strata) is a part of forest (distinguished geographically or grouped across different geographic locations) homogeneous for all the criteria applied to the stratification process (tree species, forest type, management system, ownership, etc.). Each stratum differs from other strata by at least one of the criteria of stratification.

**Sustainable forest management (practice)**. The preamble of the LULUCF Regulation (recital 16) refers to the principles of sustainable forest management as adopted in the Ministerial Conferences on the Protection of Forests in Europe (‘Forest Europe’). The Helsinki Resolution H1 (Forest Europe 1993) of Forest Europe defines “sustainable management” as: *“the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems”*. Furthermore, Annex IV A.(f) of the LULUCF Regulation states that *“the reference level should be consistent with the objective of contributing to the conservation of biodiversity and the sustainable use of natural resources, as set out in the EU forest strategy, Member States’ national forest policies, and the EU biodiversity strategy”*.

## ACRONYMS AND ABBREVIATIONS

<b>AR</b>	Afforestation and reforestation [under the KP]
<b>BAWS</b>	Biomass Available for Wood Supply
<b>C</b>	Carbon
<b>CH<sub>4</sub></b>	Methane
<b>cm</b>	Centimetre
<b>CO<sub>2</sub></b>	Carbon dioxide
<b>CP</b>	Compliance period
<b>CSC</b>	Carbon stock change method
<b>CSCF</b>	Carbon stock change factors
<b>Dbh</b>	Diameter at breast height
<b>DG CLIMA</b>	Directorate General for Climate Action
<b>DOM</b>	Dead organic matter
<b>EFI</b>	European Forest Institute
<b>EU</b>	European Union
<b>FAO</b>	Food and Agriculture Organization of the United Nations
<b>FLrFL</b>	Forest Land Remaining Forest Land
<b>FMRL</b>	Forest Management Reference Level
<b>FMP</b>	Forest management practice
<b>FRL</b>	Forest Reference Level
<b>GHG</b>	Greenhouse gas
<b>GHGI</b>	Greenhouse gas inventories
<b>HFM</b>	Harvest Fraction of Management
<b>HWP</b>	Harvested wood product(s)
<b>IIASA</b>	International Institute for Applied Systems Analysis
<b>IPCC</b>	Intergovernmental Panel on Climate Change
<b>IPCC GL</b>	IPCC Guidelines
<b>JRC</b>	Joint Research Centre of the European Commission
<b>KP</b>	Kyoto Protocol
<b>LULUCF</b>	Land Use, Land Use Change and Forestry
<b>MFL</b>	Managed Forest Land
<b>Mm<sup>3</sup></b>	Mega cubic metres (million cubic metres)
<b>ND</b>	Natural Disturbances
<b>NFAP</b>	National Forestry Accounting Plan
<b>NFI</b>	National forest inventory
<b>NIR</b>	National inventory report
<b>N<sub>2</sub>O</b>	Nitrous oxide
<b>PP</b>	Projection period
<b>RCP</b>	Representative Concentration Pathways
<b>RP</b>	Reference period
<b>SOM</b>	Soil organic matter
<b>SSP</b>	Shared Socioeconomic Pathways
<b>TBA</b>	Total Biomass Available
<b>t</b>	Tonne
<b>UNFCCC</b>	United Nations Framework Convention on Climate Change
<b>YR</b>	Year

## **ACKNOWLEDGEMENTS**

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The interpretations and any errors are however purely those of the authors.

## SECTION 1

### 1 INTRODUCTION

#### 1.1 What is this technical guidance document for?

In 2018, a new Regulation of the European Parliament and of the Council came into force, setting in place the accounting rules on the inclusion of greenhouse gas (GHG) emissions and removals from land use, land use change and forestry (LULUCF) in the 2030 climate and energy framework. The aim of this document is to provide guidance for EU Member States on the establishment of forest reference levels (FRLs) and national forestry accounting plans (NFAPs) in the context of the *Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU (Text with EEA relevance)* (hereafter referred to as the 'LULUCF Regulation'). This technical guidance document seeks to provide the best possible advice on interpreting the LULUCF Regulation, and developing the FRL and NFAP in compliance with the LULUCF Regulation. This is not a binding document. It is at the discretion of each Member State to use, or not to use, this document when establishing their national FRL and NFAP. In addition to the approaches described in this document, there may exist a number of other approaches to set the FRL in line with the LULUCF Regulation.

In the LULUCF Regulation, GHG emissions and removals from managed forest land (MFL) in each EU Member State are accounted against a FRL, a country-specific projected baseline of expected forest emissions and removals for the Compliance Period (CP) 2021-2030. The NFAPs, including a proposed FRL, shall be submitted to the Commission by 31 December 2018 for the period from 2021 to 2025, and by 30 June 2023 for the period from 2026 to 2030 (Article 8.3). As defined in the LULUCF Regulation, the FRL "*shall be based on the continuation of sustainable forest management practice, as documented in the period from 2000 to 2009 with regard to dynamic age-related forest characteristics in national forests, using the best available data*" (Article 8(5)).

This document provides advice and examples on how to prepare the FRL and NFAP, and gives guidance on how to ensure comprehensive and transparent reporting. Given that the forest characteristics, forest management practices (FMPs), as well as data and models availability, vary substantially among the Member States, specific attention has been given to including a variety of different alternative methods to accommodate different national circumstances. The goal is that this document helps the Member States to identify the set of historical management activities implemented in the Reference Period (RP), and to project the forest characteristics in the CP by simulating the continuation of historical FMPs over the CP.

This technical guidance document is structured as follows:

- Section 1: Overview of the principles for GHG accounting in forestry, the current state of reporting, and an overview of the legislative text.
- Section 2: Guidance on possible approaches to develop the FRLs, and advice on how to ensure transparent reporting. In this section, hands-on examples on different calculation steps and possible methods are elaborated as well.
- Section 3: Detailed analysis of the criteria for the FRL set out in the Annex IV of the LULUCF Regulation, to clarify details and provide help to understand the requirements of the LULUCF Regulation. This section also illustrates an example table of contents for the submission of the NFAP, in accordance with the requirements of the Annex IV of the LULUCF Regulation.
- Further details are given in the Annexes I-IV:
  - Annex I: Provides a checklist for the proposed step-wise approach
  - Annex II: Handbook for establishing FRLs.
  - Annex III: Provides filled in examples of reporting tables as suggested in section 2.
  - Annex IV: Overview of the EU Member States' reporting of LULUCF under Kyoto Protocol.

This document does not provide an exhaustive collection of all possible approaches to preparing the FRLs and NFAPs. Instead, the authors have sought to survey and analyse a wide array of possible approaches to develop and report FRLs and NFAPs. Based on this information, this document has been structured to give an overview of possible approaches for the Member States to develop their FRLs and NFAPs. In addition, this document highlights and explains important parts of the LULUCF Regulation so that the Member States can be confident in that their reporting complies with the requirements as set out in the legislative act.

## **1.2 Introduction to LULUCF in the context of climate change**

### **1.2.1 Background**

To limit the increase of the global average temperature, reducing anthropogenic (human-induced) net emissions of GHGs is essential. In the Paris Agreement adopted under the United Nations Framework Convention on Climate Change (UNFCCC), the parties, including the EU, agreed to commit themselves to a long-term goal of keeping the global temperature increase well below 2°C above pre-industrial levels; and to pursue efforts to keep it from exceeding 1.5°C above pre-industrial levels (United Nations 2015). The Paris Agreement replaces the approach taken under the 1997 Kyoto Protocol (KP), which will not be continued beyond 2020 (UNFCCC 2018).

The main anthropogenic driver of the global temperature increase is the accumulation of GHGs in the atmosphere. Processes that release GHGs into the atmosphere, such as combustion of fuels, are referred to as 'sources'. Processes that remove GHGs from the atmosphere are called 'sinks'. The most important sinks are absorption of carbon in the oceans and by biomass on land. The sum of the sources and sinks is referred to as 'net emissions'. Critical anthropogenic GHGs include carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>) and nitrous oxide (N<sub>2</sub>O). In the LULUCF Regulation, all GHGs are expressed in terms of CO<sub>2</sub> equivalent (the effect of an equivalent mass of CO<sub>2</sub> in the atmosphere on solar radiative forcing).

The Paris Agreement also calls for a balance between anthropogenic emissions by sources and removals by sinks of GHGs in the second half of the century. This asks for net-zero emissions, where the amount of carbon absorbed by the sinks equals the

amount of carbon released by the sources. Assuming that the use of fossil fuels and other human-induced emissions, such as those from agriculture, will not end completely in the coming decades, it will be necessary to achieve and enhance uptake of carbon by sinks whenever possible. This is where the LULUCF sector comes into play.

### **1.2.2 Specific characteristics of the LULUCF sector**

The LULUCF sector differs from other sectors (e.g. energy and transport) in that human actions on the LULUCF sector can at the same time contribute both to emitting GHGs and to removing them from the atmosphere. Trees remove and store carbon from the atmosphere when they grow, and carbon is also stored in wood-based products. Conversely, carbon is emitted to the atmosphere when wood decays to dead organic matter, when it is burnt, or when wood-based products decay over their life-times. In addition, forest-related activities may lead to emissions of other GHGs: for example, drainage of wetlands and nitrogen fertilization may increase N<sub>2</sub>O emissions. Consequently, LULUCF can at the same time act as a source and a sink; therefore, determining the final net balance requires a careful assessment of the emissions and removals of GHGs within the sector.

In the context of the Paris Agreement and the sharing of efforts between countries, distinguishing between anthropogenic emissions and removals, and those caused by natural processes is key. Within the LULUCF sector, and particularly within forestry, distinguishing the natural component in the carbon cycle from the component associated with the impact of human activities is not always straightforward. Natural disturbances (NDs), such as wildfires, windthrow, or insect outbreaks, may lead to large emissions or reductions in the forest sinks, and their impact may be reduced or amplified through forest management.

Furthermore, the impact of activities or disturbances on forest land does not occur fully within the same year as the occurrence takes place. Forest harvesting reduces the carbon sinks temporarily, but may over the long term lead to improved growth of forests and consequently, larger sinks. Moreover, because of the long time-span of forest cycles, different management decisions over the course of the forest rotation time may affect the removals and emissions for decades – or even centuries – after the actual operation, such as planting or thinning, took place. Similarly, emissions from the decay of organic matter are seen still years after the disturbance creating the dead organic matter. This extension of impact over time is referred to as ‘legacy effect’. In other words, the future emissions and removals in forests are impacted by the long-term legacy effects associated with age-class dynamics, determined by past activities and NDs. Unlike other sectors, in LULUCF and specifically in forestry it is typical that these legacy effects occur repeatedly over time in a cyclical fashion.

### **1.2.3 Overview of the LULUCF accounting principles**

The GHG emission reduction target of the EU of reducing the GHG emissions by at least 40% by 2030 is set economy-wide, i.e. across sectors. To ensure reliable and efficient policies and comparison between different sectors, the reporting and accounting of the emissions and removals for each sector need to be reliable, robust, and transparent.

In GHG context, ‘reporting’ refers to the emission and removal estimates prepared by the countries. In the context of mitigation targets, ‘accounting’ refers to the comparison of emissions and removals with the base value, or the counterfactual value. On the LULUCF sector, the accounting is done through policy-agreed accounting rules, which filter the reported estimates with the aim to quantify better the results of mitigation actions (e.g. Cowie et al. 2007, Schlamadinger et al. 2007, Grassi et al. 2018). The LULUCF accounting then produces ‘debits’ or ‘credits’ (i.e. extra emissions or extra emission reductions, respectively) that count toward the target. Through the debit and credit

system, the aim is to provide incentives for beneficial actions and policies, and disincentives for detrimental actions.

There are different approaches for establishing the counterfactual value for the accounting of mitigation effects by carbon sinks and sources:

- In **gross-net accounting**, the counterfactual value is set at zero. This means that the net total ('net') of all ('gross') emissions and removals occurred in the compliance period are accounted for. This approach is used in the LULUCF Regulation within Article 6, where the emissions and removals resulting from afforested land and deforested land shall be accounted for "*as being the total emissions and total removals for each of the years in the periods from 2021 to 2025 and from 2026 to 2030*".
- In **net-net accounting**, the counterfactual value is set as the emissions of the base year or level (net), and is compared with the emissions of the compliance period (net). This is the accounting principle in the LULUCF Regulation for managed cropland, managed grassland and managed wetland (Article 7), where the emissions and removals from these land use classes shall be compared to the base period from 2005 to 2009.

Another example of net-net accounting is when the actual emissions and removals in a given year are compared against a projected **reference level**. This approach is used in the LULUCF Regulation for the accounting of MFL (Article 8).

The use of different accounting approaches reflects how the activities implemented in different land uses affect the development of carbon sinks and sources within the LULUCF sector. The gross-net accounting used for land use change emphasizes the more profound change of the characteristics of that land for the future, which can also be linked to a relatively specific point in time. Gross-net accounting aims to give full incentive to reduce emissions or enhance the sinks, while assuming that all the emissions and removals are a direct consequence of human actions. In net-net accounting, the choice of the RP is emphasized. For land uses where the annual emissions and removals change relatively little from year to year (such as cropland or grassland, where the annual biomass production is relatively similar from year to year), the use of a historical base year is justified since it allows to account for efforts made for enhancing net removals of GHG emissions over time.

For MFL, accounting against a reference level provides a means of considering the long time-horizon and legacy effects of past management practices associated with forestry. This approach was applied under KP reporting for the second commitment period, and it is now adopted in the LULUCF Regulation. Note that the requirements and scope of the FRL in the LULUCF Regulation differ partly from the KP; see section 1.4 for more details. The FRL for MFL as regulated by the LULUCF Regulation ties the FRL to "*continuation of sustainable forest management practice, as documented in the period from 2000 to 2009*" (Article 8(5)). This aims to provide a baseline to show how the forest would develop if no changes to policies or practices were put in place (i.e. the counterfactual value), compared to the RP. The impact of this approach compared to net-net accounting against a base year is especially prominent in a situation where the age structure of a forest is skewed: if the forests had a relatively large share of trees in a certain age class, the total harvest would fluctuate over time purely because there are different amounts of trees reaching the harvest age during different periods in time. The use of FRL attempts to make a complete account of the impacts of changes in FMPs, relative to the practice under a historical RP, and to eliminate the differences that result purely from the age-related dynamics.

In the land use sector it is generally simpler and more accurate to measure the change in 'carbon stock', instead of the fluxes of emissions and removals. Carbon stock refers to "*the mass of carbon stored in a carbon pool*", measured at a given time. For example, the net emissions caused by land use change can be estimated through comparing the

stock of carbon per area unit before and after the land was converted (the so called 'stock-difference' method). It is important to note that the mere presence of carbon stocks will not mitigate climate change, if emissions from other sectors continue increasing. Instead, the net carbon sinks need to be maintained and ideally enhanced. This means that the total amount of atmospheric carbon needs to be reduced, and more carbon sequestered in lands and oceans. It follows that in order for the land use to contribute positively to combating global temperature increase, it is necessary that the future land-based carbon stock will be larger than the current carbon stock, and that the net carbon sinks are enhanced.

The GHG emissions and removals are estimated from different 'carbon pools'. A carbon pool means "*the whole or part of a biochemical feature or system within the territory of a Member State and within which carbon, any precursor to a greenhouse gas containing carbon or any greenhouse gas containing carbon is stored*". In the LULUCF sector, and in forest land, the carbon pools considered include living biomass (above- and below ground), dead organic matter (litter and dead wood, DOM), soil organic matter (SOM), and harvested wood products (HWP).

In the context of the LULUCF Regulation, the following six pools are considered within the Member States (Annex I.B):

- Above-ground biomass;
- Below-ground biomass<sup>2</sup>;
- Litter<sup>2</sup>;
- Dead wood;
- Soil organic carbon<sup>2</sup>;
- Harvested wood products.

In line with the Paris Agreement, accounting of GHGs within the LULUCF Regulation refers to anthropogenic emissions by sources and removals by sinks. This means that NDs may be excluded from the accounting. However, the Member States are expected to adopt active prevention measures, to reduce the risk associated with NDs, and to strengthen the resilience of the LULUCF sector (recital 8 in the preamble of the LULUCF Regulation).

On the other hand, since HWP is an anthropogenic pool, it is included in the LULUCF Regulation. This is in line with UNFCCC reporting: HWP is reported under the KP as a separate carbon pool in afforested land and in land under forest management, respectively. The accounting of HWP under LULUCF recognizes the fact that when forest is harvested and the wood used for material products, the carbon stored in the biomass is not released into the atmosphere immediately. Instead, the carbon continues to be stored in the products that have different lifetimes before eventually decaying or being burnt for energy production. In the LULUCF Regulation, the HWP that are specifically accounted for are paper, wood panels, and sawn wood (Article 9). For each of these products, specific half-life values are defined, reflecting the number of years it takes to lose one-half of the material currently in the pool, and eventually be released into the atmosphere (IPCC 2006). This accounting attempts to promote enhanced use of wood products with long life-cycles, compared to short-lived products or the combustion of virgin wood directly to energy. The accounting is based on a 'production approach', which means that the HWP is accounted by the producing country, while "*imported [HWP], irrespective of their origin, shall not be accounted by the importing Member State*". These rules prevent double-counting of the internationally traded HWP. In addition to the

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<sup>2</sup> These pools may be excluded in the accounts under the LULUCF Regulation, provided that the carbon pool is not a source (Article 5(4)).

modelling of the decay of HWP over time, the LULUCF Regulation requires also a comparison with instantaneous oxidation (which assumes that the carbon stored in the wood biomass is not stored but instead released into atmosphere directly after harvest). This comparison serves to evaluate the extent and importance of the HWP pool in relation with the whole LULUCF pool.

### **1.3 Previous reporting and accounting under the Kyoto Protocol**

#### **1.3.1 Overview**

The 1997 Kyoto Protocol (KP) established a set of accounting and reporting rules for assessing the emissions and removals from different sectors (UNFCCC 2018). It will not be continued beyond 2020. The LULUCF Regulation is part of the EU efforts towards the climate change mitigation targets of the Paris Agreement, which will replace KP after 2020. Here, we give an overview of the KP system and previous experiences with it, and highlight differences between the reporting under KP and the LULUCF Regulation.

The KP accounting system was designed with the aim accurately reflecting the atmospheric impacts of additional human actions during an established time period. The impacts of the additional actions have generally been addressed through the so-called net-net accounting approach that uses a reference year or level as a comparison point. This method excludes all those emissions and removals that would occur in the absence of the additional actions from being credited/debited (i.e. the counterfactual value).

To achieve such a goal, the accounting rules under the KP deal with:

- Legacy effect of pre-KP activities;
- Impact of NDs;
- Symmetry of processes, as removals and subsequent emissions, and vice versa, from the same C pool, or as tree cover gains and tree cover losses, and vice versa in the same land;
- Non-permanence of CO<sub>2</sub> emissions and removals. That is, the CO<sub>2</sub> removals and subsequent CO<sub>2</sub> emissions, and vice versa, are accounted when they actually occur.

Further, in case of inaccuracy due to lack of adequate data, KP allows for conservative accounting; that is, it attempts to zero out the likelihood of overestimating net benefits.

#### **1.3.2 Accounting of forest emissions and removals under the KP**

The general assumption in the KP approach is that the reference level corresponds to the GHG emissions and removals of a historical base year, i.e., generally 1990. This means that the countries are considered accountable of all emissions and removals after this date. Consequently, any deviation with a positive-sign compared to the level of the base year (i.e. more emissions/less removals) will be debited, and any negative-sign deviation (i.e. less emissions/more removals) will be credited. However, in the woody biomass pool, previous actions or historical disturbances cause significant variation to the rate of carbon stock change through time, even in the absence of subsequent actions or disturbances. This legacy effect means that a historical level of carbon stock change is not an appropriate counterfactual level for the accounting of emissions and removals related to the use of woody biomass.

For reasons such as these, all activities where the woody biomass carbon stock is negligible, or otherwise insignificant, use the base year GHG emissions and removals as their reference level<sup>3</sup>, while:

- Afforestation sets its reference level at 0 (zero), so that all CO<sub>2</sub> removals are counted as an additional contribution compared to a scenario without such forest (i.e. gross-net accounting). Further, to ensure that subsequent CO<sub>2</sub> emissions (e.g. associated with harvesting) are also accounted when they actually occur, land under afforestation cannot transit to an activity with a different reference level. Accounting all CO<sub>2</sub> removals and all subsequent CO<sub>2</sub> emissions against the 0-reference level allows to account for the actual change in the long-term average C-stock, which is also in line with what the impacts of the afforestation activity are on the atmosphere.
- For symmetry, deforestation applies the same reference level and accounting rules applied to afforestation; although, deforested land cannot transit to afforestation.
- Forest management applies a projected reference level (forest management reference level, FMRL) in order to zero out the contribution of CO<sub>2</sub> removals (and emissions) resulting from pre-KP actions or disturbances. Further, in order to exclude the impact of the inter-annual variability of NDs<sup>4</sup>, the contribution of disturbances to the reference level is set as the average that occurred during the historical period 1990-2009 (or later).

### **1.3.3 Lessons learned under the KP, and expectations for the new FRLs**

The concept of a reference level was used within the second commitment period (2013-2020) of the Kyoto Protocol, during which the Annex I parties were required to establish a reference level referred to as FMRL. A total of 38 parties submitted their FMRLs under the KP, including all EU countries. There was a wide variety of approaches used to produce the FMRL, ranging from using the emission estimate from base year 1990, or a value of zero, to using model-based projections<sup>5</sup>. Most countries applied projected FMRLs (including all EU countries), typically using the data from NFI combined with scenario analysis or demand projections with partial equilibrium models to estimate the future net emissions from forest management. Several EU countries projected FMRL following a common approach coordinated by the JRC and modelled by teams from IIASA and EFI (based on harvest demand projections). An overview of the LULUCF reporting by the EU Member States under KP commitment period 2 appears in Annex IV. A more thorough analysis on the lessons learned under the KP may be found in Grassi et al. (2018).

For the development of this technical guidance document, an electronic survey was sent to all Member States in February 2018. The aim of the survey was to get a better understanding of the experiences from the FMRLs and of the modelling capacities and data availabilities that the Member States have available now for the FRLs. The response rate was excellent, with 27 Member States providing at least partial answers within the given time of two weeks. The responses provided an overview of lessons learned under the past FMRL process and expectations for the FRL development, as well as more detailed questions and comments regarding the technical or conceptual understanding of the LULUCF Regulation. These questions and comments have been considered and addressed throughout this document.

The survey results show clearly that, at the time of the development of the FMRLs, Member States had varying institutional capacities and varying resources available to

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<sup>3</sup> i.e. cropland management, grazing land management, revegetation, wetlands drainage and rewetting.

<sup>4</sup> Identified as outliers in the normal distribution of emissions from disturbances

<sup>5</sup> See Chapter 2, Box 2.7.3 of the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol (IPCC 2014) for more detail.

develop their own national projections. Since then, the capacity within the Member States has improved and a majority of Member States feel that they are able to apply national approaches to the development of their FRL.

Past experience with the FMRL was seen to have brought insight into what the process of setting a reference level entails, including the projections, technical corrections, as well as the review process. The FMRL development under the KP also gave better understanding of the availability and characteristics of models, data, and personnel needed nationally to deliver the reference levels. A frequently occurring comment concerned the difficulty of estimating future policies appropriately in the FMRL under the KP, as these estimations were experienced to be difficult to define and were perceived to include a high level of uncertainty. As the expectations of future policies will not be part of the LULUCF Regulation, this specific problem will be avoided for the FRL.

Past challenges that are expected to persist in the development of the FRLs include lack of data and inconsistencies between different data sets and data sources. Estimation of NDs, accounting for HWP, and lack of FMP documentation were also frequently mentioned issues where the Member States expected to face challenges for the FRL estimation. The survey answers also brought clearly forward the different natural conditions in different countries: the forests within the EU include a wide variety of tree species and forest structures that are managed in a variety of ways for different purposes. Within the EU, forests range from subtropical Mediterranean forests to boreal tundra, and the forestry focus varies, from highly industrial use of timber to household firewood collection. Furthermore, often the management of forests is multifunctional, considering simultaneously several objectives such as water protection, recreation, biodiversity protection, and timber production. In this setting, it is obvious that a single system to categorize and model the forests and their importance in carbon accounting may not be meaningful. Instead, there should be flexibility to accommodate the national differences in the modelling of the FRL and LULUCF sector, while ensuring that the reporting is transparent, complete, and based on as consistent, comparable and accurate information as possible.

## 1.4 LULUCF Regulation

### 1.4.1 Background, structure and important dates

The LULUCF Regulation adopted in 2018 was published in all EU Member States' languages in the Official Journal of the European Union. It is available online at: <http://europa.eu/!cQ33UG>. Here, we give an overview of its structure and the most important aspects with respect to developing the FRLs and NFAPs.

Figure 2 sets the LULUCF Regulation into context with respect to other agreements and regulations, both internationally and within the EU. The linkages between different processes and the background for the LULUCF Regulation are also described in the preamble of the LULUCF Regulation.

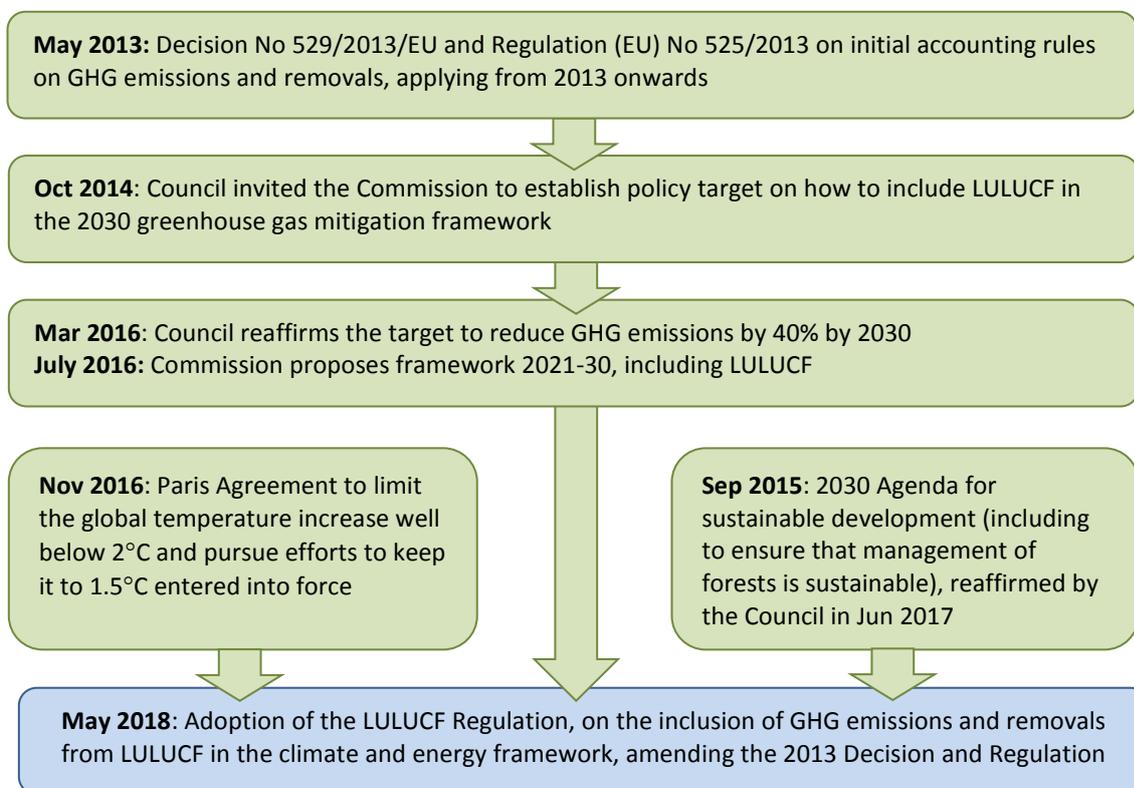


Figure 2. Overview of the context of the LULUCF Regulation and a selection of agreements that are closely related to it.

The structure of the LULUCF Regulation follows the practice and presentation of a publication in the Official Journal of the EU, consisting of a preamble, enacting terms, and annexes. Box 1 gives an overview of the contents of each part in the LULUCF Regulation. Figure 3 outlines the important dates related to the submissions and possible technical corrections as stated in the LULUCF Regulation. The LULUCF Regulation requires the Member States to submit to the Commission their NFAPs, including a proposed FRL, by 31 December 2018 for the period from 2021 to 2025 and by 30 June 2023 for the period from 2026 to 2030.

### **Box 1. Structure of the LULUCF Regulation**

The LULUCF Regulation has three parts: the preamble, the enacting terms of the Regulation, and annexes. The following gives an overview of the contents of the three parts.

#### **1. Preamble**

- Title and reference to the adopting institution/body.
- Citations, indicating the legal basis and preparatory acts for the Regulation.
  - These parts start with 'Having regard...', 'After transmission...' or 'Acting in accordance...'
- Recitals, setting out the reasons for the contents of articles of the Regulation
  - The recitals are introduced by the word 'Whereas:'. In the LULUCF Regulation, there are 36 numbered recitals that explain the context, background, and main concepts for the Regulation.

#### **2. Enacting terms**

- This part constitutes the normative part of the LULUCF Regulation. It is divided into 20 Articles, which are further subdivided into paragraphs. The LULUCF Regulation constitutes of the following:
  - Articles 1-3 describe the subject matter, scope, and definitions used in the Regulation.
  - Article 4 states the commitments for the Member States.
  - Articles 5-9 state the accounting rules for the different land uses as well as for HWP.
  - Article 10 describes the accounting rules for natural disturbances.
  - Articles 11-13 describe the flexibilities available for the Member States.
  - Article 14 details the requirements for a compliance check.
  - Articles 15 and 16 describe the registry and exercise of delegation by the European Commission.
  - Article 17 gives an overview of the review process of the submissions.
  - Articles 18 and 19 detail the amendments to Regulation (EU) No 525/2013 and Decision No 529/2013/EU that this new LULUCF Regulation imposes.
- The final article 20 specifies the entry date and binding nature of the Regulation, as directly applicable in all Member States.

#### **3. Annexes**

- The LULUCF Regulation is accompanied by seven annexes, specifying the GHGs and carbon pools addressed by the Regulation (Annex I), as well as Member State-specific thresholds of forest parameters to be considered for Forest Land (Annex II), base years (Annex III) and compensation under Managed Forest Land (MFL) flexibility (Annex VII). The annexes also give more detailed instructions on the contents and what to include in the national forestry accounting plan (Annex IV), HWP accounting (Annex V), and natural disturbances (Annex VI).

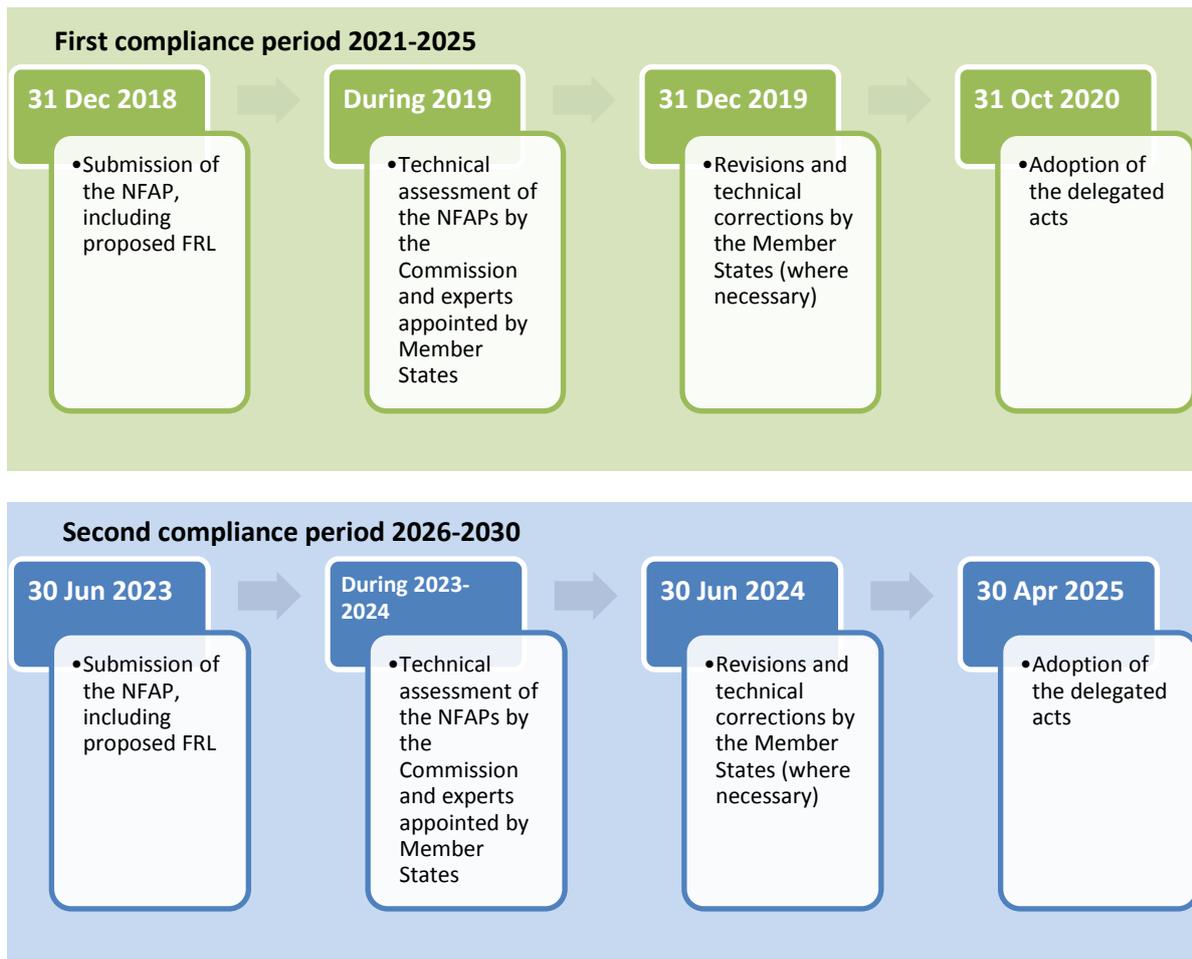


Figure 3. Timeline for the FRLs as defined in the LULUCF Regulation.

### **1.4.2 Key statements in the LULUCF Regulation concerning FRLs**

According to the LULUCF Regulation, there are several requirements for the development of the FRL. In particular, related with the methodology, the FRL shall:

According to Article 8(5) of the LULUCF Regulation:

- *"be based on the continuation of sustainable forest management practice, as documented in the period from 2000 to 2009 with regard to dynamic age-related forest characteristics in national forests"*
- use the *"best available data"*
- *"take account of the future impact of dynamic age-related forest characteristics"*
- *"not unduly constrain forest management intensity as a core element of sustainable forest management practice, with the aim of maintaining or strengthening long-term carbon sinks"*

According to Annex IV of the LULUCF Regulation:

- *"be consistent with the goal of achieving a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, including enhancing the potential removals by ageing forest stocks that may otherwise show progressively declining sinks"*
- *"ensure that the mere presence of carbon stocks is excluded from accounting"*
- *"ensure a robust and credible accounting system that ensures that emissions and removals resulting from biomass use are properly accounted for"*
- *"include the carbon pool of harvested wood products"*
- assume *"a constant ratio between solid and energy use of forest biomass as documented in the period from 2000 to 2009"*
- *"be consistent with the national projections of anthropogenic greenhouse gas emissions by sources and removals by sinks reported under Regulation (EU) No 525/2013"*
- *"be consistent with greenhouse gas inventories and relevant historical data"*
- *"be based on transparent, complete, consistent, comparable and accurate information"*
- *"be able to reproduce historical data from the National Greenhouse Gas Inventory"*

### 1.4.3 Description of key differences between FRL and FMRL

Both of the projected reference levels, the FMRL under the KP and the FRL under the LULUCF Regulation, are set to provide a baseline against which the future net forest emission can be compared for accounting purposes. The key difference between the two methods is that the FMRL included future effects of policies adopted and implemented by 2009 in the business-as-usual scenario<sup>6</sup>, however the FRL, as detailed in the LULUCF Regulation, **does not include any reference to a future scenario**. It thereby, **excludes assumptions of forest management development or expectations on future demand for wood or land use**. Instead, the FRL *“shall be based on the continuation of sustainable forest management practice, as documented in the period from 2000 to 2009 with regard to dynamic age-related forest characteristics in national forests, using the best available data.”* (Article 8(5)). This aims to make the accounting of forest-sector mitigation more transparent, as the FRL is based on documented historical information instead of assumptions for the future. This approach is also more similar to the accounting of GHGs on other sectors (Grassi et al. 2018).

The FMRL under the KP was requested in the Decision 2/CMP.6 of the Cancun Agreements on Land use, land-use change and forestry (KP 2010), and further refined in the Decision 2/CMP.7 by the Conference of the Parties in Durban (KP 2011). In the footnote 1 to paragraph 4 of the Decision 1/CMP.6 (KP 2010), the FMRL was stated to be set transparently, taking into account the following:

*“(a) removals or emissions from forest management as shown in greenhouse gas inventories and relevant historical data;*

*(b) age-class structure;*

*(c) forest management activities already undertaken;*

*(d) projected forest management activities under a ‘business as usual’ scenario;*

*(e) continuity with the treatment of forest management in the first commitment period;*

*(f) the need to exclude removals from accounting in accordance with decision 16/CMP.1, paragraph 1.*

*Points (c), (d) and (e) above were applied where relevant. The forest management reference levels also took into account the need for consistency with the inclusion of carbon pools. Reference levels including and excluding ‘force majeure’ should be provided.”*

The LULUCF Regulation does not provide a similar concise list for aspects to be taken into account in the FRL. In order to compare the list provided under the KP to requirements set out in the LULUCF Regulation, we compare the two processes in Table 1. Note that here we give only an overview of the aspects related to forest management; aspects such as the considerations to area under forest management, calculation of different carbon pools, or consideration of NDs, are covered in detail under section 2 in this document.

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<sup>6</sup> Appendix II of the Decision 2/CMP.6, see KP 2010.

Table 1. Comparison between the scope of the FMRL under the KP (KP 2010, IPCC 2014), and FRL as described in the LULUCF Regulation in terms of forest management. The points (e) and (f) in the KP referred to internal consistency within the KP, and are hence not included in this comparison with the LULUCF Regulation.

FMRL under the Kyoto Protocol:	FRL as described in the LULUCF Regulation
The scope of the FMRL is to account for changes in emissions and removals associated with Forest Management (FM) only, i.e. excluding impact of legacy and of natural disturbances	The scope of the FRL is to account for <i>“emissions and removals resulting from managed forest land”</i> (Article 8(1))
<i>“land subject to AR after 1990 transitions to Forest Land after 20 years under UNFCCC but remains in AR under the KP”</i>	<i>“Where land use is converted, Member States shall, 20 years after the date of that conversion, change the categorization of forest land, cropland, grassland, wetland, settlements and other land from such land converted to another type of land to such land remaining the same type of land.”</i> (Article 5(3))
<i>“removals or emissions from forest management as shown in greenhouse gas inventories and relevant historical data”</i>	<i>“Member States shall demonstrate consistency between the methods and data used to determine the proposed forest reference level in the national forestry accounting plan and those used in the reporting for managed forest land.”</i> (Article 8(5))  <i>“the reference level shall be consistent with greenhouse gas inventories and relevant historical data and shall be based on transparent, complete, consistent, comparable and accurate information. In particular, the model used to construct the reference level shall be able to reproduce historical data from the National Greenhouse Gas Inventory”</i> (Annex IV.A(h))
<i>“age-class structure”</i>	<i>“The forest reference level shall be based on the continuation of sustainable forest management practice, as documented in the period from 2000 to 2009 with regard to dynamic age-related forest characteristics in national forests, using the best available data.”</i> (Article 8(5))  <i>“Forest reference levels [...] shall take account of the future impact of dynamic age-related forest characteristics in order not to unduly constrain forest management intensity as a core element of sustainable forest management practice, with the aim of maintaining or strengthening long-term carbon sinks”</i> (Article 8(5))
<i>“forest management activities already undertaken”</i>	<i>“The forest reference level shall be based on the continuation of sustainable forest management practice, as documented in the period from 2000 to 2009 with regard to dynamic age-related forest characteristics in national forests, using the best available data.”</i> (Article 8(5))
<i>“projected forest management activities under ‘business as usual’ scenario”</i>	<b>NOTE:</b> no mention of a ‘scenario’ projection in the LULUCF Regulation. Instead, the FRL is to be projected assuming continuation of the FMPs as in the RP.

#### **1.4.4 General concepts about the FRL projections**

This section aims to clarify some general aspects about the FRL projections in line with the LULUCF Regulation.

The use of the FRL should allow the impact of changes in FMP relative to a historical RP to be fully reflected in the accounts. This allows the accounting of forest mitigation to be comparable to other GHG sectors, because all sectors implicitly reflect the impact of policy or management changes relative to a base year or period. Therefore, the use of a FRL allows comparability of forest credits with other sectors (Grassi et al. 2018).

The projection behind the FRL aims to represent what would occur on the MFL if the historical management regime were to be continued. Therefore, the assumed future impact of policies and markets are not to be included in the FRL estimation, since in all other GHG sectors such impacts are accounted for as credits<sup>7</sup> or debits<sup>8</sup>. The same management practices of the RP, without any rate of variation, are applied during the CP. This ensures that the FRL is a best possible estimate of the counterfactual value of emissions and removals that would have occurred in the absence of the impacts of policies and measures already in place, and of any variation of such policies and measures or of any new policy and measure put in place after the RP.

However, the FRL has to include the expected natural dynamics in forest carbon stocks in the country, through the combination of the expected changes in forest characteristics (e.g. biomass available for wood supply, net increment, etc.) and the "*continuation of forest management practice*" (Article 8(5)) in the RP.

Article 5(4) requires the Member States to include in their accounts any change in the carbon stock of above-ground biomass, below-ground biomass, litter, dead wood, soil organic carbon, and HWP. However, "*Member States may choose not to include in their accounts changes in carbon stocks of carbon pools provided that the carbon pool is not a source*". This is however not an option in the land accounting category MFL for above-ground biomass, dead wood and HWP; for these carbon pools, all changes in the carbon stocks need to be included in the accounts.

Even though, according to Article 8(5), the FRL shall not "*unduly constrain forest management intensity*", the FRL estimation cannot contradict the first paragraph of Article 8(5) "*The forest reference level shall be based on the continuation of sustainable forest management practice, as documented in the period from 2000 to 2009*". This part of the LULUCF Regulation can be understood reflecting the need to model the development of age-related characteristics of the forests over time, instead of fixing those on the level of the RP. Section 2.3 of this document provides more detailed guidance on how to take this into account in the estimations of the FRL.

It is important to understand that the FRL is not a constraint on future management, and does not place a limit or threshold that should be met or improved upon (see e.g. Matthews and Henshall 2018). Instead, the Member States are free to pursue and evolve sustainable management practices as they see fit. The purpose of the FRL is to allow the consequences to be accounted for in a transparent and reliable manner.

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<sup>7</sup> For instance, impacts of a policy in the energy sector leading to credits are those associated to a set of fiscal incentives for the production of renewable energy that determine a growth of the renewable energy market, which triggers a decrease in the cost of renewable energy production and consequently a progressive increase in the installation of renewable energy plants and in the associated carbon emissions.

<sup>8</sup> For instance, impacts of a policy in the energy sector leading to debits are those associated with the removal of subsidies to fossil fuels that has the largest impact in the year in which is applied and a degressive impact in the following years according to the decreasing use of fossil fuels.

## SECTION 2

### **2 POSSIBLE WAYS TO IMPLEMENT THE FRL REQUIREMENTS IN LINE WITH THE LULUCF REGULATION REQUIREMENTS**

This section provides guidance for Member States on how to estimate the FRLs requested in Article 8 of the LULUCF Regulation. A step-by-step approach for projecting emissions by sources and removals by sinks from MFL is proposed, and various methods to implement each sequential step are described in detail. An overview of key concepts for the development of the FRL is recalled below in Box 2. In addition, an overview of the suggested step-wise approach is presented below in Box 3. The steps proposed in this section have been organized in a structure that can be used to properly include the reporting of the FRL in the NFAP.

The aim of this section is to provide general guidance on the development of the FRL estimations for the CP, including descriptions of some of the decisions and choices that a Member State will need to consider when establishing the FRL. Also, this section provides practical suggestions on how to establish the FRL and provides guidance on how to report the FRL. The section also includes some approaches and examples of good practices, as well as several warnings about 'not good practice' examples.

Within the context of this technical guidance document, a 'good practice' refers to an advice that is interpreted as being in line with the LULUCF Regulation and that aims to help a Member State to fulfil its requirement. As the approaches and examples described in this document are not binding to the Member States, it is not mandatory to follow the advised 'good practices'. There may exist a variety of other approaches to prepare the FRL in line with the Regulation and the ultimate choice of the method to calculate the FRL will depend on the national circumstances, including data availability and modelling capacity. Moreover, while the authors have sought to use their best judgement in providing the guidance for 'good' and 'not good practices', there may exist situations where a Member State chooses to implement a 'not good practice' approach. In such a case, it is recommended to provide clear justification of why such an approach was chosen, and what effects this choice will have on the FRL.

**Box 2: Key concepts for the implementation of the FRL**

**Compliance period (CP).** The period 2021-2030, to which the LULUCF Regulation sets out the commitments of the Member States for LULUCF, and the rules for the accounting of emissions and removals from LULUCF and for checking the compliance of Member States with those commitments (Article 1 of the LULUCF Regulation).

**Dynamic age-related forest characteristics.** The LULUCF Regulation refers to "*dynamic age-related forest characteristics*" (Article 8(5)). In this technical guidance document, age-related characteristics are understood to refer to the state of 'maturity' of the forest, which can be characterized e.g. with mean age of a stand, its biomass density, and age or diameter class distribution. 'Dynamic' is understood to refer to the development of these characteristics over time, such as the movement of a stand from one age or diameter class to another over time.

**Forest Management Practice (FMP).** Refers to a set of activities being carried out at different phases of the stand development. FMP can thus be seen as a set of activities carried out and aimed at fulfilling specific functions assigned to a forest (production, protection, etc.), including, e.g., the regeneration modality, the species planted, the schedule and intensity of thinning and final cut. Examples of activities are soil preparation and thinning, and many of the activities can be used in many FMPs. In the context of this document, also 'no management' is considered as a possible FMP.

**Reference period (RP).** The period from 2000 to 2009.

**State of the forest.** Set of data and information that describe the forest, such as total area of Managed Forest Land; as well as stratum-specific variables, e.g. area, increment, biomass, age-related information.

**Stratum.** A part of forest (distinguished geographically or grouped across different geographic locations) homogeneous for all the criteria applied to the stratification process (tree species, forest type, management system, ownership, etc.). Each stratum differs from other strata by the value of at least one of the criteria of stratification.

**Box 3. Overview of the suggested step-wise approach to implement FRLs and figure highlighting how the steps are suggested to be carried out sequentially**

**Step 1:** Stratify the area of MFL, according to country-defined criteria, and apply the stratification in a consistent manner over time, including the RP 2000-2009.

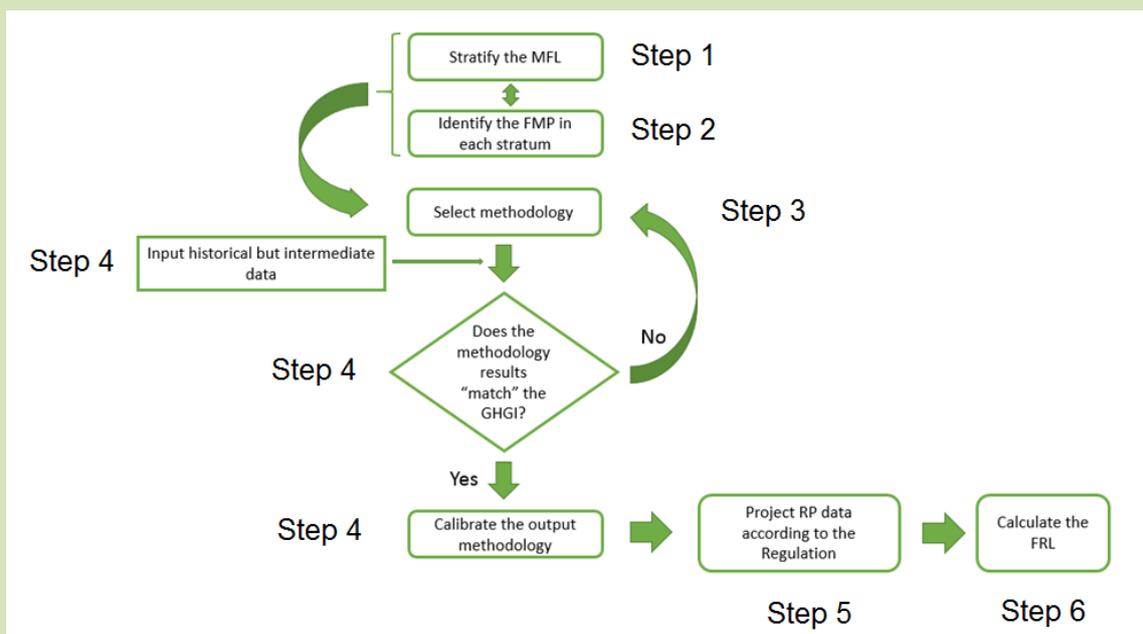
**Step 2:** Identify and document the FMPs in each strata for the 2000-2009 period, based on country-defined and quantifiable operational criteria.

**Step 3:** Select the appropriate methodology to project the development of carbon pools based on available data (including strata and management practices described in Steps 1 and 2) and national circumstances.

**Step 4:** Calibrate the selected methodology based on real observed data and show that the methodology is able to reproduce the GHGI estimates.

**Step 5:** Project the future development of anthropogenic forest GHG emissions by sources and removals by sinks for the CP.

**Step 6:** Calculate the FRLs as average of emissions and removals during 2021-2025 and 2026-2030.



As Step 1 and 2 are closely interlinked, it is possible that a Member State may have to perform these two steps in conjunction with each other. Also, (parts of) these steps may already be built in into the modelling frameworks. Nevertheless, even if a Member State had an existing modelling framework that is intended to use for the development of the FRL, it is advised that the Member State reflects on each of the suggested steps and documents in detail the data sources being used and how the model works, to allow for transparency and to accommodate an external review of the FRL.

## 2.1 Stratification

### Step 1: Stratify managed forest land

Stratify the area of managed forest land, according to country-defined criteria, and apply the stratification in a consistent manner over time, including the RP 2000-2009.

This subsection is structured as follows:

*2.1.1 Introduction (p. 32)*

*2.1.2 Possible criteria for stratification (p. 33)*

*2.1.3 Consistency requirements for stratification criteria (p. 35)*

*2.1.4 Documenting the strata (p. 36)*

*2.1.5 Additional data (p. 37)*

### 2.1.1 Introduction

In this technical guidance document, we propose to start the preparation of the FRL with stratification, in other words dividing the MFL into classes. The strata defined in the first step will then be used as a basis for defining the FMPs in Step 2.

A **Stratum** (in the context of this document) is a part of forest (distinguished geographically or grouped across different geographic locations) homogeneous for all the criteria applied to the stratification process (tree species, forest type, management system, ownership, etc.). Each stratum differs from other strata by at least one of the criteria of stratification.

Stratification is not an explicit requirement in the LULUCF Regulation. On the other hand, the FRL *"shall be based on transparent, complete, consistent, comparable and accurate information"* (Annex IV.A(h) of the LULUCF Regulation). Clear documentation of the stratification (division of the MFL into classes) helps to make the description of the forests more structured and thus more transparent and easier for reviewing.

Stratification also serves to enhance the reporting and make it easier to understand – even for those not familiar with the specific national circumstances. The Member States are hence advised to use a stratification principle that is deemed suitable to describe the forests and FMPs in the respective countries, instead of adopting a general rule set for stratification. The purpose of the stratification in Step 1 is to document clearly the basis for the allocation of the FMPs on the MFL.

The basis and level of detail for the stratification are likely to depend strongly on the national circumstances and the FMPs applied in the country. FMPs applied in forests primarily used for wood production differ from the practices applied in forests primarily serving other purposes, such as water protection or recreation. The FMPs may differ between forests on plains and forests on steep slopes, for different tree species mixtures, growing conditions, etc. State and private forest owners may have different FMPs in forests that are similar in other characteristics. With stratification, such differences can be taken into account by the Member State. In other words, stratification of the MFL serves to provide a basis for distinguishing different types of FMPs.

The LULUCF Regulation also explicitly requests the Member States to *"demonstrate consistency between the methods and data used to determine the proposed forest reference level in the national forestry accounting plan and those used in the reporting for managed forest land."* (Article 8(5)). This means that where applicable, it is good practice to use the same principles for the stratification as those used in the GHG

inventory (GHGI) or national forest inventory (NFI) (if the NFI forms the basis for reporting for managed forest land). However, when deemed appropriate and justifiable, the stratification for the FRL may differ from the stratification used in, for example, the NFI, and may sometimes be partly already implemented in the forest model.

### **2.1.2 Possible criteria for stratification**

Countries may use different **criteria to stratify MFL**, typically including some of the following examples:

- **Bio-physical context**
  - Geographic part of the country (e.g. North and South)
  - Topography (e.g. plain and mountainous, flat terrain and slope)
  - Bio-geophysical site conditions (e.g. site index)
- **Administrative/legal context**
  - Administrative boundaries (region, province, municipality, etc.)
  - Ownership (private, public)
- **Function and characteristics of forest stands**
  - Functions/objective assigned to forest (timber production, water quality protection, maintenance of habitats, recreation, conservation etc.)
  - Forest management/ silvicultural system (coppice forest vs. high forest, clearcut vs. shelterwood, even-aged forestry, etc.)
  - Tree species composition/mixture (forest categories and types, prevailing tree species, mixtures, etc.)
  - Quality of timber produced (sawlogs, pulpwood, firewood)
  - Vulnerability to external disturbances (fire, windstorms, insect outbreaks, etc.)
  - Accessibility (e.g. roads, remote forests)

**Examples of possible** (but not limited to) **stratification of MFL** in some Member States are presented in the boxes below. Note that these are examples presented previously in the literature, and do not necessarily represent the approach that will be selected by the Member States for the preparation of the FRL.

#### **Box 4: Example of stratification for Finland**

For the GHG estimations in the National Inventory Report (NIR), Finland has used stratification by region (south/north) and soil type (mineral/organic). To cover the peculiarities of forest management in the country in more detail (Yrjölä, 2002), stratification is also possible along the following criteria:

- Southern Finland and Northern Finland
- Different tree species (pine, spruce, silver birch, downy birch, larch, aspen)
- Site classes (OMT - rich, MT - medium, VT - rather poor and CT - poor forest site types and peat soil)
- Main function of forests (timber production, reindeer husbandry, protection, recreation)
- Forest owner

### **Box 5: Example of stratification for Sweden**

In earlier analysis of the forests in Sweden, the following criteria have been used to distinguish the area used for different FMPs (Skogsstyrelsen, 2015):

- Geographic region (a total of 12 regions are being used, each covering a set of counties)
- Forest ownership (non-industrial private owners, other owners (including government, municipalities, church, forest companies))
- Main function of forest (production forest, voluntarily set-aside forests, formally protected nature reserves)
- Forest type, characterized by tree species (Scots pine, Norway spruce, Lodgepole pine, Birch, Other), soil moisture and site index

### **Box 6: Example of stratification for Croatia**

According to description of forests and forest management in Croatia (Law on forests, 2014; Ordinance on forest management, 2015; NIR, 2017) managed forest area in the country can be stratified by the following criteria:

- Main function of forests (commercial, protective, special purpose)
- MFL category (high forests, plantations, forest cultures, plantations, coppices, maquia, shrub, garigue, scrub)
- Management type (e.g. even aged or uneven aged)
- Tree species
- Terrain topography
- Level of fire vulnerability
- Forest owner

### **Box 7: Example of stratification for France**

In France, the following criteria have been used to stratify the forests in order to distinguish the area used for different FMPs (Colin et al. 2016):

- Cultivated poplar stands, other stands
  - Further stratification for cultivated poplar stands based on:
    - Clone group
    - Region
  - Further stratification for other stands based on:
    - Forest cover type
    - tree species
    - Ownership category
    - Biogeographical region

An example of stratification based on the criteria listed in Box 5 for Sweden is presented in Figure 4.

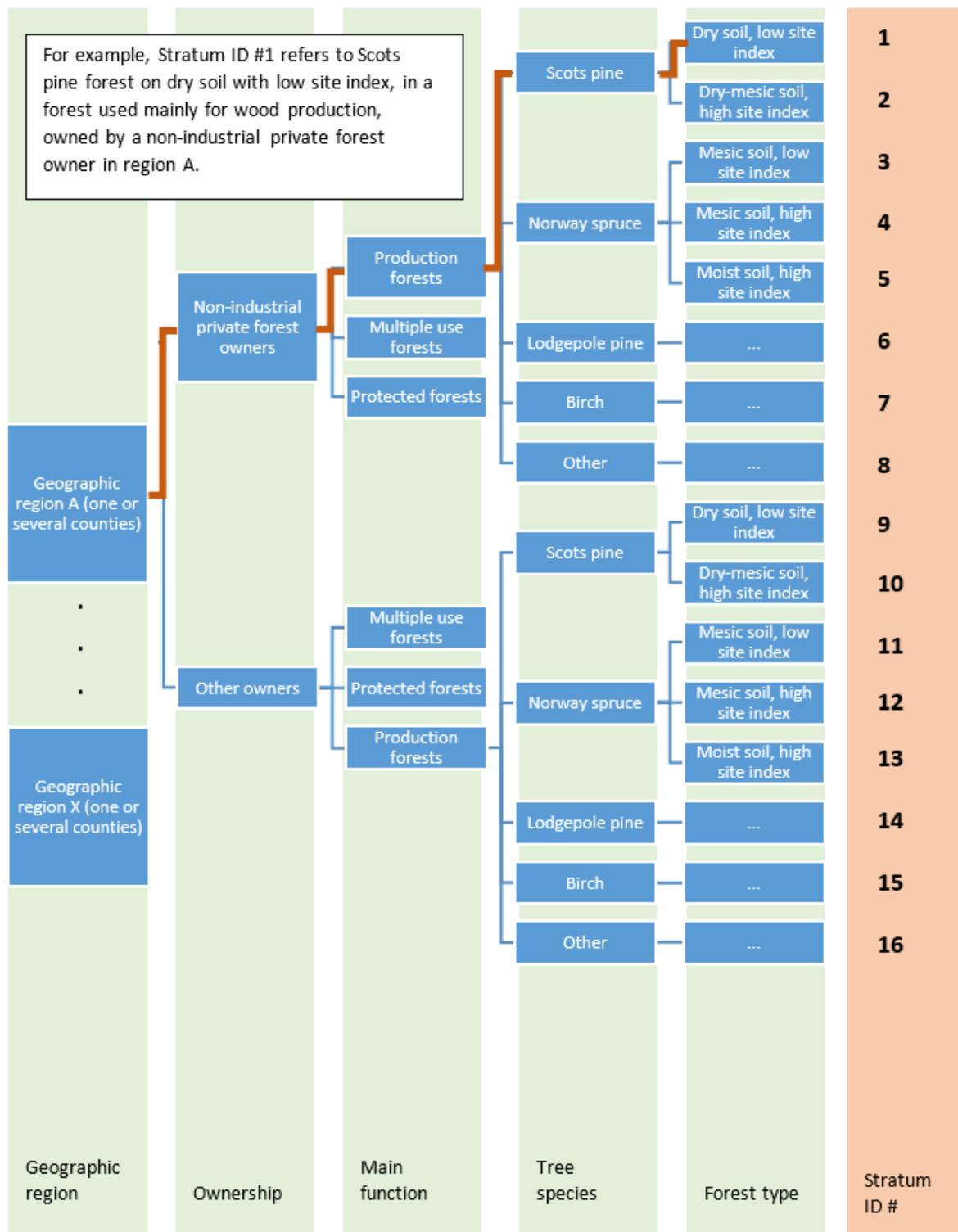


Figure 4. An example of stratification following the criteria presented in Box 5.

### 2.1.3 Consistency requirements for stratification criteria

The criteria used for stratification are to remain the same in the modelling of historical and projected emissions and removals. The number of strata is constrained by available data and method (model) requirements used for estimation of FRL.

We suggest preparing a list of data necessary for the method chosen for FRL estimation, then checking which detailing of stratification still can satisfy the data demand. The level of detail needed for the stratification depends on the method chosen for the FRL estimation, as well as on the available data.

According to Article 8(5) of the LULUCF Regulation, "*The forest reference level shall be based on the continuation of sustainable forest management practice, as documented in the period from 2000 to 2009*". This implies that the FRL is based on the continuation of (documented) sustainable FMPs in the historical RP, and the FMPs considered in the FRL are not projected to change during the CP. Similarly, once the strata are defined and FMPs associated to each stratum, they are expected to not change over the CP.

**Thus, a stratum is a coherent unit within which the FMP does not change over time.** Hence, it is not good practice to stratify the MFL by criteria that may change relatively fast over time (e.g. age class or harvest volume). The FRL is based on the continuation of (documented) sustainable FMPs as in the period 2000-2009. This in turn means that once the strata are defined and created, and FMPs associated to each stratum, these are expected to not change over the CP. However, the forest within each stratum can be divided further into units for modelling purposes (e.g. the model may be based on age classes). The modelling assumptions are discussed in detail in Step 3 (see section 2.3) and assumptions to be taken for the projection of the FRL are further discussed in section 2.5.

**It is good practice that the construction of FRL reflects as close as possible any stratification already used in the national GHGI or the NFI.** This facilitates demonstrating that the model used to construct the FRL is able to reproduce historical data from the GHGI. It is recommended that any deviation from this good practice is documented and justified by the Member State.

It is also good practice to provide a description of the forest definition used for the construction of FRL and explain whether it differs from that used in the national GHGI.

#### **2.1.4 Documenting the strata**

It is good practice to document the following information for each stratum:

- Area during the RP 2000-2009.
- Development of age-related forest characteristics during the RP (e.g., area of forest stands in each age class, average above-ground and below-ground biomass in each age class, basal area, average diameter in each age class, increments in each age class etc.; for uneven-aged forest the respective information concerns the whole forest instead of age classes) depending on data requirements of the method used for FRL estimation.
- The forest age-related characteristics for the year which is the closest to the starting year of modelling, i.e., 2009, or is representative for the starting year of modelling.
- Species composition.
- Additional forest characteristics relevant to the criteria of the stratification and method used for FRL estimation.

It is important to quantitatively define those forest characteristics which are used in the method selected by a Member State for FRL estimation. The purpose of the documentation is to comply with the requirement of "*transparent, complete, consistent, comparable and accurate information*" (Annex IV.A(h)) and to allow for proper reviewing of the FRL estimation by designated experts. The forest characteristics can be presented in a table or a set of tables. Sources of information used for description of the forest characteristics are also to be documented. An example of possible table for documenting

information sources used for determining forest characteristics in each stratum is Table 2 (a filled in example of Table 2 is presented in Annex III of this document).

Table 2: Example of a table in which Member States may document data sources used as a basis for stratification of MFL. See Annex III of this document for an example of how the table can be filled in. Member States may add additional sources of information to the table so that it accurately reflects the national circumstances.

Forest characteristics	Data references	Stratum ID where the characteristics and reference are relevant
Aboveground biomass		
Belowground biomass		
Area		
Species composition, species X, ...n		
....		

### 2.1.5 Additional data

**If a Member State does not have all data** necessary for documenting the forest characteristics (e.g., based on NFI or other research and monitoring), other published data may be used. Box 8 gives an overview of possible data sources that may be considered. Furthermore, some of the data, e.g. forest age related increments, can be approximated using forest growth models (e.g. Schelhaas et al., 2018).

#### **Box 8: Examples of possible data sources for complementing national data**

- Forest cover maps (JRC; Hansen et al., 2013),
- Maps of forest biomass (Barredo et al., 2012; Gallaun et al., 2010; Kindermann et al., 2008; Thurner et al., 2014),
- Maps of tree species (Brus et al., 2011; JRC; Mauri et al., 2017),
- Maps of wood production (Verkerk et al., 2015),
- Spatial data on logging residues (Di Fulvio et al., 2016),
- Biomass expansion factors (Zianis et al. 2005).

## 2.2 Forest management practices

### Step 2: Description of forest management practices

Identify and describe the FMPs in each strata for 2000-2009 based on country-defined operational criteria and quantifiable data.

This subsection is structured as follows:

*2.2.1 Introduction (p. 38)*

*2.2.2 What is a forest management practice? (p. 38)*

*2.2.3 Description of forest management practices (p. 39)*

*2.2.4 Documentation of forest management practices (p. 41)*

*2.2.5 Implementation of forest management practices (p. 45)*

*2.2.6 Possible data sources for documenting forest management practices (p. 49)*

*2.2.7 Sustainability of forest management practices (p. 50)*

*2.2.8 Adaptation of forest management practices to statistical harvest levels (p. 51)*

#### 2.2.1 Introduction

In this Step, the FMPs applied in the period from 2000 to 2009 are described for each stratum (see Step 1 – section 2.1) through country-defined and quantifiable operational criteria. Both the qualitative and quantitative aspects of each FMPs are to be documented. In addition, it should be demonstrated how these definitions have been implemented and applied consistently over time for the estimation of the FRL.

The justification for this Step stems from Article 8(5) of the LULUCF Regulation, which states that the FRL “*shall be based on the continuation of sustainable forest management practice, as documented in the period from 2000 to 2009*”. As the continuation of sustainable management practice forms the basis for the FRL, it is important that Member States provide a transparent documentation of the FMPs that were applied in the period from 2000 to 2009.

Although Article 8(5) refers to “*practice*” in the singular, it is interpreted that depending on the understanding and justification of this term provided by the Member State, the overall FMP within the Member State can also be considered to consist of several different practices, depending on, for example, the stratification of forests to accommodate national circumstances. Nevertheless, the documentation needs to use quantitative criteria, to show that the FRL is “*based on transparent, complete, consistent, comparable and accurate information*”, as required by Annex IV.A(h) of the LULUCF Regulation.

It is good practice to describe how large a share of the national forests was covered by a given FMP in the period from 2000 to 2009. It is also good practice that Member States document explicitly the data sources which have been used to identify and specify each FMP.

#### 2.2.2 What is a forest management practice?

In the context of this document, a **forest management practice (FMP)** refers to a set of management activities (i.e. silvicultural/forestry operations) being carried out at different phases of the stand development.

A FMP can thus be referred to a set of management activities carried out and aimed at fulfilling specific functions assigned to a forest (production, protection, etc.), including, for example, the regeneration modality, the species planted, the schedule and intensity of thinning and final cut. Examples of activities are soil preparation and thinning, and more than one activity can be used in different FMPs.

Through these activities, the FMP describes the management throughout the full cycle of the stand development in qualitative and quantitative terms. An FMP describes the origin and development of a forest stand and includes specification of, for example:

- The origin (by seed or vegetative, such as suckers or coppice) of the stand.
- The first activity being carried out (i.e. soil preparation) to the last activity of the cycle (i.e. final cut).
- When trees are harvested (e.g. specific age or dimension).
- Description of the main methods of removing trees. Are all trees removed in one final harvest (e.g. a clearcut), or are trees harvested through selective cutting?
- Description if stumps are being harvested or not.
- 'No management' is also a possible FMP.

The outcomes of FMPs are dependent on the environment, the growing conditions and tree species (hence, FMPs are linked to specific strata to reflect how the forest is being managed and the outcome of such managements). A qualitatively similar practice used in one part of the EU can in quantitative terms be different in another environment.

One way to think of a FMP is a comparison to a toolbox: it includes many tools (activities), used in different phases of the stand development. These tools or activities are not unique to a single FMP and they can be used in many FMPs, even in different stages of development (e.g. an activity example is clearcut that could be done in FMP 1 at 50 years and in FMP 2 at 120 years).

### ***2.2.3 Description of forest management practices***

**It is good practice that the Member States describe in detail the FMPs applied in the MFL in the period from 2000 to 2009.** In this subsection, we provide examples of possible descriptions of FMPs, and discuss aspects that are considered as good practice to include in the FMP description. It may, however, not be necessary to provide all details as showcased here; the appropriate level of detail in the FMP description depends on the national circumstances, including data and model availability, as well as on the chosen modelling approach.

To demonstrate that the FRL is based on "*transparent, complete, consistent, comparable and accurate information*" (Annex IV of the LULUCF Regulation), it is good practice to describe each FMP in terms of **qualitative** and **quantitative** aspects. Such aspects may be considered in the following terms:

- **Qualitative aspects:** The qualitative information concerning the FMP describes **what** is being done: which activities or operations are carried out for that specific FMP at different phases of the stand development.
- **Quantitative aspects:** The quantitative information concerning each FMP describes **when** and **how** each activity or operation is carried out.

It is good practice to provide the qualitative documentation of each FMP so that it describes the management activities throughout the full cycle of the stand development, starting from the first activity being carried out (e.g. soil preparation) to the last activity of the cycle (e.g. end-of-rotation cutting).

To the extent possible, it is good practice to define when each management activity is being carried out (i.e. the quantitative aspects of the FMP) based on age-related characteristics of a stand. This term can also be understood as the state of 'maturity' of the forest. This links the description of the practices to the requirement in the LULUCF Regulation to "*take account of the future impact of dynamic age-related forest characteristics*" (Article 8(5)), and contributes to providing a transparent basis on showing that the FMP projected for the future is truly "*continuation of sustainable forest management practice*" (Article 8(5)) as documented in the RP, and not a change in FMP. The definition of when each activity is being carried may also be linked to variables describing the state of the forest (see Box 9).

**Box 9: Examples of variables that may be used to define when and how each activity or operation is carried out**

**Examples of variables describing the state of the forest:**

- Total area of MFL
- Stratum-specific variables:
  - Area of stratum
  - Mean age
  - Mean biomass volume
  - Number of seedlings/trees
  - Basal area
  - Crown cover
  - Mean diameter
  - Volume class of the growing stock
  - Stocking level

**Examples of age-related characteristics** that describe the maturity of the stand:

- Mean age of the stand
- Mean diameter of the stand
- Mean volume of growing stock

**Examples of operations** characterizing FMP, linking the state of the forest and the timing of the operation:

- Pre-commercial thinning when the stand is 10-15 years old
- Pre-commercial thinning when trees reach the diameter class (Dbh) of 10-15 cm
- Thinning when the basal area exceeds 18 m<sup>2</sup>/ha and the age exceeds 30 years

**It is not good practice to define when each activity is being carried out based on assumptions or projected sources of information** such as future wood price development, interest rates, net present value estimates, or expected demand for wood for energy and material purposes. See Figure 5 for an overview of good practice and not-good practice examples of criteria that may be used to define when each activity is being carried out.

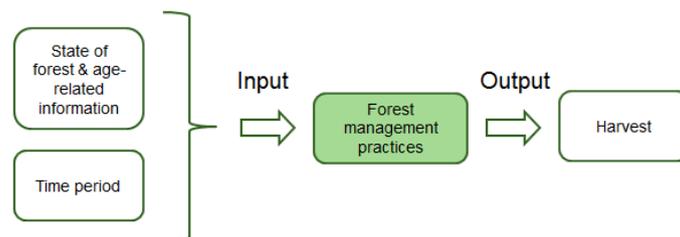
When documenting the FMPs, it is good practice to describe as closely as possible the **management practices that actually took place during RP**, and not the management that was expected, what was legally allowed during the RP, or the best possible management of the forest would have been. The aim is indeed to describe as accurately and precisely to correspond to the management practices that were actually carried out during the RP. This information will then be the basis to model the

continuation of management practices documented in the RP in the period from 2021 to 2030.

When documenting the FMPs in a Member State, it is not good practice to distinguish different FMPs (or management activities) only based on a criterion that has a large annual variability (i.e. rotation). As an example, it is not considered good practice to define one FMP (FMP 1) for which the final cut takes place when the trees are 81 to 82 years old, a second practice (FMP 2) for which the final cut takes place when the trees are 83 to 84 years old, a third practice (FMP 3) for which the final cut takes place when the trees are 85 to 86 years old, and so forth. A single FMP may instead cover a wider range of criteria for it to encompass and cover such annual fluctuations.

### Good practice examples

- Age of stand
- Diameter class of trees
- Number of seedlings
- Basal area
- Crown cover
- Stocking level
- Number of trees
- Time between operations
- Time after other operation



### Not good practice examples

- Expected demand for wood for material & energy purposes
- Changes in interest rates
- Changes in consumption patterns
- Future development of policies
- Changes and trends in forest owners' behavior
- Changes in market conditions

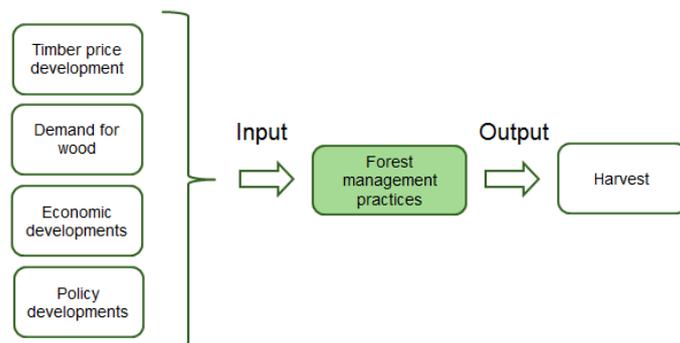


Figure 5: Good practice and not good practice example of criteria that may be used to define when a management activity within a FMP is being carried out.

## 2.2.4 Documentation of forest management practices

Since the documentation of current FMPs should reflect the country's circumstances appropriately, a large degree of flexibility can be applied to the documentation, as long as (i) the criteria/values (or similar indicators) used are transparently documented and their rationale illustrated, and (ii) the same FMPs are applied consistently when projecting the FRL (see Step 5 – section 2.5).

Here, we give two alternative examples on how to document FMPs: describing the FMPs through forestry activities (Alternative 1), and describing the FMPs by biomass removal percentage within an age or diameter class (Alternative 2).

### 2.2.4.1 Alternative 1: Describe FMPs by management activities

As a first step, it is suggested to provide a qualitative description of the FMPs as applied during the RP. In this step, the aim is to describe each FMP in terms of the associated set

of management activities (i.e. silvicultural/forestry operations) to be carried out. One alternative approach to document the qualitative information of the management practices is shown in Table 3.

It should be noted that Table 3 is only an example of how the qualitative aspects of the FMPs can be documented and Member States are free to adopt the table as they see fit to fully reflect the country's circumstances.

Table 3: Example of how Member States may describe the qualitative aspects of the FMPs as applied in the Member State during the RP. See Annex III of this document for an example of how the table can be filled in.

Forest Management Practice			
Index	Name of Practice	Short Description of Practice	Data source for practice
FMP 1	Pine clearcutting	Even aged pine forest with long rotation and regenerated by clearcut	NFI
FMP 2	Spruce clearcutting	Even aged spruce forest regenerated by clearcutting	NFI
FMP 3	Pine uniform shelterwood	Even aged pine forest regenerated with consecutive cuttings applied on the whole area	NFI
FMP 4	Close-to-nature forest	Forest with close to nature management and minimal intervention	NFI
...	...	...	...

After the qualitative description of each FMP has been defined, it is good practice to document the specific characteristics of each FMP. In such tables, it is good practice to provide quantitative information about each FMP, thereby defining when each activity is being carried out.

It is good practice that the description documents: (i) how is each activity performed, and (ii) when is each activity being carried out. It is good practice to document the characteristics of each management practice as precisely as possible to facilitate the modelling of the management practices and to clarify the difference between the management practices. It is important that Member States also provide quantitative information for all activity criteria so that they can be modelled and applied to estimate the projection of the FRL.

One alternative approach to document the quantitative information of the management practices is shown in Table 4 and Table 5. These two tables show an example of how the FMPs can be documented according to two broad categories of management: the management practices based on clear-felling (even-aged forest) (see Table 4), and the management practices without clear-felling (uneven-aged forest) (see Table 5). Member States should note that Table 4 and Table 5 are only examples of how Member States may document the quantitative aspects of the FMPs. Member States are free to adapt Table 4 and Table 5 as they see fit to fully reflect country specific circumstances.

Table 4: Example of how to quantify each FMP in terms of its management activities (silvicultural/forestry operations). In this table only the FMPs that include a final harvest of the forest is described. The same Index and name of FMPs as set out in in Table 3 are applied. Each activity (i.e. silvicultural/forestry operation) should be defined and reported in terms of two aspects: I) the criteria for when the operation is carried out (e.g. at a specific minimum age, time interval, or a specific diameter class (Dbh)); II) the percentage of living biomass removed. See Annex III of this document for a detailed example of how the table can be filled in.

Forest management practice		Silvicultural operations with final harvesting							
		Pre-commercial thinning		First commercial thinning		Second commercial thinning		Final cutting	
Index	Name of Practice	Age (yrs) or Dbh (cm)	% biomass harvest	Age (yrs) or Dbh (cm)	% biomass removals	Age (yrs) or Dbh (cm)	% biomass removals	Age (yrs) or Dbh (cm)	% biomass removals
FMP1	Pine clearcutting long	>10	15%	>20	15%	N.A.	N.A.	120 - 140	95%
FMP2	Spruce clearcutting	>10	15%	>20	15%	N.A.	N.A.	80-100	95%
FMP3	Pine uniform shelterwood	N.A.	N.A.	>20	15%	>30	15%	80-120	95%
...	...	...	...	...	...	...	...	...	...

Table 5: Example of how to quantify each national FMP in terms of its description of its management activities (silvicultural/forestry operations). In this table, only the FMPs without final harvesting of the forest is described. The same Index and name of FMPs as set out in in Table 3 are applied. See Annex III of this document for a detailed example of how the table can be filled in.

Forest management practice		Silvicultural operations without final harvesting	
Index	Name of practice	Years between two subsequent operations	% biomass removals
FMP 4	Single tree selection	15-20	15%
...	...	...	...

After the qualitative and quantitative aspects of each FMPs have been documented, it is good practice to document the use of FMPs according to the stratification of the forest land, as developed in Step 1 (see section 2.1).

One example of how this can be documented is shown in Table 6. The main aim of documenting the use of management practices in different strata is to clarify in which stratum the management practices are being implemented and to provide clear indications about the difference between strata in term of how they are being managed.

Table 6: Example of how to document the percentage distribution of FMPs for each stratum of the country. Member States are encouraged to amend the table according to the number of strata defined in Step 1 (see section 2.1), and the number of FMPs as defined in Table 3. For each stratum, the sum over the percentage distribution of FMPs should sum up to 100% and should be indicated in the row called Sum Total (%). See Annex III of this document for a detailed example of how the table can be filled in.

Stratification of MFL			% distribution of FMPs					Sum Total (%)
Strata categorization level I	Strata categorization level II	...	FMP Index 1	FMP Index 2	FMP Index 3	FMP Index 4	...	
Type I (e.g. Private commercial forest owners)	Type I (e.g. Pine)		85%	0%	0%	15%		100%
			75%	0%	0%	25%		100%
	Type II (e.g. Spruce)		0%	100%	0%	0%		100%
			0%	82%	0%	0%		100%
	Type III (e.g. Birch)		...	...	...	...	...	...
	Type IV (e.g. Aspen)							
Type II (e.g. State owned forest)	Type I (e.g. Pine)							
	Type II (e.g. Spruce)							
	Type III (e.g. Birch)							
	Type IV (e.g. Aspen)							

#### 2.2.4.2 Alternative 2: Describe FMPs by biomass removals in forest age or diameter classes

A second alternative for describing the FMPs is to define the biomass removal as a function of the age and state of the forest (e.g. age class, diameter class). This is slightly different from Alternative 1, in which the FMP are mainly documented according to the biomass removal for each specific management activity. In Alternative 2, the biomass removal (e.g. the % removal of the growing stock) is not defined according to each specific activity, but directly as a function of the age and state of the forest. As such, the difference between Alternative 1 and Alternative 2 is only in terms of how the FMPs are documented.

Similarly to Alternative 1, it is good practice to document both the qualitative and the quantitative information of the each FMP. Alternative 2 is largely based on well-established and available references of the descriptions of the FMPs, while Alternative 1 may be better suited for situations where earlier documentation is poor or does not exist.

Table 7 gives a possible example of how to document the qualitative description of the FMPs. Compared to Alternative 1, this example relies heavily on other documentation, and only provides overall principles of the FMPs. To ensure transparent documentation of the practices, careful and complete references to published documentation are here essential.

Table 7: Example of a qualitative description of FMP, following Alternative 2.

Forest management practice		
Index	Short description of practice	Determination of the actual biomass removal rates
FMP <sub>spruce</sub>	FMP <sub>spruce</sub> consists of soil preparation through scarification, planting of seedlings, pre-commercial thinning of young stands, one to three thinnings over the rotation period, and a final harvest through clearcutting. The harvest schedule and biomass removals in harvests are regulated by Forest Law (please provide reference here), and guidelines for good FMP.	The biomass removals used in the FRL are based on observations of actual harvests in the period 2000-2009. The biomass removal as a % of growing stock is determined through calculating harvest probability for a given age class using the method described in (please provide reference here).
...	...	...

Table 8 provides an example of the quantitative details to document the FMPs within Alternative 2. The rationale behind this description of FMPs is to identify as accurately as possible the characteristics of FMPs that affect the emissions and removals of GHGs from the forests. In this respect, it is good practice that the stratification of the forests (see Step 1 – section 2.1) includes at a minimum differentiation between tree species or species groups, and geographic regions in cases where it has a clear impact on forest growth. Given that the FRL shall “*take account of the future impact of dynamic age-related forest characteristics*” (Article 8(5)), it is good practice to define the harvest removals based on age-related characteristics such as age or diameter classes, seeking to provide as accurate and complete information on the FMPs as possible.

Table 8: Example of how to quantify each national FMP in terms of the percentage of biomass removal of the total growing stock in a certain age or diameter class, following Alternative 2.

Age (or Dbh) class	Biomass removal as a % of growing stock within each age or diameter class					
	0-20	21-40	41-60	61-80	81-100	...
Index						
FMP <sub>spruce</sub>	50%	20%	35%	0%	45%	...
...	...	...	...	...	...	...

### 2.2.5 Implementation of forest management practices

Some models used for the projection of the FRL may require that each management activity takes place at a specific timing of a criterion (i.e. final clearcutting takes place when the stand is 85 years old) instead of a range for a criterion (e.g. final clearcutting takes place when the stand is 80-100 years old). As such, the timing of when an activity is to be carried out may have to be set according to a single static value (or a criterion). Depending on the model being used to project the FRL, a number of quantifiable variables may have to be defined for each FMP in terms of when and how each associated management activities are being carried out (see section 2.2.3).

For simplicity, the dataset including the specification of when and how each FMP and the associated management activity actually were implemented during the RP will be referred

to as the **actual management practice**. The dataset including the quantified FMPs that will be used to by the model to project the FRL are hereafter referred to as the **modelled management practices**.

If such a static value is selected for a FMP, it is good practice that Member States do so based on the range during which the activity was implemented during the RP.

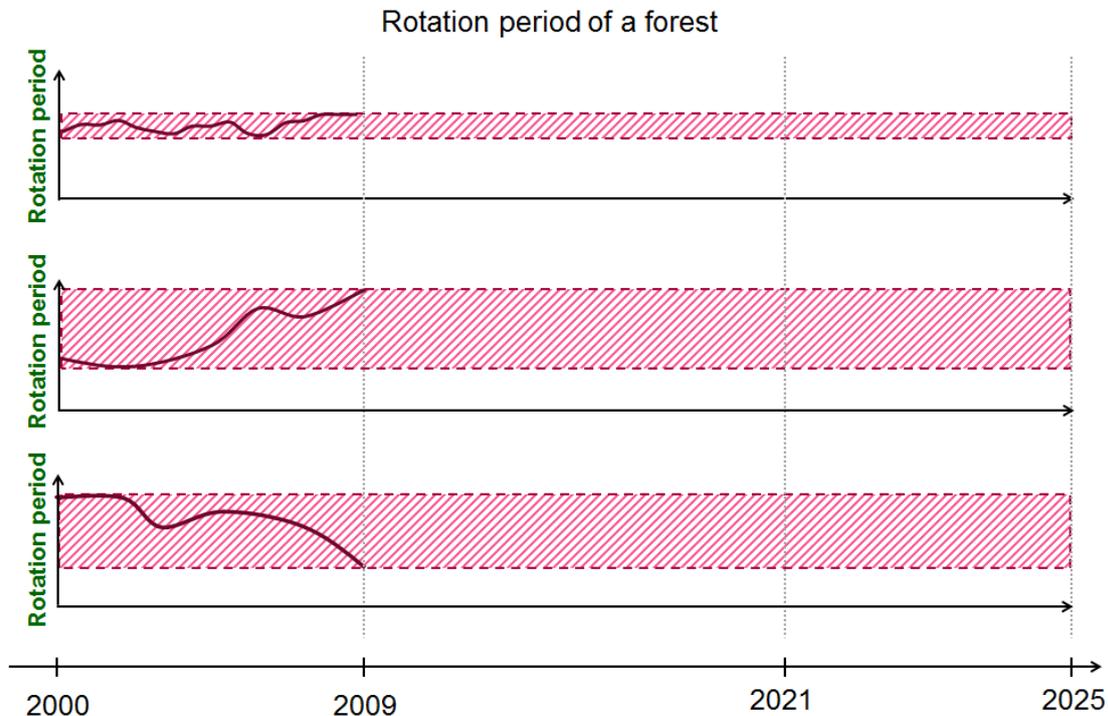


Figure 6. Three examples of historical trends in the timing of a management activity for an FMP. In this example 'Rotation period' refer to the age at which the final clearcutting takes place. The solid line shows the historical values as documented for the period from 2000 to 2009 that follow a trend over time. Continuation of such trends in the CP is not considered good practice. Instead, the shaded area shows the minimal and maximal range of the operation criteria as observed for the period from 2000 to 2009.

When deciding upon the definition of the exact criteria for when an activity is to be carried out, **it is good practice that the minimum and maximum values of when the activity was carried out during the RP set the boundary conditions for when the activity is to be carried out during the CP.**

In other words, the static value for when the management activity (silvicultural/forestry operation) does take place is to be selected by the Member State, but it is to be within the observed range during the RP and thereby not to deviate from the historical values as observed.

This implies that even if a trend in when an activity is carried could be observed and documented during the period from 2000 to 2009 (e.g. that the final clearcutting is taking place earlier in 2009 than in 2000), **it is good practice not to project such trends to continue during the CP and to confirm this in the documentation.**

Following this same logic, also situations where the praxis is to systematically change from one tree species to another after final felling, may be considered as a trend, and is not to be continued during the CP. In this case, a change in tree species would also be considered a change in FMP and as such not to be included in the FRL: as discussed in

section 2.2.3, FMP describes the management activities throughout the full cycle of the stand development, starting from the first activity being carried out (e.g. soil preparation) to the last activity of the cycle (e.g. end-of-rotation cutting). Box 10 gives a more detailed example of a situation where tree species are changing during the RP.

Because of the inter-annual variability, it is considered to be good practice to define the FMPs based on data across a period of time, instead of a single year as for other GHG categories. That is, if a quantifiable variable used to describe when a FMP is carried out (for example rotation period) varies during the RP and no clear trend can be established, then the average value for the RP would normally be used to quantify the FMP (see top example in Figure 6). However, if the quantifiable variable follows a trend or changes its value abruptly during the RP, then it could be justified that (and documented why) the latest value is applied to characterize the FMP (see middle and bottom examples in Figure 6).

Consequently, it is good practice that each FMP characteristic is quantified according to a single and static value (or criterion), not by a trend nor by a rate of change.

Further guidance on verifying the consistency between the actual management practice and the modelled management practices is provided in section 2.4.2.

**Box 10. Example of a systematic change in tree species**

Figure 7 shows an example of a situation where one tree species is systematically replaced by another in the RP. In this illustrative example, conifers were systematically replaced by broadleaved trees. In 2000, the share of broadleaved trees was only 10%, while 90% of the area was covered by conifers. Over the RP, the broadleaved trees replaced conifers, and in the end of the RP in 2009, 55% of the area was covered by broadleaved trees.

In this situation, it is good practice to model the tree species shares as those in the end of the RP, i.e. 55% broadleaved trees and 45% conifers (assuming that the MS starts the projection of the FRL as of 2010). A further change in tree species would be considered a change in FMP and as such not to be included in the FMP. Therefore, “*continuation of the sustainable forest management practice [...] with regard to age-related forest characteristics in national forests, using the best available data*” (Article 8(5)) is understood to refer to a possibility to project age-related effects, such as periodic harvests and regeneration of a given stratum. However, a change in stratum is not considered to comply with continuation of FMP as referred to in Article 8(5).

In other words, it is interpreted that it is good practice that the FRL project age-related effects within a stand (change in age structure<sup>9</sup>), but not good practice to project a change in tree species, change in management and change in area<sup>10</sup> (see section 2.3.2).

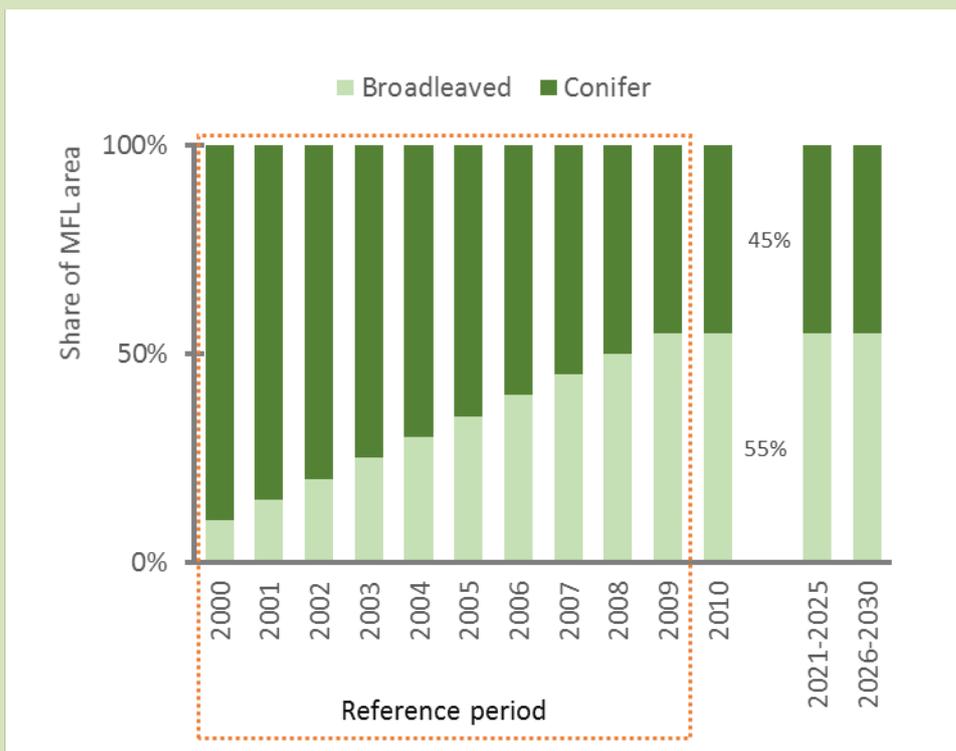


Figure 7. Example of systematic change in tree species under the RP, where conifers have systematically been replaced by broadleaved trees under the RP. In the end of the RP, the share of broadleaved trees was 55% and the share of conifers 45%. It is good practice to assume this state of the forest to prevail during the CP, instead of further change in the coverage of the tree species.

<sup>9</sup> It is important to point out that the references to age, age class, and age structure should be understood as the state of ‘maturity’ of the forest. In the case of even-aged forest, the age of the stratum could be used. However, in case of uneven-aged forest, it will correspond to the current average “size” of the forest, and it is described by parameters different than age (e.g. mean diameter, volume classes of growing stock, etc.).

<sup>10</sup> With the possible only exception of conversions to/from forest (See section 2.5.3).

### 2.2.6 Possible data sources for documenting forest management practices

Numerous Member States have long time series of information concerning the state of their forest from the NFIs. NFI usually provides data concerning the state of the forest at a given time, and a comparison of NFI plots from two different points can be used to derive information on yields and removals. All such information may be already used for GHG reporting, and hence considered also as input data for the construction of the FRL. For example, information on the FMPs that were applied in the period from 2000 to 2009 can be derived through a comparison of permanent inventory plots between years.

NFI data commonly has the disadvantage that it does not provide information about the management purposes, but only that a specific management practice has taken place. For the purpose of defining the FMPs and filling in the Table 3 to Table 8, this is not a problem as the FMPs should be defined according to the management that took place. Other data sources than NFI may of course also be used to define the FMPs, such as forest laws and other legal documents, forest management guidelines, and forest management plans, provided that it is shown that these sources describe the actual management practices, instead of only the theoretically allowed practice. For example, if there is a forest management plan adopted by the owner of a stand, and it can be shown that the owner is strictly implementing the plan, then the practices foreseen within the management plan may be used to define the FMPs for the stand.

When documenting the FMPs, **it is good practice that Member States only use data sources from the period 2000 to 2009**, as required in the LULUCF Regulation. This is the case as the Article 8(5) states that *"The forest reference level shall be based on the continuation of sustainable forest management practice, as documented in the period from 2000 to 2009"*.

A challenge when applying NFI data to document the FMPs may be that the inventory period may not match with the requirement of using data that was documented in the period from 2000 to 2009. In many EU Member States, the inventories take place over several years, and the inventory periods may not be compatible with the RP of 2000 to 2009. For instance, as illustrated in Figure 8, a Member State may perform the forest inventories based on a five-year cycle, meaning that each year 1/5 of the sample plots are measured. Furthermore, in this example, the total estimates as reported in the year 2005 are based on the inventories carried out during the period 2003 to 2007.

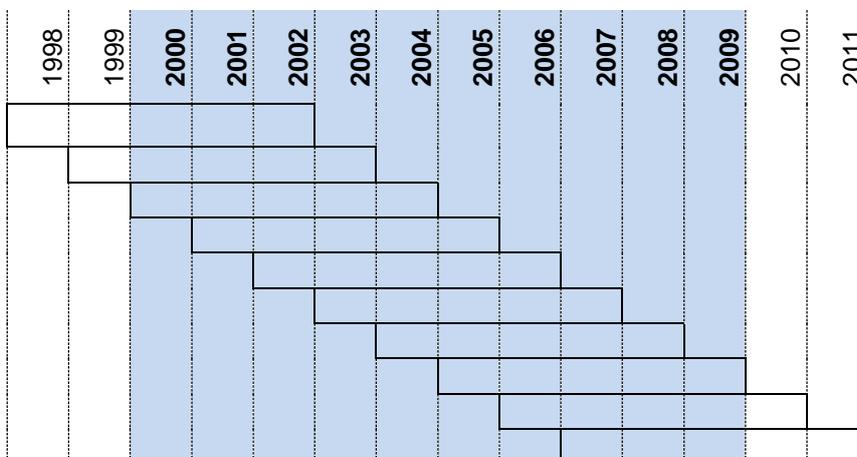


Figure 8. Example of an NFI where the inventory follows a running five-year average, reported in year X. In this example, the NFI as reported in the year 2000 is based on inventories carried out during the period 1998 to 2002.

In this example, it would be good practice that only the sample plots measured in the time period from 2000 to 2009 (shaded in blue) would be used for the documentation of the FMPs. In other words, it would be the reported total estimates for the period of 2002 to 2007 that would be used for documenting the FMPs.

However, it is likely that most Member States do not have such detailed inventory information available of their forests, and in some cases the NFI period may be completely outside the RP. **If data sources outside the period from 2000 to 2009 are used, it is good practice to document and justify this deviation.** Also, if this is the case, it is good practice to reflect on how choosing data outside the RP represents the conditions under the RP, and to document an assessment of the impact of this deviation on the FRL.

**The use of all available data sources on FMPs to construct the time series of management practices is certainly good practice as it integrates all available information.** It is good practice to document which data sources have been used to specify the FMPs and justify why these sources have been used.

In the worst case, no information may be available or suitable for the description of specific FMPs. In such cases, expert judgement may be carried out on the basis of knowledge gained concerning country specific FMPs that are being carried out. While the judgement by experienced experts may be essentially of good quality, it is difficult to verify. This is why expert judgement should be the last alternative as an approach. If expert judgement is carried out, it is highly recommended that the “elicitation protocol” from the IPCC Guidelines for expert judgment is being followed.<sup>11</sup>

### **2.2.7 Sustainability of forest management practices**

It is important to understand that the purpose of the FRL is to reflect in the accounts the impact of changes in FMP relative to a historical RP; the FRL is not a sustainability or best-management benchmark, and thus is not a benchmark of the quality of forest management in a Member State. Nevertheless, as noted in section 3.1, Member States are encouraged to provide in the NFAP information on how sustainable forest management policies and practices evolved, and to describe how these have been taken into account in the modelling of the FRL.

According to the LULUCF Regulation, the FRL “*shall be based on the continuation of sustainable forest management practice, as documented in the period from 2000 to 2009*” (Article 8(5)). The preamble (recital 16) of the LULUCF Regulation refers to the principles of sustainable forest management as adopted in the Ministerial Conferences on the Protection of Forests in Europe (‘Forest Europe’). According to Forest Europe, a forest management is defined sustainable if it maintains “*(forest) biodiversity, productivity, regeneration capacity, vitality and (forest) potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and does not cause damage to other ecosystems*”. Forest Europe’s most recent report shows the advanced progress of adoption of sustainable national forest programs across its member countries, that **in general show consistent adoption of sustainable practices** (Forest Europe 2015).

**Nonetheless, it is good practice that a Member State documents in a transparent manner how the principles of sustainable FMP are being applied within their country.** Documentation that clarifies and highlights what is defined in practice as sustainable forest management, and how such principles are being enforced

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<sup>11</sup> See IPCC 2006 (Volume 1, Annex 2.1) for further guidance

through means such as national regulations, forest certification and endorsements of specific criteria and principles, would fulfil this recommendation.

In exceptional circumstances, a Member State might signal that a (part of) FMP documented for part or the whole of the 2000-2009 RP does **not** fulfill the criteria of being **sustainable**. In principle, this does not present a problem for the estimation of the FRL; improvements (indeed, any change) in current FMP should be reflected in the **accounting** against an FRL (that assumes a **continuation** of the RP practices). However, in exceptional circumstances it might arise that the Article 8(5) condition of "**continuation of sustainable forest management practice**" invalidates the FRL modelling. In such a rare circumstance, it is good practice that the Member State:

- Fully documents (in accordance with section 2.2.4) and consequently justifies why the previous FMP infringed **sustainable FMP during the RP 2000-2009**, with reference to Forest Europe.
- Documents the (subsequently) adopted sustainable FMP (again in accordance with section 2.2.4) that **replaced** the previous non-sustainable FMP, including the date from which it was adopted and has been applied, and justifying why the replacement FMP provided an improvement in terms of sustainability.
- Documents the expected impact of the practice change, where applicable quantifiably, with respect to the key criteria and principles listed in Annex IV of Regulation 2018/841.

Note that there can be other, methodologically consistent ways of resolving such issues, instead of adopting a revised set of sustainable FMPs (for example, stratification, or use of the flexibility in selecting the value of a variable within the RP (see section 2.2.5)). It is good practice therefore to evaluate these options in priority; only in exceptional circumstances, and when all the above-mentioned aspects have been transparently documented and justified, should a replacement (adopted) FMP be considered for the projection of the FRL.

### **2.2.8 Adaptation of forest management practices to statistical harvest levels**

To complement NFI data and to acquire missing information (e.g. thresholds for operational criteria as defined in Table 4 and Table 5) modelling exercises may also be employed. As it is good practice to describe the FMPs as closely as possible to the management practices that actually took place during RP, such approaches may also be used to refine the quantitative aspects of the FMPs have been defined and documented.

A first example of such an approach is to derive the average threshold (or distribution function) for when a management activity is carried out (e.g. age to perform the final cutting) through combining the historical harvest levels with the age structure<sup>12</sup>. Through combining such data sources, information can be derived to assist the specification of the specific criteria of each FMP.

A second example of such an approach is based on obtaining harvest rates by stratum, FMP and age-class during the RP in line with the documented practices and the actual statistics of harvest at national level. If only total harvest (or aggregated harvest) is available, it is suggested to disaggregate that data by stratum and age-class based on bibliographical information describing the FMP regarding theoretical harvest<sup>13</sup> by area for each stratum and age-class.

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<sup>12</sup> An example of such an approach is described in Grassi and Pilli 2017.

<sup>13</sup> By theoretical harvest it is understood the amount of harvest documented in the forest management plans or legal texts.

Using this information and the areas in the RP, a theoretical harvest based on documented practices can be estimated and compared with the statistical harvest. This ratio between the estimated and the statistical harvest can be used improve upon the parameterization of the FMPs.

The suggested procedure is as follows:

1. Obtain the total statistical harvest for each year of the RP ( $TSH_{RP}$ ).
2. Using the FMPs as defined and documented in Step 2 (see section 2.2), estimate a theoretical harvest by area for each stratum and age ( $THbA_{RP}$ ).
3. Multiply the area of each stratum in the RP ( $A_{RP}$ ) by the theoretical harvest by area ( $THbA_{RP}$ ) to obtain a theoretical total harvest ( $TTH_{RP}$ ).
4. Verify the difference between the theoretical total harvest ( $TTH_{RP}$ ) and the statistical harvest ( $TSH_{RP}$ ).
5. Adapt the parameterization of the FMPs so that the theoretical total harvest ( $TTH_{RP}$ ) matches the statistical harvest ( $TSH_{RP}$ ).

## 2.3 Methodology

### Step 3: Selection of appropriate methodology

Select the appropriate methodology to project future development of anthropogenic forest GHG emissions by sources and removals by sinks based on available data and national circumstances.

This subsection is structured as follows:

*2.3.1 Introduction (p. 53)*

*2.3.2 Fixed parameters and dynamic variables (p. 54)*

*2.3.3 Requirements for the selected methodology (p. 56)*

*2.3.4 Modelling carbon pools in forest (p. 57)*

*2.3.5 Modelling the development of the harvested wood products (p. 63)*

*2.3.6 Modelling the development of natural disturbances (p. 67)*

*2.3.7 Modelling frameworks (p. 69)*

*2.3.8 Documenting the methodology used (p. 69)*

#### 2.3.1 Introduction

This part of the technical guidance document provides information on how to select the appropriate methodology or modelling framework for projecting the development of carbon stocks in the carbon pools in the CP. The objective is to use this methodology to project continuation of the sustainable FMPs of the RP regarding dynamic age-related forest characteristics in national forests, using the best available data.

The objective is to estimate future development of the MFL carbon pools in the CP in line with the stratification developed in the Steps 1 (see section 2.1) and the FMPs as defined in Step 2 (see section 2.2). It is important to point out that the set of strata and FMPs must consider all the variables needed in the methodology for the estimation of the FRL projections selected in Step 3 (see section 2.3).

Finally, it is important to point out that although a unique methodology could be used for all strata and FMP, a Member State may use different methodologies to project the different strata and FMP, so that it can take into account the differences in management practices and forest composition. For example, a forest model could be used for the commercial forest whilst other strata (e.g. protected national parks) could be estimated based on a completely different methodology. As changes between strata/FMP are not allowed (see section 2.5), the use of different methodologies presents no further problems, meanwhile the methodologies results are consistent with the ones presented in the GHGIs (see Step 4 below).

It should be mentioned that the natural disturbances estimation requires special consideration, and detailed information on the possible approaches on considering the NDs in the FRL estimation is included in this section (see 2.3.6). Additionally, further information on the treatment of the HWP pool is also provided in this section (see 2.3.5).

For the estimation of the FRL, two sets of input data are foreseen to be required by a model for projecting the FRL for the CP:

- a) Data describing the **state of the forest** for each stratum (e.g. area, increment, biomass volume).
- b) Description of the **FMPs** in 2000-2009 for each stratum.

According to the LULUCF Regulation, the methodology used for projecting the FRL needs to model "*continuation of sustainable forest management practice [...] with regard to dynamic age-related forest characteristics*" (Article 8(5)). To comply with this, in most cases, the methodology will need to take into account the stratification previously introduced in Step 1 (see section 2.1), the FMPs introduced in Step 2 (see section 2.2), and the age-structure development of the forest.

### **2.3.2 Fixed parameters and dynamic variables**

The LULUCF Regulation lays out rules and criteria that need to be taken into account when choosing methodology and data for the estimation of the FRL. Most importantly, the projections need to be made with attention to the terms used in Article 8(5): "*continuation of sustainable forest management practice*", which implies that some parameters describing the FMPs need to be fixed to the RP level in the projections over the CP, while "*regard to dynamic age-related forest characteristics*" implies that the age structure of the forest should be allowed to evolve over the CP.

For this reason, all aspects directly related to the description of the FMP (e.g. which management activities are included in an FMP, when and how each activity is carried out) and the criteria used to stratify the MFL (e.g. geographic part of the country, ownership, tree species) need to remain constant throughout the CP. A change in these aspects would indicate a change in the FMP during the CP, and is not to be included in the FRL.

In other words, **it is good practice that all information and descriptions regarding the FMPs remain unchanged throughout the CP, and are considered as fixed parameters**. It is important to note that only the FMPs that were implemented in the period from 2000 to 2009 are to be applied in the CP for the estimation of the FRL (see section 2.2.3 for more details).

Additionally, it is good practice that the area of land allocated to each stratum and FMP remains constant from the **starting year of the projection** onwards (thereby not extrapolating any possible trends observed historically into the future)<sup>14</sup>. Any deviation in terms of area allocation would be considered as a change in management, and is as such not good practice to include in the projection of the FRL. It is important to note that just because the area of land dedicated to a stratum or FMP remains constant does not imply that the age-related characteristics of the forest within the strata remains constant<sup>15</sup>.

On the other hand, **it is good practice that the dynamic age-related characteristics<sup>16</sup> of the forest do not remain fixed throughout the CP**, meaning that the age structure of the forest is modelled to develop over time. This allows to "*not unduly constrain forest management intensity as a core element of sustainable forest management practice*" (Article 8(5)). For example, the total annual area of clearcuts may vary between years and also differ between the RP and CP. As a consequence, the total harvest volume may vary between years in the CP (i.e. it is dynamic), and may also differ from the total harvest volume during the RP.

Therefore, it is good practice that the selected model takes into account the age ('maturity') distribution within each stratum (usually age or diameter class distribution) in a way that allows for age structure to change over time. Here, by 'age structure' we mean the area of forest in each age class. This means that while the total area of land allocated to a certain stratum-FMP combination remains fixed<sup>14</sup>, the area of each age

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<sup>14</sup> With the possible only exception of conversions to/from forest (See section 2.5.3).

<sup>15</sup> The area of land dedicated to a specific age class or diameter class does not have to remain constant from the starting year of the projection onward.

<sup>16</sup> It is important to point out that the references to age, age class, age structure should be understood as the state of 'maturity' of the forest. In the case of even-aged forest, the age of the stratum could be used. However, in case of uneven-aged forest, it will correspond to the current average "size" of the forest, and it is described by parameters different than age (e.g. mean diameter, volume classes of growing stock, etc.).

class within a stratum-FMP combination may change over time (i.e. forest hectares will move from one to another age class, while the stratum-FMP description does not change).

However, the parametrization of the model with regards to the characteristic of each combination of stratum, FMP and age class (e.g. growth or mortality functions) should not be changed in the projections.

Therefore, all parameters related to the amount of wood harvest obtained by performing a specific management activity within a FMP (i.e. implementing an option covered by an FMP) are to remain constant throughout the CP<sup>17</sup>. That is, the outcome of performing a specific management activity is fixed for each specific combination of stratum, FMP and age class. However, as the age structure of the forest may change over time (to take into account the age dynamic characteristics), the total volume of wood harvested is not fixed in the CP.

Table 9 summarizes the main variables and parameters needed for the modelling of the GHG emissions and removals, and indicates the parameters to be fixed over the CP, and variables that are modelled to develop over time.

Table 9. Types of data according to the methodology.

Input data	Fixed parameters in the CP	Dynamic variables in the CP	Final output
<b>FMP</b>	<b>FMP</b>		
Silvicultural/forestry operations	Silvicultural/forestry operations		
Harvest (% of biomass)	Harvest (% of biomass)		
How each operation is carried out	How each operation is carried out		
		Area harvested	
<b>State of forest</b>			
Total area of the stratum-FMP	Total area of the stratum-FMP <sup>14</sup>		
Age structure within a stratum-FMP		Age structure within a stratum-FMP	
Parameterization of the model for each stratum-FMP-age-class <sup>18</sup>	Parameterization of the model for each stratum-FMP-age-class		
		Total volume of wood harvested	
			Variations in living biomass, soil organic carbon and dead organic matter pools

<sup>17</sup> With the possible only exception for models that account for climate change (see section 2.5.2).

<sup>18</sup> This includes aspects such as growth, mortality and yield functions.

### 2.3.3 Requirements for the selected methodology

The methodology as selected by the Member State needs to be able to:

- Apply fixed parameters.
- Estimate the evolution of the dynamic variables.
- Estimate the C pool variations.
- Estimate the changes in the HWP pool.

So, it is good practice that the methodology be able to estimate the dynamic data, based on input data:

- The age structure.
- The total wood harvested.

Finally, based on fixed and dynamic data, it is good practice that the methodology also be able to estimate:

- The C pool variations.
- The changes in the HWP pool.

Hereafter, we provide a proposal for a subdivision of the previous estimation procedure into what we will be refer to as 'modules':

- **Age structure module:** models the development of age-related characteristics<sup>16</sup> over time and the dynamics of areas within a stratum/FMP.
- **Harvest module:** models the total volume of wood harvested.
- **C pool variation module:** would use the outputs of the previous models (dynamic variables) and the fixed variables to estimate the variations in the carbon pools.
- **HWP module:** would use the total volume of wood harvested to estimate the variations in the HWP pool.

Figure 9 shows the structure of the FRL methodology:

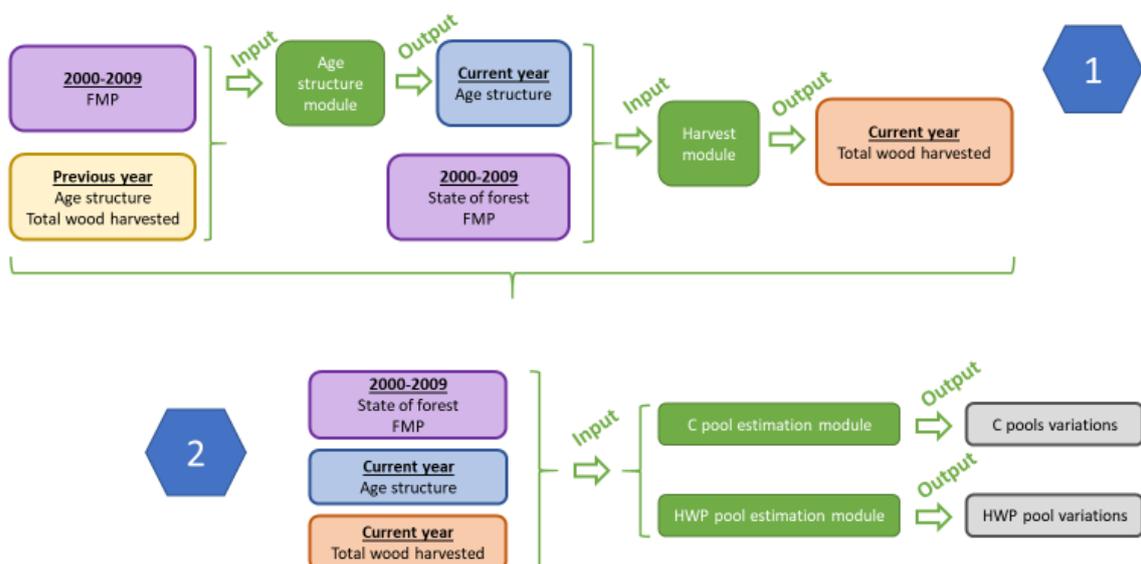


Figure 9. Methodology structure.

### 2.3.4 Modelling carbon pools in forest

As explained in the previous section, the methodology could use three modules for estimating the dynamic variables and, therefore, the variations in the C pools of the forest. The characteristics of each of these modules will be described in more detail in this section.

#### 2.3.4.1 Age-structure module

This module is aimed to predict the next year age-structure of forest, based on the information of the current year age-structure and FMPs.

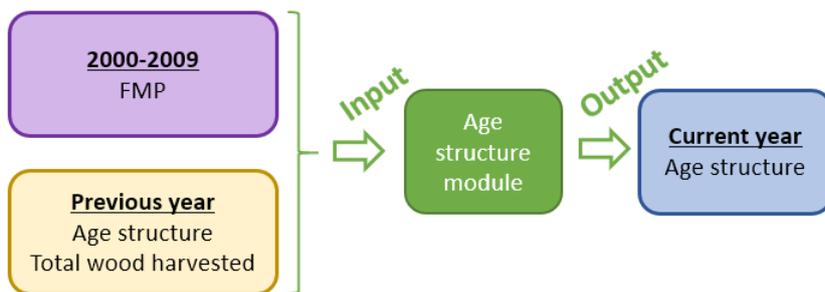


Figure 10. Age-structure module description.

For age-classes based on years, the module only needs to move forward in time the areas from one class to another based on the number of years projected and the possible losses. It is good practice that Member States use all available data sources to define the age distribution within each age class, and to document which data sources have been used. In case where the age distribution within each age class is not known, it could be justifiable to assume that the distribution is uniform (i.e. the area of forest is the same for all ages included in the age-class, e.g. if 40 kha are allocated in the age class "21-40 y", then it is assumed that 2 kha are 21 years, 2 kha are 22 kha...). However, given that assumptions concerning age-classes may influence the FRL, such a choice needs to be justified and clearly documented by the Member State (see Step 1 and 2 in sections 2.1-2.2).

However, if the age classes are based on volumes or Dbh, the age-structure model has to be able to estimate the yearly amount of increase of those variables to model the changes between age classes over the years.

In order to model these changes of area, the Member State could use a forest management probability matrix that matches the development of volume in each age class during the RP, thereby describing the forest management as was applied during the RP. As already explained, this forest management probability matrix has to be developed for each stratum-FMPs combination, as defined in Steps 1 and 2 (see section 2.1-2.2).

The basic idea behind this approach is that a country would use inventory data and the matrix approach to calibrate historical harvest to the management actually taking place in the inventory plots. Once calibrated, it is good practice that the same parametrization is applied to the CP.

**Box 11. Examples of changes in the age structure distribution estimated by the age-structure module**

**Areas by strata/FMP/age class for year *i***

Strata/FMP		Age classes/Area (kha)				
Pine commercial/FMP1		0-20 y	20-40 y	40-60 y	>60 y	Total
		60	50	80	20	210
Pine conservation/FMP2		0-30 y	30-70 y	70-100 y	>100 y	Total
		10	30	60	20	120
Mixed Forest centre/FMP3		0-50 m3/ha	50-150 m3/ha	150-250 m3/ha	>250 m3/ha	Total
		30	30	25	20	105
Mixed forest south/FMP4		0-50 m3/ha	50-100 m3/ha	100-200 m3/ha	>200 m3/ha	Total
		60	50	40	20	170
Eucalyptus plantation/FMP5		0-10 y	10-20 y			Total
		20	30			50

**Combined with the activities of the FMP by strata/FMP/age class**

Strata/FMP		Age classes				
Pine commercial/FMP1		0-20 y	20-40 y	40-60 y	>60 y	
		No cut	No cut	No cut	Cut (30%)	
Pine conservation/FMP2		0-30 y	30-70 y	70-100 y	>100 y	
		No cut	No cut	No cut	No cut	
Mixed Forest centre/FMP3		0-50 m3/ha	50-150 m3/ha	150-250 m3/ha	>250 m3/ha	
		No cut	No cut	Thinning (10%)	Thinning (20%)	
Mixed forest south/FMP4		0-50 m3/ha	50-100 m3/ha	100-200 m3/ha	>200 m3/ha	
		No cut	No cut	Thinning (5%)	Thinning (15%)	
Eucalyptus plantation/FMP5		0-10 y	10-20 y			
		No cut	Cut (at 20y)			

**Note:** More detailed information in the activities composing a FMP has to be given (this only focus on harvest, but it is not the only variable)

**Produce the areas by strata/FMP/age class for the year *i+1***

Strata/FMP		Age classes/Area (kha)				
Pine commercial/FMP1		0-20 y	20-40 y	40-60 y	>60 y	Total
		62	51	76	21	210
Pine conservation/FMP2		0-30 y	30-70 y	70-100 y	>100 y	Total
		5	30	60	25	120
Mixed Forest centre/FMP3		0-50 m3/ha	50-150 m3/ha	150-250 m3/ha	>250 m3/ha	Total
		28	29	27	21	105
Mixed forest south/FMP4		0-50 m3/ha	50-100 m3/ha	100-200 m3/ha	>200 m3/ha	Total
		55	52	42	21	170
Eucalyptus plantation/FMP5		0-10 y	10-20 y			Total
		22	28			50

### 2.3.4.2 Harvest module

The aim of this module is to estimate the total volume of wood harvested, based on the current year age-structure (dynamic) and the FMP (fixed). It has to take into account all kinds of harvesting practices in the country as documented in Step 2 (see section 2.2), including both clearcutting and thinning.

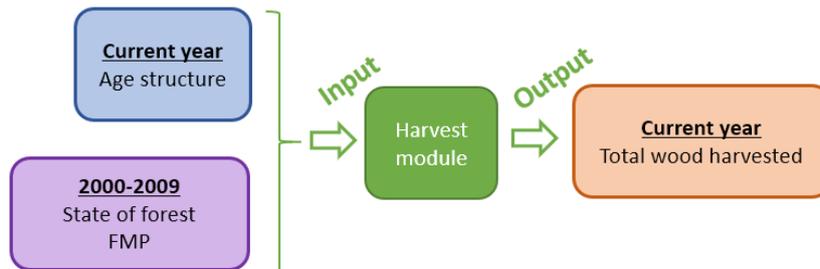


Figure 11: Harvest module description.

According to Article 8(5), the FRL shall not "*unduly constrain future forest management intensity*".

There are several alternatives for the implementation of this concept as shown in Box 12.

### **Box 12. Alternatives for the harvest module**

The following three alternatives may be considered for calculating the harvest for each combination of strata, FMP and age-class<sup>19</sup>.

#### **Alternative 1: Maintain the 'harvest to biomass available for wood supply' ratio**

This alternative, included as part of the JRC approach (Grassi and Pilli 2017, Grassi et al. 2018), is based on maintaining the ratio between the harvest and the amount of biomass available for wood supply in MFL (for both final felling and thinning) constant over time.

- Step a: Calculate the 'biomass available for wood supply' in the RP ( $BAWS_{RP}$ , e.g. biomass within 80 and 140 years if clear-cutting or 20% of total biomass for silvicultural operations without final harvesting).
- Step b: Document the harvest amount during the RP ( $H_{RP}$ ).
- Step c: Estimate the Harvest Fraction of Management ( $HFM_{RP}$ ) during RP as:  $HFM_{RP} = H_{RP} / BAWS_{RP}$ .  $HFM_{RP}$  is a proxy that expresses the impact of all constraints on the harvest during RP.
- Step d: Estimate the future biomass available for wood supply ( $BAWS_{CP}$ ) by applying the same FMP of the RP to the expected age-related evolution of forest characteristics (e.g., biomass and increment).
- Step e: Set future harvest ( $H_{CP}$ ) as:  $H_{CP} = HFM_{RP} \times BAWS_{CP}$ .

This approach may help in overcoming the situation where no precise information on specific FMP are available during the RP.

#### **Alternative 2: Maintain the 'harvest to biomass' ratio**

This is a more general alternative based on the previous Alternative 1. It uses the same step-by-step method but replaces the biomass available for wood supply ( $BAWS_{RP}$  and  $BAWS_{CP}$ ) by the total biomass ( $TBA_{RP}$  and  $TBA_{CP}$ )<sup>20</sup>. The steps for this alternative then become:

- Step a: Calculate the total biomass in the RP ( $TBA_{RP}$ ).
- Step b: Document the harvest amount during the RP ( $H_{RP}$ ).
- Step c: Estimate the Harvest Fraction of Management ( $HFM_{RP}$ ) during RP as:  $HFM_{RP} = H_{RP} / TBA_{RP}$ .  $HFM_{RP}$  is a proxy that expresses the impact of all constraints on the harvest during RP.
- Step d: Estimate the future biomass available for wood supply ( $TBA_{CP}$ ) by applying the same FMP of the RP to the expected age-related evolution of forest characteristics (e.g., biomass and increment).
- Step e: Set future harvest ( $H_{CP}$ ) as:  $H_{CP} = HFM_{RP} \times TBA_{CP}$ .

#### **Alternative 3: Maintain the harvest amount**

This alternative is to be considered as a last resort in cases where there is a lack of modelling capability to assess the relation between harvest and wood available. The procedure is to document the harvest amount during the RP ( $H_{RP}$ ) and use it for the CP ( $H_{CP}$ ). It is important to point out that this alternative does not consider any information on the evolution of the forest and just assume the continuation of the current harvest and, therefore, is not in line with the LULUCF Regulation.

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<sup>19</sup> If a country does not have statistics on harvest at such a level of disaggregation (strata/FMP/age class), the approach as presented in section 2.2.8 could be applied.

<sup>20</sup> A further generalization of this approach based on areas instead of wood available will not be in line with the LULUCF Regulation as it would not take into account the age-structure dynamics. So, it is not a good practice to base the estimations on areas in this harvest module.

### 2.3.4.3 Carbon pool variation module

The aim of this module is to estimate the variation in all C forest pools (above-ground biomass, below-ground biomass, dead wood, litter and soil organic carbon) based on the fixed data and the information estimated by the previous modules (dynamic data).



Figure 12: C pools variation module description.

The results of this module have to be consistent with the estimations in the GHGI. Additionally, it is good practice that the input data (i.e. wood density, emission factors) are consistent with those of the GHGIs. So, this module would probably use a methodology similar to the one used in the national GHGI.

### **Box 13. Alternative of modelling for countries using stock-difference method**

This modelling takes into account jointly the effect of harvest and the C pool variations at stratum/FMP/age class level. Nevertheless, a model for the age-structure is still needed to complement this approach.

This approach is focused on the EU Member States that apply the Stock-Difference Method (usually known as carbon stock change method, CSC) of the 2006 IPCC Guidelines for the estimation of their national GHGs. This method of assessing carbon stock changes is applied where carbon stocks in relevant pools are measured at two points in time (e.g. measurements of the NFIs).

If based on NFI measurements, and if the NFI is reliable, this method is able, usually with low uncertainty to estimate the net change of carbon in a pool. However, it does not provide information on potential gains or on the amount and type of the losses, which are key for the developing of sound projections. In addition, the information of these gains and losses may not be available, which impairs the use of other approaches based on gains and losses.

The aim of this approach is to estimate the projected FRL based on the information currently used in the GHGI in a simple way such that it is able to both be perfectly consistent with the GHG results, and take into consideration the FMP of 2000-2009 and the variations in the forest structure.

The NFI inventory data, eventually combined with other data, may deliver activity data (usually the areas) and carbon stock change factors (CSCF)<sup>21</sup> for different forest classes (temporal and spatial as well as for other characteristics). A forest inventory can thereby provide data on the areas of forests classified by a number of parameters (i.e. it can provide information by stratum).

At GHGI level, it is common to use a single country specific CSCF (or a small set of CSCFs), based on repeatedly measured NFI data for a historical year or time period. However, using the raw data of the NFI, it is also possible to derive different CSCFs by forest stratum and age class using the same approach<sup>22</sup>. The CSCF per area unit for a single stratum and age reflects the impact of the forest management on this stratum regarding net emissions or removals per unit of area.

So, the CSCFs of each stratum based on 2000-2009 data should reflect the FMP in those years. These CSCFs could be combined with the best available data for describing the areas and their combination will provide the C pool variations in the CP.

The procedure will be the following:

1. Calculate the areas evolution using the age-structure module.
2. Calculate the CSCFs for each stratum/FMP/age class based on the NFI information that was used for the GHGI using RP (2000-2009) data.
3. Estimate the projections multiplying the RP CSCFs by the projected areas.

#### **2.3.4.4 The 'fall-back' approach**

This is a really simplified approach aimed to provide an estimation method in the absence of data to properly model the FRL. It can only be applied if the Member State can clearly demonstrate and document the complete lack of the minimum of data needed to model the forest dynamics. It is important to point out that here we refer to the lack of input data, not of a model or a modelling framework. If a country has no model available but has available data, this approach is not an option and it is deemed good practice to either develop or obtain a suitable model for estimating the FRL (see section 2.3.7 for an overview of existing modelling frameworks that may be utilised).

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<sup>21</sup> By CSCF, in this context, we refer to C variations in each pool by unit (usually ha).

<sup>22</sup> Strata in the FRL estimations and the categorization used in the GHG Inventory could differ (e.g. forest types vs. regions). However, as both classifications are based on the NFI data, the aggregated results should be equal.

For the carbon pool that the approach is selected to be applied for (i.e. above-below ground biomass, litter, dead-organic matter, or soil organic carbon), the approach would assume the continuation of historical GHG emissions and removals as observed in the RP. Therefore, the FRL will be calculated as the average of emissions and removals for the pool in the RP as included in the most up-to-date GHGI (i.e. the 2018 submission).

### **2.3.5 Modelling the development of the harvested wood products**

This section provides information on how to implement the calculation framework for estimating emissions and removals of CO<sub>2</sub> from HWP on the basis of changes of the carbon pool and contains some background information on the assumption of instantaneous oxidation.

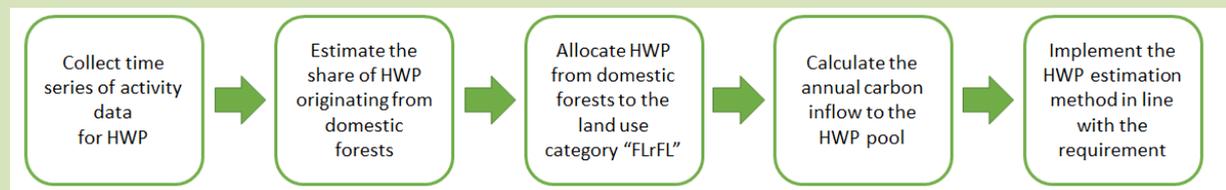
#### **Box 14. Overview of key steps for estimating the carbon pool in HWP**

**Phase I:** Collect time series of HWP activity data comprising the defined HWP default categories 'sawnwood', 'wood-based panels' and 'paper and paperboard' as well as harvest data to allocate HWP to domestic forests.

**Phase II:** Calculate HWP originating from the domestic forest land category 'Forest Land remaining Forest Land' (FLrFL).

- a) Estimate the share of HWP originating from domestic forests by means of relevant feedstock categories.
- b) Allocate HWP from domestic forests to the land use category 'Forest Land remaining Forest Land'.
- c) Calculate the annual carbon inflow to the HWP pool.

**Phase III:** Implement the HWP estimation method in line with the requirements (cf. Figure 13).



#### **2.3.5.1 Estimating the carbon pool in HWP**

In order to implement the requirements for estimating emissions and removals associated with HWP as set out in the LULUCF Regulation and in line with the requirements of the relevant IPCC guidelines, countries need to fulfil the following three phases.

- I. Collect activity data for the defined HWP categories from relevant production and trade statistics, reflecting the national circumstances and assort data time series for further data processing accordingly, e.g. in a spreadsheet programme. Following elements need to be considered in relation to the collection of the required activity data:
  - I.1. HWP categories
    - I.1.1. Activity data that could be used with the default method to estimate HWP contribution (i.e. first order decay function) as defined in Annex V of the LULUCF Regulation.

These estimates on the basis of the change of the carbon pool in HWP shall include (a) paper (b) wood panels and (c) sawnwood. The FAO and IPCC guidelines provide internationally agreed definitions of these aggregated wood product commodities and further specify their included subcategories. Detailed guidance can be found in section 2.8.1.1 of IPCC (2014). For calculating the carbon content of those commodities, the relevant carbon conversion factors are provided in Table 2.8.1 of section 2.8.3.1 IPCC (2014)<sup>23</sup>.

In the case that countries want to apply country-specific activity data, section 2.8.4.1 of IPCC (2014) further specifies the possible sets of data or sources which would be in line also with the LULUCF Regulation.

These data comprise HWP item data following the international HS nomenclature and classification system (i.e. the categories 'sawnwood', 'wood-based panels' and 'paper and paperboard')

*"These data could be available from country-specific statistics containing further disaggregated items of the subcategories as specified in Table 2.8.2. Examples would be coated particle board, fibreboard with specific density or surface, or coniferous sawnwood made from specific tree species (e.g. larch). Introducing disaggregated item data using appropriate carbon conversion factors e.g. based on information on wood densities can contribute to considerably improve the accuracy of the HWP estimations." (IPCC 2014).*

The type of activity data that could be combined with the default first order decay function (Annex V of the LULUCF Regulation) could be derived from either:

- National statistical offices in the case of the above mentioned country-specific HWP item data following the international HS nomenclature, or
- International statistics, e.g. FAOSTAT (which supposed to be consistent with data from national sources).

I.1.2. Activity data that would require also country-specific methods to estimate the emissions and removals of CO<sub>2</sub> from HWP

Other country-specific activity data which do not follow the international HS nomenclature and classification system could be either:

- Finished HWP that are further processed from the above mentioned categories, or
- Data on buildings with different wooden construction components (made of those defined commodities).

Both type of data would require the application of also country-specific methodologies as set out in section 2.8.4.2 of IPCC (2014) and could not be combined with the first order decay function as referred to in Annex V of the LULUCF Regulation.

I.2. Data for allocating HWP to 'Forest Land remaining Forest Land' (FLrFL)

In order to allocate the HWP to the originating forest land category 'Forest Land remaining Forest Land' as set out in the LULUCF Regulation, further data on harvest amounts originating from those lands is needed to estimate the share of HWP removed thereof. Following IPCC (2014) this includes the feedstock

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23 The same information is expected to be included in Table 12.2 of section 12.5.2 of the IPCC 2019 Refinement.

commodities 'industrial roundwood' and 'wood pulp'. It is suggested to also include 'recovered paper' as feedstock commodity for the HWP category 'paper and paperboard' when estimating emissions and removals from HWP applying the 'production' approach<sup>23</sup>.

### I.3. Time series

To fulfil the requirements of IPCC for estimating the initial carbon stock both in the annual reporting as well as in calculating the HWP contribution to the projected FRL, the activity data time series needs to comprise the years starting in 1990. Further information is provided in section 2.8.3 of IPCC (2014).

## II. Calculate the annual carbon inflow to the HWP pool following the 'production' approach as set out in the LULUCF Regulation

According to the LULUCF Regulation, only carbon in HWP originating from domestic forests ('Forest Land remaining Forest Land') is to be considered in the FRL estimates<sup>24</sup>. In consequence, the times series of data reflecting the annual production of HWP commodities as described in I.1 need to be allocated to the relevant domestic forest land category. This comprises three intermediate steps:

**STEP a:** Estimate the share of carbon in HWP coming from domestic forests. For this purpose, calculate the share of the relevant HWP feedstock categories 'industrial roundwood', 'wood pulp' and if applicable 'recovered paper' being used (i.e. consumed) for manufacturing the relevant HWP categories 'sawnwood', 'wood-based panels' and 'paper and paperboard' and at the same time originating from domestic forests.

**STEP b:** Estimate the annual fraction of feedstock for the HWP categories 'sawnwood', 'wood-based panels' and 'paper and paperboard' originating from the particular land category 'Forest Land remaining Forest Land'<sup>24</sup>. It is important to note, that in line with the requirements of the LULUCF Regulation, harvested wood originating from Deforested Land is to be treated on the basis of 'instantaneous oxidation'. In the case that the data used for this purpose (e.g. harvest amounts as considered for previous steps) deviate from harvest amounts as contained in production statistics such as FAOSTAT, please explain the differences and the relation between those sets of data.

**STEP c:** In order to obtain the annual fractions of HWP which originate from domestic harvest and the relevant land category to be considered in the FRL, combine the information obtained from steps a and b.

Further methodological guidance with relevant equations is provided in section 2.8.1.2 of IPCC (2014)<sup>25</sup>.

## III. Implementation of the default first order decay function

In a next step, the calculated annual carbon inflow is to be used for estimating the annual carbon stock and its changes over time by means of the first order decay function as set out in Annex V of the LULUCF Regulation. The following Figure 9 provides an example with relevant formulae on how to implement this equation consistent with IPCC (2014) in a spreadsheet model (e.g. Microsoft Excel).

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24 NOTE: "In the case that it is not possible to differentiate between the harvest from Lands subject to Afforestation and the FM, it is conservative and in line with good practice to assume that all HWP entering the accounting framework originate from FM." (IPCC 2014).

25 Similar information is expected to be included in section 12.5.2.1 ("Compilation of activity data for the 'production' approach") of the IPCC 2019 Refinement.

	A	B	C	D
1		half-life (hl)	35	
2		decay constant $k$	=LN(2)/C1	
3		term ' $e^{-k}$ ' of Eq. 12.2	=EXP(-C2)	
4		term ' $[(1 - e^{-k})/k]$ ' of Eq. 12.2	=(1-EXP(-C2))/C2	
5				
6	years	Inflow	HWP $_j$ carbon stock	stock-change
7	1990	100,00	=AVERAGE(B7:B11)/C2	=C8-C7
8	1991	101,00	=\$C\$3*C7+\$C\$4*B7	=C9-C8
9	1992	150,00	=\$C\$3*C8+\$C\$4*B8	=C10-C9
10	1993	103,00	=\$C\$3*C9+\$C\$4*B9	=C11-C10
11	1994	95,00	=\$C\$3*C10+\$C\$4*B10	=C12-C11
12	1995	105,00	=\$C\$3*C11+\$C\$4*B11	=C13-C12
13	1996	100,00	=\$C\$3*C12+\$C\$4*B12	=C14-C13
14	...	...	...	...

The initial carbon stock for the year 1990 is calculated in cell C7 as suggested in IPCC (2014). The FOD function used for calculating the carbon stock for the start of each subsequent year is implemented in cells C8:C13. Based on the development of the carbon stock of the particular HWP category, the stock-changes (i.e. carbon pool changes are calculated in the cells of column D).

Figure 13: Example for implementing the first order decay function in a spreadsheet (e.g. MS Excel).

### 2.3.5.2 Assuming 'instantaneous oxidation'

The criterion d) of Annex IV of the LULUCF Regulation for calculating emissions and removals of CO<sub>2</sub> from HWP as part of the FRL requires a comparison "*between assuming instantaneous oxidation and applying the first-order decay function*". Furthermore, Annex V of the LULUCF Regulation defines that also "*HWP from solid waste disposal sites and HWP that were harvested for energy purposes shall be accounted for on the basis of instantaneous oxidation*".

The assumption of 'instantaneous oxidation' is based on the notion that the carbon pool in HWP is stable (i.e. carbon inflow to the HWP pool equals carbon outflow from the HWP pool). In consequence, the assumption of 'instantaneous oxidation' corresponds to an estimate of no changes in HWP carbon stocks, with the result that emission and removals of CO<sub>2</sub> from HWP are zero (cf. also IPCC 2006). Mathematically, this equals the assumption that all carbon in the biomass harvested is oxidized in the removal year (i.e. year of harvest). It is important to note that the assumption of 'instantaneous oxidation' only relates to the HWP pool; carbon losses from the above ground biomass carbon pool in the forest (e.g. through harvest) are still included in the forest carbon pool estimates.

Following calculated example assuming a gain/loss method for implementing the forest carbon pool estimates illustrates the assumption of 'instantaneous oxidation' to be applied to the HWP pool only:

1. Forest C-pool above ground biomass
  - C-pool Inflow (i.e. forest growth) = -100
  - C-pool Outflow (i.e. harvest) = +90
  - Emissions and removals from above ground biomass carbon pool = -10
2. HWP C-pool
  - C-pool Inflow = -35 (example)
  - C-pool Outflow = +35
  - Emissions and removals from HWP carbon pool = 0

As a result of the assumption that all carbon in the biomass harvested is oxidized in the removal year (i.e. in the year of harvest) (cf. *inter alia* IPCC 1997), in the above example, no additional emissions and removals are to be added to the +90 (harvest).

In consequence of applying 'instantaneous oxidation', only emissions and removals associated with the use of harvested wood as material are to be estimated in the context of the LULUCF Regulation. Emissions associated with the use of wood for energy purposes are implicitly included in the forest carbon pool estimates.

Further detailed information on the assumption of instantaneous oxidation which is described consistently with relation to the carbon pool in HWP is provided in IPCC (1997) and IPCC (2014).

### **2.3.6 Modelling the development of natural disturbances**

In the LULUCF Regulation, NDs are defined as "*any non-anthropogenic events or circumstances that cause significant emissions in forests and the occurrence of which is beyond the control of the relevant Member State, and the effects of which the Member State is objectively unable to significantly limit, even after their occurrence, on emissions*" (Article 3(1.9)).

NDs, such as wildfires, insect and disease infestations, extreme weather events and geological disturbances are recognized to result in emissions that are beyond the control of the Member States (recital 20 of the LULUCF Regulation preamble). Consequently, the LULUCF Regulation provides a possibility to exclude emissions resulting from NDs that exceed the average emissions caused by NDs in the period from 2001 to 2020<sup>26</sup>.

The (voluntary) exclusion of the NDs from the Member States' accounts is done through including a 'background level' in the FRL (Article 10). The background level is a level of annual disturbances based on average historical occurrences, and calculated as "*the average emissions caused by natural disturbances in the period from 2001 to 2020, excluding statistical outliers*" (Article 10). At the end of each five-year CP, the emissions caused by NDs that exceed this background level (with a margin of a probability of 95%) may be excluded from the accounts. The calculation and use of the background level is further specified in Annex VI of the LULUCF Regulation.

If a Member State chooses to use this ND provision, the background level will be included in the FRL and the emissions from NDs are implicitly excluded from accounting up to the background level. This means that if a Member State uses this provision, the projection of the FRL must exclude any further assumptions of the effect of the ND (e.g. stochastic modelling of storms and their effects on forest) in the FRL and only consider the background level of emissions from NDs.

If the ND provision is used, the Member State is required to submit information on the background level and the methodologies used to the Commission (Article 10.2(a)). Also, the Member State "*shall exclude from accounting until 2030 all subsequent removals on the land affected by natural disturbances*" (Article 10(2)).

Note that in the context of LULUCF accounting, 'removal' refers to anthropogenic removals of carbon from the atmosphere; that is, it should not be mixed with harvesting of wood from logging sites. Article 10(2) means therefore that if a land is affected by a ND and this emission is excluded from the accounts, management of this land after the ND (e.g. replanting) may not be considered to contribute to GHG removals until 2030. It is also important to note that, as defined in Annex VI of the LULUCF Regulation,

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<sup>26</sup> This approach is consistent with the principles and approaches described in IPCC 2014 (section 2.3.9.6, "Guidance on the development of the background level and margin").

emissions resulting from harvesting and salvage logging that took place after the ND **shall not be excluded from the accounts** (Annex VI.4(a)). In addition, emissions from prescribed burning or deforestation after the ND shall not be excluded (Annex VI.4(b)-(c)).

Annex VI of the LULUCF Regulation provides details for how the background level of NDs is to be calculated and documented. The main aspects are recalled in Box 15.

### **Box 15. Calculation of background levels for natural disturbances**

#### **Background level definition**

The background level of NDs is calculated as the average of the 2001-2020 time series, excluding statistical outliers (years with abnormal levels of emissions).

#### **Information to be provided regarding the calculation of the background level**

- (a) Historical levels of emissions caused by NDs
- (b) The type(s) of ND included in the estimation
- (c) Total annual emissions for those ND types for the period from 2001 to 2020, listed by land accounting categories
- (d) A demonstration of the time series consistency in all relevant parameters, including minimum area, emissions estimation methodologies, coverages of carbon pools and gases.

#### **How to identify a statistical outlier?**

- (a) Calculate the arithmetic average value and the standard deviation for the full time series 2001-2020.
- (b) Exclude all years for which the annual emissions are outside twice the standard deviation.
- (c) Calculate the arithmetic average value and standard deviation again, excluding the years identified in point (b).
- (d) Repeat point (b) and (c) until no outliers can be identified.

If a Member State pursues Article 10(2) to exclude emissions exceeding the background level, the following information will need to be provided (Annex VI.5 of the LULUCF Regulation):

- (a) Identification of all land areas affected by NDs in that particular year, including their geographical location, the period and types of NDs
- (b) Evidence that no deforestation has occurred during the rest of the CP on lands excluded from accounting because of NDs
- (c) A description of verifiable methods and criteria to be used to identify deforestation after the CP
- (d) Where feasible, a description of measures taken to prevent or limit the impact of NDs that occurred
- (e) Where feasible, a description of measures taken to rehabilitate the lands affected by NDs

### 2.3.7 Modelling frameworks

A number of existing modelling frameworks may be used by countries to estimate the FRL. Box 16 provides some examples of modelling frameworks that are available and may be employed to project the development of forests. An overview of a number of these modelling frameworks can be found in Schelhaas et al. (2017). However, this is not an exhaustive list, and new systems may be developed to project the FRLs.

#### **Box 16. Examples of modelling frameworks to project the development of forests**

- G4M – The Global Forest Model (Kindermann et al. 2008; Gusti 2010)  
<http://webarchive.iiasa.ac.at/Research/FOR/globiom/forestry.html>
- EFISCEN – The European Forest Information Scenario model (Verkerk et al. 2014)  
<http://www.efi.int/portal/>
- CBM-CFS3 - Carbon Budget Model of the Canadian Forest Sector (Pilli et al. 2013)  
<http://www.nrcan.gc.ca/forests/climate-change/carbon-accounting/13107>
- EFDM - The European Forest Dynamics Model (Packalen et al. 2014)
- YASSO model (for SOC) (Liski et al. 2005)  
<http://en.ilmatiiteenlaitos.fi/yasso>
- FVS - Forest Vegetation Simulator  
<https://www.fs.fed.us/fvs/>
- CASMOFOR – Carbon Sequestration Model for Forestations  
[www.scientia.hu/casmofofor](http://www.scientia.hu/casmofofor)

To increase reliability of the estimation, a Member State may use projections of more than one model, especially in case if Member State does not have country specific model (Boettcher et al., 2012).

A number of national forest system models also exist that may be utilized within the context of the FRL, such as CALDIS (Ledermann et al., 2017), FOHOW (Schwarzbauer and Stern, 2010), CARBWARE (NIR Ireland, 2018), Heureka (Wikström et al. 2011), SF-GTM and MELA (FMRL Finland, 2011), and CARBINE and RECONCILE (NIR UK, 2018).

It is important to point out that these models are designed to provide the best estimates of the future development of the forest. However, FRL estimations are constrained by a number of mandatory requirements included in the LULUCF Regulation. Therefore, it is responsibility of the country to make sure that those constraints (e.g. FMP practices from 2000-2009, lack of changes in the total area of a stratum/FMP) are properly included in the model, so the results are in line with the LULUCF Regulation.

### 2.3.8 Documenting the methodology used

According to the LULUCF Regulation, the FRL “*shall be based on transparent, complete, consistent, comparable and accurate information*” (Annex IV.A(h)). It is good practice for Member States to extensively document the method that has been applied for the projection of the FRL in order to provide the needed transparency for the reviewing process.

## 2.4 Consistency with greenhouse gas inventories

### Step 4: Calibration and consistency with greenhouse gas inventory estimates

Calibrate the selected methodology based on real observed data and show that the methodology is able to reproduce historical data from the national GHGI.

This subsection is structured as follows:

2.4.1 Introduction (p. 70)

2.4.2 First phase: consistency of the management practices (p. 71)

2.4.3 Second phase: consistency of the emissions and removals estimates (p. 72)

2.4.4 Third phase: consistency of the time series (p. 74)

#### 2.4.1 Introduction

In this step, it is shown that the methodology as selected in Step 3 (see section 2.3) is able to reproduce the existing and documented historical data as reported in the latest publicly available national GHGI for MFL.<sup>27</sup> Historical data here refers to the period 2000-20XX; where **20XX is the latest inventory year available in the national GHGI at time the FRL is constructed**. It is suggested that Member States document that the methodology is able to reproduce historical data through the use of the set of tables provided in Table 10.

The calibration step has two separate and concurrent goals:

1. to verify that the model is able to reproduce historical GHG estimates. This means that, given the set of equations and parameters that compose the model and the set of input data for FMPs, the model produces output-values of GHG estimates that are actually consistent with those reported for the historical time period.

Differences between historical data and the model-outputs may be explained:

- i. as errors in the model formulation and/or parametrization ( $Errors_{model/parameter}$ ) – e.g. the function for calculating the biomass increment does not calculate correctly the increment actually occurred in the historical period – or
- ii. as inconsistencies between the input dataset and actual variables in the RP ( $Errors_{management\_dataset}$ ) – e.g. forests of type X are assumed to be subject to a thinning at age 20 (with intensity Y) and 40 (with intensity Z) and a final harvest at age 60, although thinning actually occurs in average only once between age 20 and 40 (with intensity within the range Y-Z) and the final harvest not always occurs -and usually not exactly at the established age-;

i.e.  $Estimate_{modelled} = Estimate_{historical} + Errors_{model/parameter} + Errors_{management\_dataset}$

To exclude the second source of errors, the calibration step needs also:

2. to verify that the set of management practices used as input into the model are consistent with those actually applied in the RP.

To achieve both goals, a 4-phase serial procedure for the **calibration process** is hereafter proposed.

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<sup>27</sup> As publicly available by the time of submission of the FRL.

### 2.4.2 First phase: consistency of the management practices

In the **first phase**, the datasets of **actual management practices**<sup>28</sup> in the RP ( $AMP_{RP}$ ), as compiled at Step 2 (see section 2.2.5), and **modelled management practices** ( $MMP_{PP}$ ) to be applied as input data in the Projection Period (PP) to project the FRL, as compiled at Step 2 (see section 2.2.5), are checked to verify their mutual consistency.

Such checking may be done at the national level of e.g. total harvest, or at level of harvest allocated at each stratum, depending on the features of the applied model.

The guidance in Box 17 applies to quantitative variables of management practices (e.g. the age at which the final clearcutting takes place, harvested wood over the total wood available for harvest). However, non-quantitative variables, if any, impact the quantitative variables and therefore are indirectly checked (e.g. it is a management practice to salvage log all wood in all forests impacted by disturbances), the impact of such management practice can be identified in the variable "*harvested wood over the total wood available for harvest*" and accordingly verified.

#### **Box 17: Description of the two proposed alternatives for verifying mutual consistency between the set of actual management practices ( $AMP_{RP}$ ) and modelled management practices ( $MMP_{PP}$ )**

##### **Alternative A:**

In cases where  $AMP_{RP}$  shows a variability in the management practices across RP (e.g. "*harvested wood over the total wood available for harvest*") without a clear trend, the central value of the distribution of  $AMP_{RP}$  is used as  $MMP_{PP}$ , and the following conditions should be met:

- the  $MMP_{PP}$  should be either the mean or the median<sup>29</sup> value, or a value comprised between those two, of the distribution built. This aims at identifying the  $MMP_{PP}$  as the central value of  $AMP_{RP}$ ;
- the outliers in the distribution of actual management practices should have been excluded from the calculation of its central value.

##### **Alternative B:**

In cases where  $AMP_{RP}$  shows a variability in the management practices across RP (e.g. "*harvested wood over the total wood available for harvest*") with a clear trend, the latest value of the distribution of  $AMP_{RP}$  is used as  $MMP_{PP}$ , and the following conditions should be met:

- the  $MMP_{PP}$  is the latest value of  $AMP_{RP}$ ;
- the  $MMP_{PP}$  is not a rate of change observed between the latest value and any other value of the  $AMP_{RP}$ . Indeed, any change projected in the future implies a change in BAU conditions that have caused that change and therefore a deviation from historical BAU conditions, and such deviation is the subject of the accounting mechanism (which means that its impact on accounting cannot be zeroed through its inclusion in the FRL).

Note that it may occur that data on actual management may not be suitable (robust) to ensure that the model may correctly reproduce historical estimates. However, any gap-

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28 The modelled management practice are the FMPs with quantitative values that specifies each management practice associated with the FMP. For instance, assuming that an FMP includes a final clearcutting, the timing of when the clearcutting take place may vary each year across the RP 2000-2009. The modelled management practice is the FMP with a single value specifying when the final clearcutting takes place to be used to project the FRL. Another example is the management practice "*harvested wood over the total wood available for harvest*" which value varies each year across the RP 2000-2009; the modelled management practice is the single value of "*harvested wood over the total wood available for harvest*" that represents such variable in the RP. See section 2.2.5 for further details. Two alternatives for verifying the consistency between the actual and modelled management practices are provided in Box 16.

29 Given that the RP is a relatively short period, the set of available data will likely be an incomplete distribution of values. In case of incomplete distributions, the median is a better estimator of the "typical" value of a variable than the mean since it is not skewed so much by extremely large or small values typical of incomplete distributions. Furthermore, the median always has equal probability to be either over or under the true value (although it does not necessary represent the value that minimizes the error).

filling of information should be done after the second phase is carried out with the information available (without any gap-filling).

### **2.4.3 Second phase: consistency of the emissions and removals estimates**

After verifying mutual consistency between the actual management practices implemented in the RP (AMP<sub>RP</sub>) and the modelled management practices applied for projecting the FRL (MMP<sub>PP</sub>), the second phase is to be performed.

The main aim of the second phase is to verify the consistency between historical data (2000-20XX), as reported in the national GHGI, and model projected estimates for the same historical period.

When verifying the ability of the model to reproduce historical GHG estimates, **the set of actual management practices (AMP) across for the RP and the subsequent historical period (i.e. 2000-2009 and 2010-20XX) is to be used instead of the modelled management practice (MMP)**. The verification is to be done in this manner regardless of whether alternative A or B was used in the first phase to verify the consistency between AMP and MMP (see Box 16). For the state of forest and age-related information, the data to be used by the model to project the historical period 2000-20XX are either the closest to 20XX, if the model is capable to project backward, or those closest to the beginning of the RP. See Figure 14.

The FRL is the projection of forest C stocks according to historical management practices. Where forest C stocks vary because of:

- the legacy effect of management activities and disturbances that occurred before the first year of the time period for which the projection is made;
- the management practices and disturbances that will occur in the time period for which the projection is made, under the assumption that the same management practices as those applied in the historical period will apply.

Because the verification of outputs may only be done for historical periods, the model used for projecting the FRL must produce estimates for the same historical period. The historical data on forest area and C stocks (i.e. the state of forest & age-related information), as stratified according to relevant variables that determine the C stock gains and losses, used by the model to project the historical period 2000-20XX are either the latest (if the model is capable to project backward), or those closest to the year 2000.

Verification consists in the comparison of model's outputs and actual data as reported in the national GHGI:

- Ideally, two variables are to be verified: gains and losses;
- Pools to be verified are all those for which a non-zero net change is included in the FRL. Ideally the biomass pools are verified in isolation; although also other C pools i.e. dead organic matter, soil organic matter and HWP may be verified in isolation. In any case, the verification is also performed at level of total GHG emissions and removals;
- These will be verified at the level of aggregation at which they are projected (e.g. fuelwood vs industrial roundwood);
- Both the level and the trend need to be verified:
  - For verifying the level, the sum of the time series of historical data should be compared with the sum of model's outputs. The verification is positive if

they are one within one standard deviation (i.e. the 68% confidence interval<sup>30</sup>) of the other, otherwise the model's outputs need to be refined.

- Other statistical tests may be applied; to evaluate the similarity of the precisions of the two datasets (e.g. the Fisher's test) or the bias (as the Student's t-test, the Cochran t-test, the Anova test); although the shortness of time series may impair the validity of such tests.
- For verifying the trend (this test is done before the impact of disturbances is replaced by its background level of emissions):
  - the inter-annual variability within the projected time series should not be larger than that reported in the GHGI;
  - the direction of the trend should be the same, i.e. same highs and lows, same trendline when applying moving averages<sup>31</sup>.

If the model results for the verification do not match the above-listed requirements, it is recommended to:

- first assess if information on historical management can be gap-filled to enhance the consistency of model's outputs with historical estimates. In cases where such gap-filling does not enhance the quality of model's outputs making them match the above-listed requirements,
- then revise the model applied or use an alternative model.

A procedure of **gap-filling of information on the management practices applied in the RP** should:

- First provide the information needed for gap-filling. This could be done for similarities with management activities of the following period if information needed is available for the period following RP; or by using expert judgement.
- Second provide information to support the validity of the use of such information.
- Third describe the impact on the model's outputs for the historical period of the information applied for gap-filling.
- Fourth describe the impact on the model's outputs for the projected period of the information applied for gap-filling.

The verification is done with historical data of the period 2000-20XX.

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<sup>30</sup> This is consistent with the IPCC approach to define "likely" confidence in the likelihood of an outcome or result  
<sup>31</sup> E.g. 3 or 5 years rolling average.

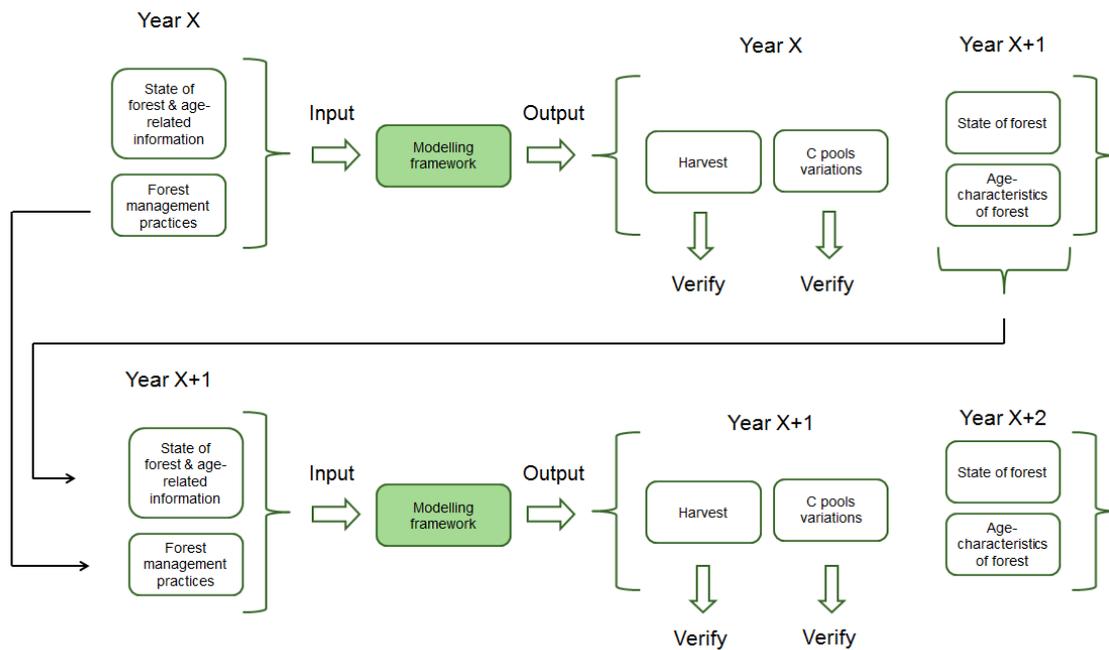


Figure 14: An overview of the process of reproducing the historical estimates as documented in the latest national GHGIs for MFL.

#### 2.4.4 Third phase : consistency of the time series

This phase is applied to check if the entire time series of estimates (i.e. historical estimates and projected estimates) is consistent and where inconsistencies are found, to **adjust the projected estimates**.

An inconsistency in the time series is quantified as follows:

- **Step I.** apply an iterative process to the entire time series: historical period and projected period, to exclude outliers (if any) that are larger than the mean plus two times the standard deviation in each successive iteration. From the remaining values of the time series, calculate a new dataset of the interannual rate of change (e.g.  $(\text{Estimate}_{2016} - \text{Estimate}_{2015}) / \text{Estimate}_{2015}$ );
- **Step II.** calculate the average value and the standard deviation of the new dataset;
- **Step III.** identify an inconsistency in the time series between the last historical year and the first projected year that are not affected by NDs, if the interannual rate of change is larger than the average value plus twice the standard deviation.

In cases where no inconsistency is found, this phase does not apply.

In cases where an inconsistency is found, one of the techniques provided in section 5.3.3 of volume 1 of the 2006 IPCC Guidelines, should be applied to ensure time series consistency.

The aim of these techniques is to ensure that no any inconsistencies occur in the time series. That means that any differences between subsequent years should not be larger than the observed variability in the time series of historical data. Further, trends should have consistent behaviour across time.

In cases where the two trends show a consistent behaviour across time, an adjustment factor of the projected estimates can be calculated by comparing the overlap between a set of annual estimates composed from as many years as possible (this is because comparing only single years will likely lead to bias and make it impossible to evaluate trends). The following equation taken from Volume 1 of the 2006 IPCC Guidelines (equation 5.1) applies:

$$y_0 = x_0 * \left( \frac{1}{(n - m + 1)} * \sum_{i=m}^n \frac{y_i}{x_i} \right)$$

Where:

$y_0$  = the recalculated emission or removal estimate computed using the overlap method;

$x_0$  = the estimate developed using the previously used method;

$y_i$  and  $x_i$  are the estimates prepared using the new and previously used methods during the period of overlap, as denoted by years  $m$  through  $n$ .

Table 10: Suggested set of tables (one for the three variables: Biomass gains, Biomass losses, Net GHG emissions/removals) to document that model estimates for the CP are within the estimated range of variability of the GHGI estimates.

Year	Model estimate of either - Biomass gains - Biomass losses - Net GHG emission/removals	GHGI estimates for the same variable	68% confidence interval of GHG estimates
2000			
2001			
2002			
2003			
2004			
2005			
2006			
2007			
2008			
2009			
2010			
2011			
2012			
2013			
2014			
2015			
2016			

## 2.5 Projections

### Step 5: Projection of emissions and removals

Project the future development of anthropogenic forest GHG emissions by sources and removals by sinks for the CP.

This subsection is structured as follows:

*2.5.1 Introduction (p. 76)*

*2.5.2 Assumptions concerning climate change (p. 77)*

*2.5.3 Assumptions concerning area development of managed forest land (p. 78)*

*2.5.4 Starting year for the projection of the FRL (p. 80)*

*2.5.5 Assumptions concerning the period from 2010 to 2020 (p. 82)*

*2.5.6 Assumptions concerning harvested wood products (p. 84)*

*2.5.7 Possible problems with the projections and how to address them (p. 86)*

#### 2.5.1 Introduction

In this step, the methodology as selected in Step 3 (see section 2.3) and calibrated in Step 4 (see section 2.4) is used to project the future development of anthropogenic forest GHG emissions by sources and removals by sinks for the CP. That is, the modelling framework applied by a Member State in this Step is used to project the FRL for the periods 2021-2025 and 2026-2030 (see Figure 15).

In this part of the technical guidance document we will focus on key assumptions that need to be taken for carrying out this particular task.

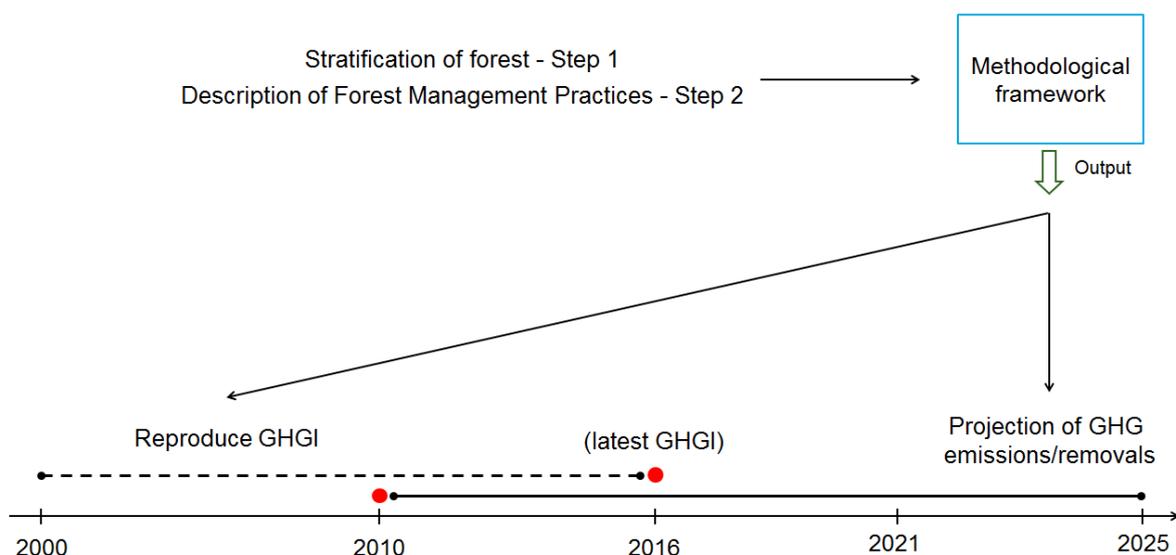


Figure 15: Overview of how the various steps fit together in relation to a timeline of the reference and CPs. In this figure, the red dot at 2010 illustrates the default starting years for the projections (See section 2.5.4 for further details).

## **2.5.2 Assumptions concerning climate change**

### **2.5.2.1 Overview**

Estimates of the FRL may be affected by changes in future climatic conditions such as changes in precipitation, temperature, and CO<sub>2</sub> and nitrogen deposition feedbacks. These changes may have a direct impact on aspects such as forest growth, mortality and biomass decomposition rates, thereby influencing the projection of emissions by sources and removals by sinks from MFL.

Depending on the modelling framework as selected in Step 3 (see section 2.3), different assumptions may be made concerning future climatic conditions and the related carbon impacts for the projection of the FRL.

Box 18 shows two distinct alternatives proposed for dealing with climate change during the CP.

#### **Box 18. Consideration of climate change during the CP**

##### **Alternative 1: No consideration to future climate effects**

For the projection of the FRL, use the same climatic conditions as for a historical time period (depending on data availability) for which the climatic conditions are known. If this alternative is selected and applied by a Member State, it is simply assumed that the climatic conditions will not change during the CP (i.e. constant over time).

It is good practice that a Member State selects to apply this alternative if the modelling framework selected in Step 3 (See section 2.3) to project the FRL is not able to consider changes in climatic conditions. This alternative may also be selected if the modelling framework selected in Step 3 is able to consider changes in climatic conditions, but the uncertainty associated with the climate change modelling is deemed too high.

##### **Alternative 2: Projection of the assumed future climatic conditions**

This alternative is for Member States that consider a change to future climatic conditions while projecting the FRL. By this alternative, it is assumed that the future climatic conditions are known and the impacts of the related changes are taken into account in the projection of the FRL. If the methodology selected in Step 3 is able to model future changes in climatic conditions, a Member State may select to apply this alternative and take such changes into account in the projection of the FRL.

For this alternative, country-specific climate projections may be applied, including downscaled climatic conditions for the SSP-RCP scenarios (Moss et al. 2010). National estimates of the historical trend in climatic conditions may also be applied to project the FRL. A simple example of such an approach would be to calculate a geographically explicit historical trend in climatic conditions, and assume that the same trend will continue during the CP.

Given that the FRL for the CP shall be based on *“the continuation of sustainable forest management practice, as documented in the period from 2000 to 2009 with regard to dynamic age-related forest characteristics in national forests”* (Article 8(5)), it is not good practice to adapt or modify the quantifiable information that define when and how a management practice is carried in the CP based on changes in climatic conditions. Change in climatic conditions may for example impact site specific growing conditions and related emission factors, but the management activities for each FMP, as defined and documented in Step 2 for the RP, are to be consistently applied from the starting year of the projection onward (see section 2.5.5).

### **2.5.2.2 Documentation and technical corrections**

It is good practice that a Member State clearly specifies, documents and justifies which of the two alternatives is applied for climate change assumptions in the projection of FRL for the CP.

If Alternative 2 is selected by a Member State, it is good practice to document in detail which assumptions and projections for future climatic conditions are being applied, and where the data for the projection can be found. In addition, if Alternative 2 is selected to be applied, it is good practice that a Member State documents the potential impact on the FRL of selecting Alternative 2 instead of Alternative 1.

If a Member State selects to apply Alternative 2, it is good practice to submit a technical correction to correct for any potential differences between the projected and actual climatic conditions during the CP. As long as methodological consistency is fulfilled, a technical correction may be applied by a Member State based on the climatic conditions that actually took place during the CP instead of the projected climatic conditions applied for the calculation of the FRL.

Estimating and applying when necessary such a technical correction would remove any erroneous estimates of carbon balance development simply caused by differences between the projected climatic conditions and the climatic conditions that actually occurred.

### **2.5.3 Assumptions concerning area development of managed forest land**

#### **2.5.3.1 Overview**

The area of MFL may change during the CP due to two related processes:

- Afforestation, where 'land converted to forest land', as reported in the GHGIs, has reached the end of the 20-year conversion period<sup>32</sup> and starts being reported as MFL.
- Deforestation, where MFL is converted other land uses and starts being reported as 'forest land converted to other land uses' (as reported in the GHGIs).

There are two distinct alternatives proposed to project the area of MFL during the CP, shown in Box 19.

#### **2.5.3.2 Documentation and technical correction**

It is good practice that Member States document and justify which of these alternatives they have applied for the projection of the MFL. As the two processes of afforestation and deforestation both affect the area of MFL and the carbon impacts, it is important that two processes are dealt with in a consistent manner. It is therefore not good practice that a Member State applies one of the above described alternatives for afforestation and a different alternative for deforestation.

It can be noted that Alternative 2 requires that a Member State applies a methodological framework to project the FRL that over time considers area gains and area losses. Furthermore, the framework needs to consider the geographically explicit change of land

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<sup>32</sup> The conversion period is normally 20 years (Article 5(3)). However, as stated in Article 6(2), a 30-year conversion period may be used *"if duly justified based on the IPCC Guidelines"*.

and the corresponding updates of the area allocated to strata and FMPs. In such a case, it is good practice that area gains and area losses are allocated to strata and FMPs according to 2000-2009 data, and that Member States clearly document and justify the selected approach.

**For both alternatives, it is good practice to perform and submit a technical correction** based on the area development and changes to strata that actually took place during the CP, instead of the area development initially applied for the calculation of the FRL. Such a technical correction removes any erroneous estimates of carbon development simply caused by differences between the assumed area development and the area development that actually took place during the CP. This technical correction has to be done ensuring methodological consistency between the method used for calculating the FRL and the technical correction.

In conclusion, **as long as a Member State applies a technical correction, the outcome of applying Alternative 1 or Alternative 2 are expected to be the same.**

### ***Box 19. Assumptions concerning the development of MFL area during the CP***

Two distinct alternatives are proposed for modelling the development of MFL area over time. Independently of the alternative selected for the development of MFL, it is good practice to estimate and apply a technical correction to remove any erroneous estimates of carbon development caused by differences between the assumed area development and the area development that actually took place during the CP.

#### **Alternative 1: Assume constant area of managed forest land**

For this alternative it is assumed that the area of MFL aggregated remains constant over time. In other words, the area of land allocated to each stratum remains constant from the starting year of the projection (thereby not extrapolating into the future any possible trends observed during the RP) and no significant yearly changes are considered in the projection of the FRL. The stratification of the MFL (and the area of land allocated to each stratum) as documented for the year of start of the projection is thereby to remain constant throughout the CP.

#### **Alternative 2: Assume dynamic development of managed forest land**

In this alternative, changes in future area development of MFL are modelled in the projection of the FRL.

For this alternative, it is good practice to estimate area gains (land entering to the MFL category) based on the historical and documented area of land classified as 'land converted to forest' as reported in the GHGIs. Based on this data source and the default 20-years transition period, the area gains for a specific year can be calculated as the area of 'land converted to forest' that reached the end of the 20-year transition period. In other words, the area of land that entered into the category 'land converted to forest' in the year 2000 provides the estimate of area gains for the year 2020 (as this is when the 20-years transition period will end). The area gains may be allocated to strata according to historical or geographic explicit data sources. To summarize, the area of land under 'land converted to forest' during the period of 2000 to 2010 and documented in the GHGIs becomes the area gains for the period of 2020 to 2030.

To estimate area losses, it is good practice that a Member State uses the average of the historical and documented area of 'forest land converted to other land-uses' for the period from 2000 until 2016 as reported in the GHGIs. In other words, it is good practice that a Member State calculates the yearly average of 'forest land converted to other land-uses' for the period from 2000 to 2016, and apply this yearly average from the starting year of the projection of the FRL.

When applying this alternative, it is important to calculate the area of MFL for each individual year during the CP using the annual projection of area gains and area losses. In other words, the projected area of MFL should be calculated for each individual year by adding the estimated gains in area and subtracting the expected losses in area.

## **2.5.4 Starting year for the projection of the FRL**

### **2.5.4.1 Overview**

As a default, it is good practice that Member States start the projection of the FRL as of 2010 or earlier. Consequently, 2010 will be the first year that the modelling framework projects the development of the MFL (i.e. the total volume of wood harvested as of 2010 will be estimated and is an output of the modelling framework).

It is good practice that the projection is initialized for a year as close as possible to 2010. It is important that the starting year is selected so that all relevant data sources are available for the modelling framework and provide a consistent representation of the status of the MFL. However, a Member State may select a different starting year for the projection of the FRL if this is shown to be appropriate and justifiable. If the projection is started after 2010, it is good practice to clearly document and justify why this is done.

It is good practice that the Member State verifies that the modelling framework is able to reproduce historical data from the national GHGI in the period from 2000 to the latest year documented in the latest publically available GHGI. Such an evaluation should be performed based on the real observed management of the forest (see section 2.4.2) during the period after 2009 instead of a continuation of the FMPs in 2000-2009. In other words, it is good practice that a Member State shows that the selected modelling framework is able to reproduce the latest national GHGI through the use of the latest available data.

### **2.5.4.2 Data sources to be used**

In terms of data sources to be used for the projection of the FRL, the LULUCF Regulation states that the FRL shall be developed "*using the best available data*" (Article 8(5)) and shall be "*transparent, complete, consistent, comparable and accurate information*" (Annex IV.A(h) of the LULUCF Regulation). Therefore, the data sources used should be in line with the good practices of IPCC (2006 IPCC GL, volume 1, chapter 1, section 1.4).

Data describing the **state of the forest** (e.g. total area of MFL; information by stratum such as area, increment, biomass, age related information and area allocated to each FMP) have to be used for the projection of the FRL. Depending on the starting year of the projection, either earlier data from the RP (i.e. data up to 2009) or the latest available data (at the time of FRL setting, e.g. up to 2016) can be applied for the projection of the FRL.

It is good practice to use the **best available data** sources to define the state of the forest as of the starting year of the projection of the FRL. For example, if 2010 is the start year of the projection, it is good practice to use data from the latest NFI or latest publically available GHGI (i.e. GHGI 2018) to define the state of the forest (2010), rather than the reported data that was available at the starting year of the projection (i.e. GHGI 2010-2011).

### **2.5.4.3 Documentation and technical correction**

In terms of documentation, it is good practice that Member States document for which year the projection of the FRL starts, and which starting year is selected for the projection of the FRL.

If the projection is selected to be started after 2010, it is good practice that Member States justify why they have selected to use that specific year (e.g. why more recent data is considered more reliable and applied for the projection of the FRL).

It is of particular importance and good practice that a Member State transparently documents what data sources are applied to define the state of the forest, as of the starting year of the FRL projection. Furthermore, independently of the starting year of the projection, it is good practice that a homogenous and consistent set of data sources be applied, to provide a logical and rational representation of the state of the forest for that year.

If the projection is started as of 2010, or earlier, it is not good practice that a Member State applies a technical correction to alter the starting year of the projection of the FRL. However, if the projection starts after 2010, a technical correction may be applied, if this allows for the consideration of best available data describing the state of the forest (e.g. increment, biomass) or the age-related forest characteristics of the forest.

Independently of the starting year of the projection, a technical correction may be applied (as described in Art 8(11) before the compliance check) by a Member State to correct for differences between the actual and projected state of the MFL up to the start of the CP (i.e. 2021). As long as methodological consistency is fulfilled, a technical correction may be applied by a Member State based on the observed state of the MFL as of the start of the CP instead of the projected state of the forest as applied for the calculation of the FRL.

A technical correction thereby allows a Member State to utilize NFIs carried out after 2016/2017 to improve the description of the age-related forest characteristics at the start of the CP.

## **2.5.5 Assumptions concerning the period from 2010 to 2020**

### **2.5.5.1 Overview**

For the projection of the FRL, assumptions have to be made concerning the development of the MFL in the period from 2010 to 2020.

In terms of the stratification of MFL, **the approach for stratifying the area of MFL as developed in Step 1 should be applied consistently** for the RP 2000 to 2009, 2010 to 2020, and for the projection of the FRL for the period of 2021-2025 and 2026-2030.

It is important to note that it is good practice that the criteria used for the stratification remain constant in the modelling of historical and projected emissions by sources and removals by sinks. This means that the same approach for stratifying the area of MFL is to be applied independently of the selected starting year of the projection of the FRL and throughout the CP.

Furthermore, **it is good practice that the area of land allocated to each stratum remains constant from the starting year of the projection** (thereby not extrapolating into the future any possible trends observed during the RP)<sup>33</sup>. In other words, the stratification of the MFL (and the area of land allocated to each stratum) as documented for the year of start of the projection is to remain constant throughout the CP. However, while the total area of land allocated to a certain stratum remains constant<sup>33</sup>, are of each class within a stratum may change over time (see section 2.3.2).

This implies that during the CP, only the overall state of the forest will adapt to the implementation of the FMPs, which in turn will adapt to aspects such as the age dynamics of the forest.

In terms of the FMPs, **it is good practice that the set of the FMPs as defined and documented in Step 2 for the RP are consistently applied from the starting year of the projection onwards**. It is important to note that only the descriptions of the FMPs that were implemented in the period from 2000 to 2009 are to be applied for the estimation of the FRL.

Therefore, the country-defined operational criteria (i.e. the quantification of the FMPs) for the period of 2000-2009 are also to be applied to project the FRL. Independently of the starting year of the projection, the same FMPs should be enforced from the starting year of the projection of the FRL for the CP.

Given that the FRL shall be projected based on a continuation of FMP, **it is good practice that the areas allocated to the each FMP remain constant from the starting year of the projection of the FRL through the CP**. Even if a trend of area being converted from one FMP to another FMP could be observed and documented during the RP, it is not good practice to continue such a trend during the CP.

This implies that if the stratification as documented in Step 1 (see section 2.1) and the FMP as documented in Step 2 (see section 2.2) are species specific, then including a conversion from one tree species to another species in the CP estimates (e.g. planting broadleaf trees after the final clearcutting of coniferous) would not be good practice.

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<sup>33</sup> The only foreseen exemption from this good practice is if the area of MFL is assumed to develop over time (see section 2.5.3). If this is the case, then it is good practice to allocate area gains and area losses to strata's as documented during the RP.

### **2.5.5.2 Documentation and technical correction**

In terms of documentation, it is good practice that Member States document what assumptions are made for the period 2010 to 2020.

Given that the FRL for the CP shall be based on "*the continuation of sustainable forest management practice, as documented in the period from 2000 to 2009 with regard to dynamic age-related forest characteristics in national forests*" (Article 8(5)), it is not good practice to perform a technical correction of the FRL, based on the FMPs that actually were carried out during the CP instead of the FMPs as documented in Step 2 (see section 2.2).

The definition of when each management activity is carried out, as documented in the period from 2000 to 2009, is to be consistently applied throughout the CP. It is therefore not good practice to perform a technical correction of the operational criteria describing when an activity is carried out.

As an example, if a management activity has been specified to be carried out at a specific age-related characteristic of the forest (e.g. the first pre-commercial thinning is carried out when trees reach the diameter class (Dbh) of 10-15 cm), this value cannot be changed through a technical correction (e.g. the first pre-commercial thinning is carried out when trees reach the diameter class (Dbh) of 5-9 cm).

Furthermore, it would not be good practice to perform a technical correction of the operational criteria describing when a management activity is carried out, based on updated information concerning such aspects as wood price development, interest rates, net present value estimates, and demand of wood for energy and material purposes.

This is the case as the operational criteria are to be defined, to the extent possible, according to the age-related characteristics of the national forests, not to projected data sources.

## **2.5.6 Assumptions concerning harvested wood products**

### **2.5.6.1 Overview**

As set out in criterion e) of Annex IV.A of the LULUCF Regulation, for calculating the HWP contribution to the FRL, "*a constant ratio between solid and energy use of forest biomass as documented in the period from 2000 to 2009 shall be assumed*".

Independent from potentially available information on developments and/or changes in the consumption or production patterns of the relevant HWP commodities, the above criterion for setting the FRL implies that the proportion of harvest manufactured to the defined semi-finished wood products representing the material or solid use of HWP remain unchanged as well as the HWP composition of their production during the RP 2000-2009.

In order to implement the projection for HWP in the FRL, the starting basis for the calculations consists of the projected harvest amounts that have been estimated following the methodology as set out in the previous steps (Step 3 - section 2.3.5 and Step 5 – sections 2.5.4 to 2.5.5). Similar to an example as described in section 2.8.5 of IPCC (2014), the following steps need to be implemented for calculating the projected carbon Inflow to the HWP pool in line with this requirement and consistent with the relevant IPCC guidance on HWP:

1. **STEP I:** Calculation of the rates of change of the projected harvest as compared to the average of the historic harvest within the period 2000 to 2009.

*Numeric example:*

- (i) Average historic harvest for the years 2000-2009: 50 Mm<sup>3</sup> yr<sup>-1</sup>
- (ii) Projected harvest (in Mm<sup>3</sup> yr<sup>-1</sup>): in 2021=52, in 2022=53, in 2023=55...
- (iii) Rates of change as compared to historic average: in 2021=4%, in 2022=6%, in 2023=10%

2. **STEP II:** Application of these annual change rates to the same time period average (i.e. 2000-2009) of historic carbon inflow to the HWP pool, which has been calculated from HWP production, in order to project the future carbon inflow to the HWP pool (reflecting the material or solid wood use).

*Numeric example:*

- (i) Average production of sawnwood for the years 2000-2009: 10 Mm<sup>3</sup> yr<sup>-1</sup>
- (ii) Projected production of sawnwood (in Mm<sup>3</sup> yr<sup>-1</sup>): in 2021=10.4, in 2022=10.6, in 2023=11 ...

As a result, it is assumed that the same average proportion of harvested timber used as feedstock for the subsequent production of the defined HWP categories (i.e. sawnwood, wood-based panels and paper and paperboard, reflecting in the solid wood use) in the defined time period 2000-2009 will also apply in the projection period.

3. **STEP III:** Estimate future emissions and removals from HWP applying the methods as set out earlier in Step 3 (See section 2.3.5).

In the case that additional information on timber assortments and their respective use for the subsequent manufacture of the defined HWP default categories (i.e. semi-finished wood products) is being used for an alternative approach, countries need to ensure consistency with the requirement to maintain the same proportion of harvest manufactured to the defined semi-finished wood products in their projection as in the

period 2000 – 2009. It is furthermore good practice that Member States document the applied methods and justify why such an alternative has been applied.

For projecting the future development of emissions and removals, the annual carbon inflow to the HWP pool is calculated from 1990 onwards including the latest activity data derived from the relevant statistics (not later than from 2020). This is to be implemented independently of the selected starting year of the projection (see section 2.5.4), as the carbon stock in the HWP pool is to be estimated on the basis of separate activity data (see section 2.3.5). Subsequent to available statistical data, the projected production of the relevant HWP commodities as derived from Step II are to be used to continually estimate the future carbon inflow to the HWP pool.

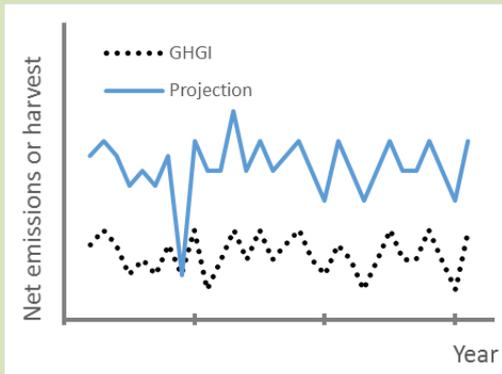
#### ***2.5.6.2 Documentation and technical correction***

In terms of documentation, it is good practice to document how the projected emissions and removals from the HWP pool have been implemented. This includes a description of what data sources both for HWP activity data (default categories) and projected harvest amounts for implementing the Steps described above have been applied as well as a description of how the described Steps above have been implemented. In the case that a technical correction following the descriptions under section 2.5.2-2.5.5 is conducted with a subsequent change of the projected harvest amounts as modelled following the methodological guidance provided under section 2.3.5, it is good practice to also recalculate the projected emissions and removals from the HWP pool as part of the FRL.

### 2.5.7 Possible problems with the projections and how to address them

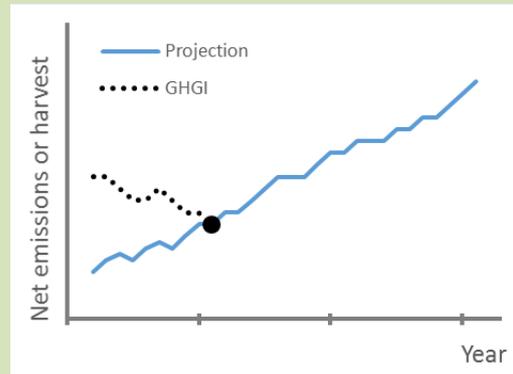
Box 20 gives an overview of possible problems that the Member States may encounter when projecting the FRL, and proposes solutions for addressing them.

#### Box 20: Possible problems with the FRL projections and how to address them.



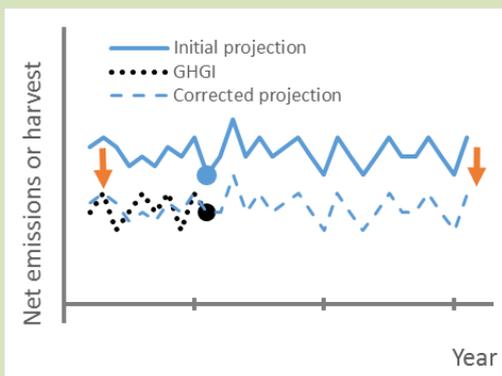
**Problem:** The projection only matches a single time point in the GHGI, not the overall GHGI.

**Solution:** Calibrate the projection ignoring outliers (see also section 2.4.3).



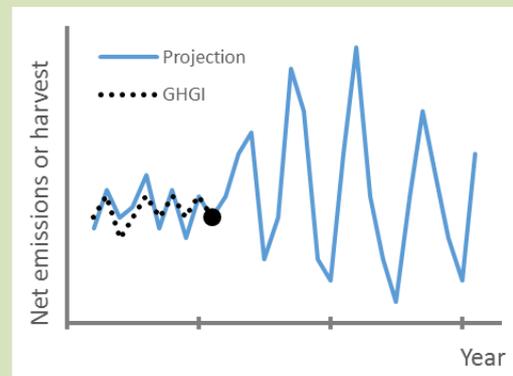
**Problem:** The trend of the GHGI is not consistent with the trend of the projection.

**Solution:** Refine the model (see also section 2.4.3).



**Problem:** The initial projection is on a different overall level from the GHGI.

**Solution:** Calibrate the projection to be in line with the overall level of the GHGI (shown with dashed line). See also section 2.4.4.



**Problem:** The projected inter-annual variability is much larger than the inter-annual variability in the GHGI.

**Solution:** Refine the model. See also section 2.5.

## 2.6 Calculate the forest reference level

### Step 6: Calculate the forest reference level

Calculate the FRL as average of emissions and removals during 2021-2025 and 2026-2030.

Once the GHG emissions and removals have been calculated, the 5-year average of projected values is taken as FRL values for the periods 2021-2025 and 2026-2030. Once the FRL has been calculated it cannot be modified. However, technical corrections to the FRL may subsequently be applied, to ensure methodological consistency with the estimates of actual GHG emissions and removals.

In particular:

- Biomass C stock gains need to be corrected in cases where the increment is calculated by using:
  - Climate-related variables; in such a case the same set of climate data (i.e. those during the CP) will be applied to the estimates of actual increment and to recalculate the projected increment (see section 2.5.2).
  - Direct measurements (e.g. NFI) or empiric relations (e.g. yield curves); where the functions 'increments-other variable'<sup>34</sup> have been used to project the increment and such functions have a different trajectory with the new data collected during the CP. Note however, that the correction is to be applied only if the relations increment-other variable has not been impacted by changes in management. For instance, a yield curve age-increment is applied to estimate the increment of forest type X. The yield curve has been built according to the usual management practice that e.g. includes a thinning at age 40. During the CP the management practice of forest type X has been changed e.g. no thinning at age 40. In such a case the change in management practices impacts the relations age-increment so that a technical correction of the FRL is not to be implemented.
- Biomass C stock losses, need to be corrected only if parameters (e.g. biomass expansion factors, allometric functions) applied are recalculated.
- C stocks inputs to and outputs from non-biomass pools need to be corrected in case of corrections implemented in the biomass pools. Further, those are corrected also if any parameters or empirical or functional functions that has been applied for calculating the FRL is subsequently revised (e.g. decay factors or mortality rates), although only if changes in management practices have not impacted those parameters or functions.
- non-CO<sub>2</sub> emissions from C pools need to be corrected only if any parameters applied is revised (e.g. C:N ratio).
- Technical corrections for changes in activity data, as roundwood harvested, fuelwood collected, losses due to other disturbances, or areas is applied only if those data are recalculated in the national GHGI for the historical period i.e. 2000-2009 (or 2000-20XX). An exception is made for the total area of MFL in Alternative 2 of Step 5 (see section 2.5.3 and box 18).

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<sup>34</sup> Likely age or biomass density dependent increment curves

Once a technical correction has been calculated and applied, the calibration of the corrected FRL needs to be performed again, as it was done for the FRL, to ensure that no inconsistencies in the time series originated from the recalculation.

If a technical correction is to be applied, it is good practice to justify and transparently document the updates as implemented.

## SECTION 3

### 3 CRITERIA FOR THE FOREST REFERENCE LEVEL AND THE CONTENTS OF THE NATIONAL FORESTRY ACCOUNTING PLAN

#### 3.1 Description of Annex IV criteria for constructing FRLs

As described in section 1, the LULUCF Regulation consists of a preamble describing the context and background, of enacting terms with the different articles of the Regulation, and of seven annexes that give further detail as to how to comply with the LULUCF Regulation.

Annex IV.A of the LULUCF Regulation defines criteria for determining the FRL. Here, we present these criteria as stated in the LULUCF Regulation, and give guidance on how to interpret or address the different criteria. The following statements should be considered as interpretations of the authors of this document, and not as exhaustive explanations.

As stated Annex IV.A of the LULUCF Regulation, a *“Member State’s forest reference level shall be determined in accordance with the following criteria”*:

*“(a) the reference level shall be consistent with the goal of achieving a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, including enhancing the potential removals by ageing forest stocks that may otherwise show progressively declining sinks;”*

This notion links the LULUCF Regulation to the Paris Agreement that the EU and Member States have ratified, and encourages the Member States to reflect on the long-term development of the forest sinks, also beyond the CP. This criterion can be understood to imply that a momentary change in harvest volume because of forest age structure can be justified, if it leads to enhancing potential removals by forest increment in the long term. Note, however, that the above cannot contradict the first paragraph of Article 8(5) *“The forest reference level (FRL) shall be based on the continuation of sustainable forest management practice, as documented in the period from 2000 to 2009”*. It is good practice to discuss the long-term implications of the FMPs estimated in the FRL in qualitative (and if possible, quantitative) terms, in relation to the objective of enhancing the long-term LULUCF sinks.

This criterion thereby refers also to Article 13 of the LULUCF Regulation (Managed forest land flexibility), which details the conditions on which a Member State may compensate emissions from the LULUCF sector that incur during the CP, including long term strategy.

*“(b) the reference level shall ensure that the mere presence of carbon stocks is excluded from accounting;”*

This criterion is compatible with the KP Decision 16/CMP.1 (KP 2005), where this same principle was affirmed. It reflects the objective of enhancing the carbon stocks and the net carbon sinks where possible, instead of only preserving existing carbon stocks. It is understood that a pre-existing carbon stock in terrestrial vegetation such as a forest on a given area of land does not contribute towards the reduction of atmospheric carbon. Therefore, it is appropriate for the FRL to support accounting for net changes in forest carbon stocks, rather than accounting for total existing carbon stocks in forests.

***"(c) the reference level should ensure a robust and credible accounting system that ensures that emissions and removals resulting from biomass use are properly accounted for;"***

This criterion reflects the need to provide trustworthy accounting. Note also that combustion of wood is excluded from the energy sector accounting on the basis that it is instead accounted for in the LULUCF sector, hence underlining the needs to properly account for biomass used within the LULUCF.

***"(d) the reference level shall include the carbon pool of harvested wood products, thereby providing a comparison between assuming instantaneous oxidation and applying the first-order decay function and half-life values;"***

This criterion asks to provide explicitly an assessment of the size of the HWP carbon pool. This would in most Member States result in two different FRL estimates provided by the Member State: one assuming instantaneous oxidation (where no carbon is stored in HWP, and that pool is essentially zero), and an FRL where carbon storage within HWP is accounted for.

It is good practice to explicitly state the difference between the estimates, for example:

*"The forest reference level for [country] is XX tons CO<sub>2</sub> eq, in which the HWP pool constitutes of xy tons CO<sub>2</sub> eq. If instantaneous oxidation of HWP was assumed, the FRL would be YY tons CO<sub>2</sub> eq."*<sup>35</sup>

See more guidance on how to fulfil this criterion under section 2.3.5 of this document, and Annex V of the LULUCF Regulation.

***"(e) a constant ratio between solid and energy use of forest biomass as documented in the period from 2000 to 2009 shall be assumed;"***

See more guidance on how to fulfil this criterion under section 2.5.6 of this document.

***"(f) the reference level should be consistent with the objective of contributing to the conservation of biodiversity and the sustainable use of natural resources, as set out in the EU forest strategy, Member States' national forest policies, and the EU biodiversity strategy;"***

This criterion ties the FRL projections to the concept of sustainable use of natural resources. That is, the FRL should be based on the continuation of sustainable FMP in 2000-2009 (Article 8(5)). It is good practice to confirm that the FMPs upon which the FRL is constructed are consistent with the objective of contributing to the conservation of biodiversity and other criteria for sustainable use of natural resources, as set out in the EU forest strategy, Member States' national forest policies, and the EU biodiversity strategy.

It is recognised that the conservation or enhancement of forest carbon stocks and net carbon sinks comprise just one objective of sustainable forest management. The pursuit of wider sustainable management objectives may have positive and/or negative consequences for the development of forest carbon stocks and net carbon sinks that may vary over time. The Member States are encouraged to provide commentary on how sustainable forest management policies and practices are evolving, where relevant, and to describe how sustainable use of natural resources has been taken into account in the modelling of the FRL. In this way, the consistency between the modelling of the FRL and historical and evolving sustainable FMPs may be demonstrated. More guidance on how to

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<sup>35</sup> The relation between the FRL and HWP pools will be:  $YY + xy = XX$ .

consider sustainability and continuation of forest management is given in section 2.2.7 of this document.

***"(g) the reference level shall be consistent with the national projections of anthropogenic greenhouse gas emissions by sources and removals by sinks reported under Regulation (EU) No 525/2013;"***

This criterion ties the FRL submitted within the LULUCF Regulation (EU) 2018/841 to the overall policies and requirements as set out earlier in Regulation (EU) No 525/2013. See section 2.4 for how to ensure consistency with the GHGIs.

***"(h) the reference level shall be consistent with greenhouse gas inventories and relevant historical data and shall be based on transparent, complete, consistent, comparable and accurate information. In particular, the model used to construct the reference level shall be able to reproduce historical data from the National Greenhouse Gas Inventory."***

This criterion is addressed in detail under section 2.4 of this document.

## **3.2 Common table of contents for the NFAP**

Annex IV B. of the LULUCF Regulation sets out the key elements that the national forestry accounting plans shall contain. Based on the elements (a) to (e), it is suggested that Member States develop their NFAP according to the following common table of contents. This table has been developed to accommodate the need to document each Step of the suggested approach to implement the FRL requirements in line with the LULUCF Regulation.

### **Chapter 1: General introduction**

- 1.1: General description of the forest reference level for [the Member State]
- 1.2: Consideration to the criteria as set in Annex IV of the LULUCF Regulation<sup>36</sup>

### **Chapter 2: Preamble for the forest reference level**

- 2.1: Carbon pools and greenhouse gases included in the forest reference level
- 2.2: Demonstration of consistency between the carbon pools included in the forest reference level
- 2.3: Description of the long-term forest strategy
  - 2.3.1: Overall description of the forests and forest management in [the Member State] and the adopted national policies
  - 2.3.2: Description of future harvesting rates under different policy scenarios

### **Chapter 3: Description of the modelling approach**

- 3.1: Description of the general approach as applied for estimating the forest reference level
- 3.2: Documentation of data sources as applied for estimating the forest reference level
  - 3.2.1: Documentation of stratification of the managed forest land
  - 3.2.2: Documentation of sustainable forest management practices as applied in the estimation of the forest reference level
- 3.3: Detailed description of the modelling framework as applied in the estimation of the forest reference level

### **Chapter 4: Forest reference level**

- 4.1: Forest reference level and detailed description of the development of the carbon pools
- 4.2: Consistency between the forest reference level and the latest national inventory report
- 4.3: Calculated carbon pools and greenhouse gases for the forest reference level

## **References**

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<sup>36</sup> Under this heading, we suggest to reflect on the criteria of Annex IV A. (see section 3.1 on p. 99), and to include an equivalence table such as the one suggested in Table 11, to reflect on Annex IV B.

In the NFAP, the Member states are encouraged to include a section (chapter 1.2 in the suggested table of contents) that explicitly reflects on the criteria and guidance for the FRL as detailed in Annex IV A. of the Regulation. In addition, the Member States are encouraged to include an equivalence table, in the form of a filled-in version of Table 11, showing where the different elements of Annex IV B. of the Regulation are found in the national submission. The purpose of the equivalence table is to assist the review process, and it is therefore good practice to be as specific as possible when referring to the different chapters or pages of the NFAP submission.

Table 11. Suggested equivalence table to be included in the NFAP (*Chapter 1.2, Consideration to the criteria as set in Annex IV of the LULUCF Regulation*), where the Member State may show explicitly where the Annex IV B. elements are documented in the NFAP submission.

Annex IV B. paragraph item	Elements of the national forestry accounting plan according to Annex IV B.	Chapter or page number(s) in the NFAP
(a)	A general description of the determination of the forest reference level.	
(a)	Description of how the criteria in LULUCF Regulation were taken into account.	
(b)	Identification of the carbon pools and greenhouse gases which have been included in the forest reference level.	
(b)	Reasons for omitting a carbon pool from the forest reference level determination.	
(b)	Demonstration of the consistency between the carbon pools included in the forest reference level.	
(c)	A description of approaches, methods and models, including quantitative information, used in the determination of the forest reference level, consistent with the most recently submitted national inventory report.	
(c)	A description of documentary information on sustainable forest management practices and intensity.	
(c)	A description of adopted national policies.	
(d)	Information on how harvesting rates are expected to develop under different policy scenarios.	
(e)	A description of how the following element was considered in the determination of the forest reference level:	
(i)	<ul style="list-style-type: none"> <li>• The area under forest management</li> </ul>	
(ii)	<ul style="list-style-type: none"> <li>• Emissions and removals from forests and harvested wood products as shown in greenhouse gas inventories and relevant historical data</li> </ul>	
(iii)	<ul style="list-style-type: none"> <li>• Forest characteristics, including:                             <ul style="list-style-type: none"> <li>- dynamic age-related forest characteristics</li> <li>- increments</li> <li>- rotation length and</li> <li>- other information on forest management activities under 'business as usual'</li> </ul> </li> </ul>	
(iv)	<ul style="list-style-type: none"> <li>• Historical and future harvesting rates disaggregated between energy and non-energy uses</li> </ul>	

### 3.3 Where to find advice for Annex IV elements in this document?

Table 12 and Table 13 provide links and references for where to find more guidance on Annex IV criteria and elements in this technical guidance document.

Table 12. References for where to find advice on Annex IV A. criteria in this technical guidance document.

Criterion in Annex IV A.	Chapter in the technical guidance document
(a) the reference level shall be consistent with the goal of achieving a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, including enhancing the potential removals by ageing forest stocks that may otherwise show progressively declining sinks;	Sections 1.2.1 and 3.1
(b) the reference level shall ensure that the mere presence of carbon stocks is excluded from accounting;	Sections 1.2.3 and 3.1
(c) the reference level should ensure a robust and credible accounting system that ensures that emissions and removals resulting from biomass use are properly accounted for;	Sections 1 and 3.1
(d) the reference level shall include the carbon pool of harvested wood products, thereby providing a comparison between assuming instantaneous oxidation and applying the first-order decay function and half-life values;	Sections 2.3.5 and 2.5.6
(e) a constant ratio between solid and energy use of forest biomass as documented in the period from 2000 to 2009 shall be assumed;	Section 2.5.6
(f) the reference level should be consistent with the objective of contributing to the conservation of biodiversity and the sustainable use of natural resources, as set out in the EU forest strategy, Member States' national forest policies, and the EU biodiversity strategy;	Sections 2.2.7 and 3.1
(g) the reference level shall be consistent with the national projections of anthropogenic greenhouse gas emissions by sources and removals by sinks reported under Regulation (EU) No 525/2013;	Section 2.4
(h) the reference level shall be consistent with greenhouse gas inventories and relevant historical data and shall be based on transparent, complete, consistent, comparable and accurate information. In particular, the model used to construct the reference level shall be able to reproduce historical data from the National Greenhouse Gas Inventory.	Sections 2.1, 2.2, 2.4 and 2.5

Table 13. References for where to find advice on Annex IV B. elements in this technical guidance document.

Annex IV B. paragraph item	Elements of the national forestry accounting plan according to Annex IV B.	Chapter and page number(s) in the technical guidance document
(a)	A general description of the determination of the forest reference level.	Sections 1.2.3 and 1.4
(a)	Description of how the criteria in LULUCF Regulation were taken into account.	Sections 3.1 and 3.2
(b)	Identification of the carbon pools and greenhouse gases which have been included in the forest reference level.	Section 1.2.3
(b)	Reasons for omitting a carbon pool from the forest reference level determination.	Sections 1.2.3 and 1.4
(b)	Demonstration of the consistency between the carbon pools included in the forest reference level.	Section 2.4
(c)	A description of approaches, methods and models, including quantitative information, used in the determination of the forest reference level, consistent with the most recently submitted national inventory report.	Section 2
(c)	A description of documentary information on sustainable forest management practices and intensity.	Section 2.2
(c)	A description of adopted national policies.	Not applicable
(d)	Information on how harvesting rates are expected to develop under different policy scenarios.	Not applicable
(e)	A description of how the following element was considered in the determination of the forest reference level:	
(i)	<ul style="list-style-type: none"> <li>• The area under forest management</li> </ul>	Sections 2.1.4, 2.2.5, 2.3.2 and 2.5.3
(ii)	<ul style="list-style-type: none"> <li>• Emissions and removals from forests and harvested wood products as shown in greenhouse gas inventories and relevant historical data</li> </ul>	Sections 2.1.4, 2.3, 2.4 and 2.5
(iii)	<ul style="list-style-type: none"> <li>• Forest characteristics, including:                             <ul style="list-style-type: none"> <li>- dynamic age-related forest characteristics</li> <li>- increments</li> <li>- rotation length and</li> <li>- other information on forest management activities under 'business as usual'</li> </ul> </li> </ul>	Sections 2.1, 2.2, 2.3 and 2.5
(iv)	<ul style="list-style-type: none"> <li>• Historical and future harvesting rates disaggregated between energy and non-energy uses</li> </ul>	Section 2.5.6

## ANNEXES

### ANNEX I

#### **Checklist of aspects to consider when following the approach suggested in this technical guidance document**

In this annex we provide a series of checklists for preparing the FRL. The checklists as detailed below follows the stepwise approach for estimating the FRL as suggested in this document. For each Step, a list of key items to be document and specified is provided.

These checklists are intended as an internal tool for the national teams for helping to structure the work. These lists are not meant to be included in the NFAPs.

Step 1: Stratify the area of MFL, according to country-defined criteria, and apply the stratification in a consistent manner over time, including the RP 2000-2009.	
Document how the area of Managed Forest Land is considered in the determination of the FRL (Annex IV B.) of the LULUCF Regulation)	<input type="checkbox"/>
Document how large a share of the national forests was covered by a given FMP in the period from 2000 to 2009	<input type="checkbox"/>
Document each criterion used for the stratification of the MFL.	<input type="checkbox"/>
Document data sources used to perform the stratification.	<input type="checkbox"/>
Document and justify any deviation between the stratification for the FRL and any stratification already used in the GHGI or NFI.	<input type="checkbox"/>
Document the sources of information used to determine the forest characteristics for each stratum (see Table 2 for an example of this can be documented).	<input type="checkbox"/>
Document the forest definition used for the construction of FRL and explain whether it differs from that used in the national GHGI.	<input type="checkbox"/>

Step 2: Identify and document the FMPs in each strata for 2000-2009 based on country-defined operational criteria and quantifiable data.	
Document the sources of information used to identify and specify the FMPs.	<input type="checkbox"/>
Describe in qualitative terms each FMP as applied during the RP (see Table 3 for an example of how this can be documented).	<input type="checkbox"/>
Describe in quantitative terms each FMP as applied during the RP (see Table 4 and Table 5 for examples of how this can be documented).	<input type="checkbox"/>
Document the use of FMPs according to the stratification of the forest land (see Table 6 for an example of how this can be documented).	<input type="checkbox"/>
Verify that the documentation of the FMPs include specifications about: (i) how each management activity is performed, and (ii) when is each management activity being carried out.	<input type="checkbox"/>
Check that the above descriptions of FMPs and forest characteristics include a description of the following forest characteristics (Annex IV B.): - dynamic age-related forest characteristics - increments - rotation length - other information on forest management activities	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Confirm that any trends in when an management activity is carried as observed during the period from 2000 to 2009 are not projected to continue during the CP	<input type="checkbox"/>
Document and confirm that only data sources from the period 2000 to 2009 are being used to define the FMPs. If data sources outside the period from 2000 to 2009 are used, document and justify this deviation. Also, document an assessment of the impact of this deviation on the FRL.	<input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
Document how the principles of sustainable FMPs are being applied within the country.	<input type="checkbox"/>
Document the use of the FMPs in each strata of the MFL (see Table 6 for an example of this can be documented).	<input type="checkbox"/>

Step 3: Select the appropriate methodology to project the development of carbon pools based on available data and national circumstances.	
Document the methodology as selected to project to the development of carbon pools.	<input type="checkbox"/>
Document the 'Age structure module'	<input type="checkbox"/>
Document the 'Harvest module'	<input type="checkbox"/>
Document the 'C pool variation module'	<input type="checkbox"/>
Document how natural disturbances have been estimated in the projection of the FRL, including data sources as applied.	<input type="checkbox"/>
Document how the HWP pool has been estimated in the projection of the FRL, including data sources as applied.	<input type="checkbox"/>

Step 4: Calibrate the selected methodology based on real observed data and show that the methodology is able to reproduce the GHGI estimates.	
Document the model estimates of Biomass gains, Biomass losses, and Net GHG emissions/removals from the year 2000 until the starting year of the projection of the FRL.	<input type="checkbox"/>
Document the emissions and removals from forests and HWP as shown in GHGIs and relevant historical data (Annex IV (B)), from the year 2000 until the starting year of the projection of the FRL.	<input type="checkbox"/>

Step 5: Select the appropriate methodology to project the development of carbon pools based on available data and national circumstances.	
Specify the assumptions taken concerning climate change and documentation of data sources applied.	<input type="checkbox"/>
If a projection of future climate conditions are used (Alternative 2 in Box 17), document: - Assumptions and projections for future climatic conditions as applied - Document the potential impact on the FRL by not considering the future climate effect (i.e. applying Alternative 1 instead of Alternative 2 (see Box 17))	<input type="checkbox"/> <input type="checkbox"/>
Specify and justify the assumptions taken concerning the area development of MFL and documentation of data sources as applied.	<input type="checkbox"/>
Specify the assumptions taken concerning the area development of MFL and documentation of data sources as applied.	<input type="checkbox"/>
Document and justify the selected starting year for the projection of the FRL.	<input type="checkbox"/>
Document and justify the assumptions taken concerning the period from 2010 to 2020.	<input type="checkbox"/>
Specify the data sources used to describe the State of the forest as of the starting year of the projection of the FRL.	<input type="checkbox"/>
Confirm that area of land allocated to each stratum remains constant from the starting year of the projection	<input type="checkbox"/>
Confirm that the FMPs as defined and documented in Step 2 for the RP are consistently applied from the starting year of the projection onwards.	<input type="checkbox"/>
Describe the historical and future harvesting rates disaggregated between energy and non-energy uses. (Annex IV B.)	<input type="checkbox"/>

Step 6: Calculate the FRLs as average of emissions and removals during 2021-2025 and 2026-2030.

Document the 5-year average of projected values for the periods 2021-2025 and 2026-2030.



## ANNEX II

### Handbook for establishing forest reference levels

A total of six steps are envisioned to be taken for the implementations of the FRLs. The sequence in which these steps are expected to be implemented and performed is visualized in Figure 16. It is important to note that while some of these steps are to be performed sequentially (i.e. Step 5 is only to be performed after Step 4), there are also some steps that can be performed at the same time. As an example, Step 1 and Step 2 may very well be performed simultaneously as the selection of the stratification is highly interlinked to the identification of the FMPs.

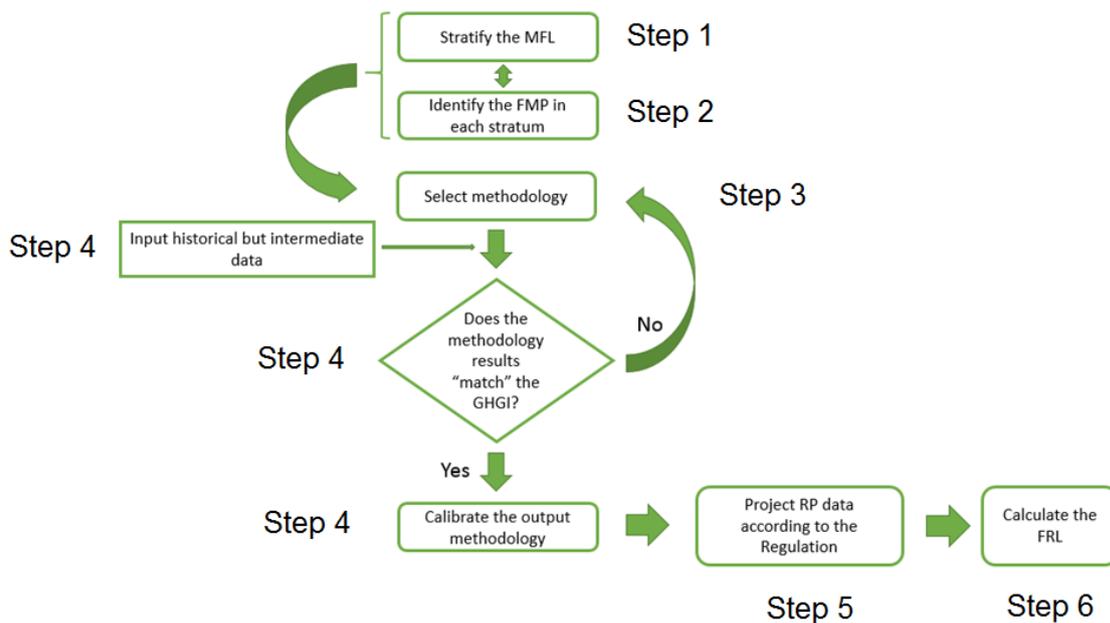


Figure 16: An overview of the step by step process that is envisioned to be taken to establish the FRL and how the steps are suggested to be carried out sequentially.

In this handbook we highlight and list the key aspects to consider during the implementation of each of these steps. The main aim of this description is to provide additional information concerning how these steps fit together and the flow of information that follows. For detailed description about each step we refer to section 2 of this document.

#### Step 1: Stratification

- Main aim of this Step is to define and document the stratification of MFL.
- The stratification of forest land serves to distinguish different types of FMPs.
- It is important that the stratification covers the entire area of MFL.
- It is good practice that the criteria used for the stratification remain constant in the modelling of historical and projected emissions by sources and removals by sinks.
- The number of strata and their definition are to be selected in consideration of available data and methodological (model) requirements for estimating the FRL.

## **Step 2: Description of forest management practices**

- In this Step, the FMPs that were applied in the period from 2000 to 2009 are to be documented through country-defined and quantifiable operational criteria.
- For each stratum identified in Step 1, the FMPs that took place in the stratum are to be documented.
- The focus is to document and describe in detail the management practices that actually took place during the RP, i.e. not the management practices that were expected to take place or that were legally allowed to take place
- The information collected and document in this Step will serve as input to the methodology developed to project the FRL in Step 3, thereby forming the basis to model the continuation of FMPs during the CP.

## **Step 3: Select the appropriate methodology**

- In this Step, the methodology used to estimate the FRL are to be selected, calibrated and documented.
- The objective is to select a method that can estimate future development of the MFL carbon pools in the CP, in line with the stratification as selected in Step 1 and the FMPs documented in Step 2.
- It is important to note that the Member States can use different methods for different strata, to take into account differences in management practices, forest composition, and tree species.

## **Step 4: Calibration and consistency with greenhouse gas inventory estimates**

- In this Step, the methodology as selected in Step 3 is calibrated based on the real observed data, including the data concerning each strata and FMP as collected in Step 1 and 2.
- It should be shown that the methodology as selected in Step 3 is able to reproduce the existing and documented data as reported in the latest national GHGIs for MFL.
- It should be shown that the modelling framework is able to reproduce historical GHGI estimates from the year 2000 until the latest inventory year available in the national GHGI at the time the FRL is constructed. Figure 17 provides an illustration of how this can be done sequentially for each year that is being assessed.

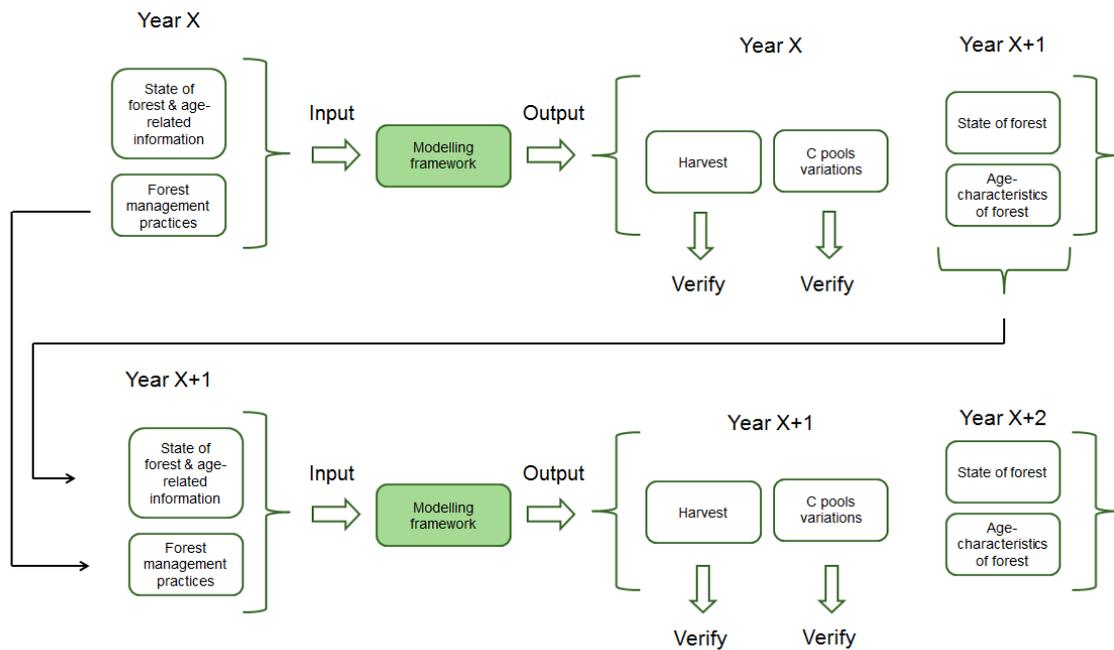


Figure 17: An overview of the process of reproducing the historical estimates as documented in the latest national GHGI for MFL.

### Step 5: Projection of emissions and removals

- In this Step, the methodology as selected and calibrated in Step 4 would be used to project the future development of anthropogenic forest GHG emissions by sources and removals by sinks for the CP.
- Key input to the methodological framework includes the data concerning each strata and FMP as collected in Step 1 and 2.
- Key output from the methodological framework is the projection of emissions by sources and removals by sinks from the starting year of the projections until 2025.

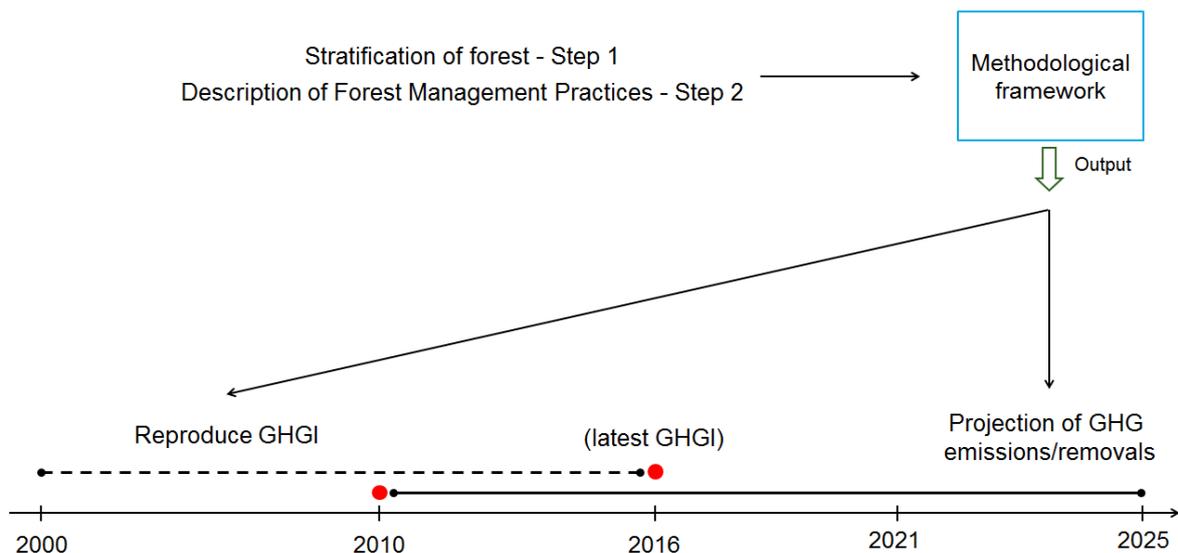
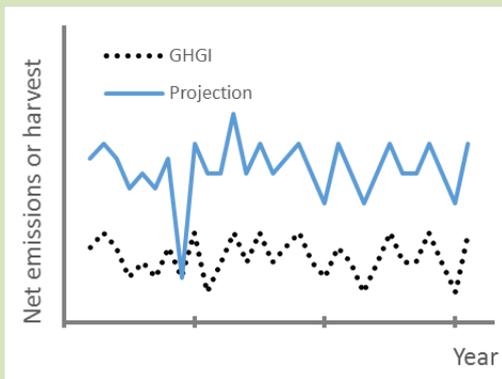


Figure 18: Overview of how the various Steps that are to be implemented fit together in terms of a timeline. In this figure, the red dots at 2010 illustrate the preferred starting years for the projections.

## Step 6: Calculate the forest reference level

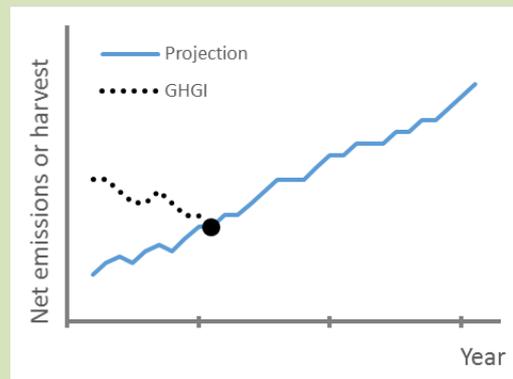
- Based on the yearly estimates of GHG emissions and removals for MFL that has been developed in Step 5, the 5-year average of projected values can be calculated based on the FRL values for the periods 2021 - 2025 and 2026 - 2030.
- The calculations of the average estimates should be fully performed based on the estimates as developed within Step 5.

### Possible problems with the projection and how to address them



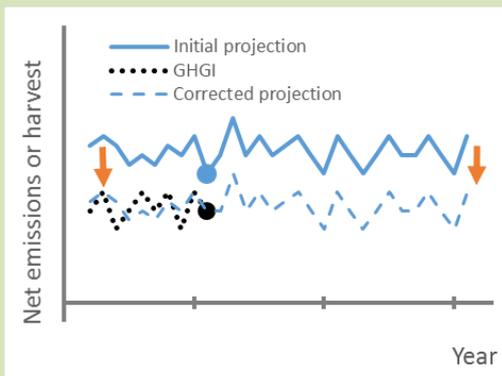
**Problem:** The projection only matches a single time point in the GHGI, not the overall GHGI.

**Solution:** Calibrate the projection ignoring outliers (see also section 2.4.3).



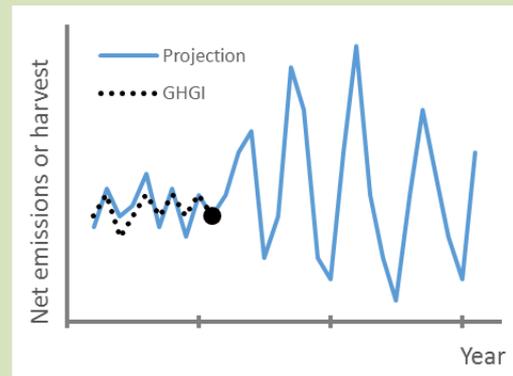
**Problem:** The trend of the GHGI is not consistent with the trend of the projection.

**Solution:** Refine the model (see also section 2.4.3).



**Problem:** The initial projection is on a different overall level from the GHGI.

**Solution:** Calibrate the projection to be in line with the overall level of the GHGI (shown with dashed line). See also section 2.4.4.



**Problem:** The projected inter-annual variability is much larger than the inter-annual variability in the GHGI.

**Solution:** Refine the model. See also section 2.5.

## ANNEX III

### Filled in example of table for Step 1

In this annex to the technical guidance document, we illustrate how a Member State may document information sources for forest characteristics in strata through the use of tables. The tables below only serve as examples and a Member State is of course free to select another way of documenting the information sources.

Table 14: Filled in example of Table 2.

Forest characteristics	Data references	Stratum ID where the characteristics and reference are relevant
Aboveground biomass	NFI, 2009	All
Belowground biomass		
1) Floodplain forests	Krejza et al., 2017	1-9
2) All other forests	Zianis et al., 2005	10-250
Area of strata	NFI, 2009	All
Species composition		
1) State forests	NFI, 2009	1, 5, 15, 25, 30-250
2) Private forests	Brus et al., 2011	2-4, 6-14, 16-24, 26-29

#### References for the Table 14:

Brus, D.J., Hengeveld G.M., Walvoort D.J.J., Goedhart P.W., Heidema A.H., Nabuurs G.J., Gunia K. (2011) Statistical mapping of tree species over Europe. *European Journal of Forest Research* 131 (1): 145–157

Krejza J., Světlík J., Bednář P. (2017) Allometric relationship and biomass expansion factors (BEFs) for above- and below-ground biomass prediction and stem volume estimation for ash (*Fraxinus excelsior* L.) and oak (*Quercus robur* L.). *Trees*, 31 (4): 1303-1316

NFI (2009) National Forest Inventory.

Zianis D., Muukkonen P., Mäkipää R., Mencuccini M. (2005) Biomass and stem volume equations for tree species in Europe. *Silva Fennica Monographs* 4, 63 pp.

## Filled in examples of tables for Step 2

In this subsection we illustrate how Member State may document their FMPs through the use of Table 3 to Table 6. The table below only serve as examples and a Member State is of course free to select to document their nationally specific FMPs in other ways.

Table 15: Filled in example of Table 3.

Forest Management Practice		
Index	Name of Practice	Short Description of Practice
FMP 1	Pine clearcutting long	Even aged pine forest with long rotation and regenerated by clearcut
FMP 2	Pine clearcutting short	Even aged pine forest with short rotation and regenerated by clearcut
FMP 3	Pine uniform shelterwood	Even aged pine forest regenerated with consecutive cuttings applied on the whole area
FMP 4	Pine non uniform shelterwood	Even aged pine forest regenerated with consecutive cuttings applied on groups, strips or different spatial patterns
FMP 5	Spruce clearcutting	Even aged spruce forest regenerated by clearcutting
FMP 6	Spruce non uniform shelterwood	Even aged spruce forest regenerated with consecutive cuttings applied on groups, strips or different spatial patterns
FMP 7	Spruce close to nature	Spruce forest with close to nature cuttings and natural regeneration (e.g. group selection)
FMP 8	Beech timber shelterwood	Even aged beech forest managed to produce timber and regenerated with consecutive cuttings
FMP 9	Beech close to nature	Beech forest with close to nature cutting and natural regeneration (e.g. group selection, single tree selection)
FMP 10	Oak timber provision	Oak forest with long rotation and regenerated by clearcut or shelterwood
FMP 11	Mixed forests with selective systems	Forest with mixed tree species and uneven aged management (e.g. group selection, single tree selection)
FMP 12	Oak coppice	Oak coppice with short rotation cycle for firewood production
FMP 13	Chestnut timber coppice	Chestnut coppice with standards for timber
FMP 14	Eucalyptus pulpwood	Eucalyptus plantation for pulpwood production with short rotation cutting cycle
FMP 15	No intervention	Forest without active management
FMP 16	Nature conservation and biodiversity protection without management	Forest without management and aimed to protect and preserve biodiversity
FMP 17	Nature conservation and biodiversity protection with management	Forest with management oriented to biodiversity protection and preservation
FMP 18	Soil protection	Forest with management oriented to soil protection
FMP 19	Water purification	Forest with management oriented to water purification
FMP 20	Close to Nature Forest	Forest with close to nature management and minimal intervention

Table 16: Filled in example of Table 4.

Forest management practice		Silvicultural operations with final harvesting							
		Pre-commercial thinning		First commercial thinning		Second commercial thinning		Final cutting	
Index	Name of practice	Age (yrs) or Dbh (cm.)	% biomass harvest *	Age (yrs) or Dbh (cm.)	% biomass removals *	Age (yrs) or Dbh (cm.)	% biomass removals *	Age (yrs) or Dbh (cm.)	% biomass removals *
FMP 1	Pine clearcutting long	>10	15%	>20	15%	N.A.	N.A.	120 - 140	95%
FMP 2	Pine clearcutting short	>10	15%	>20	15%	N.A.	N.A.	60 - 80	95%
FMP 3	Pine uniform shelterwood	N.A.	N.A.	>20	15%	>30	15%	80-120	95%
FMP 4	Pine non uniform shelterwood	N.A.	N.A.	>20	15%	>30	15%	80-120	95%
FMP 5	Spruce clearcutting	>10	15%	>20	15%	N.A.	N.A.	80-100	95%
FMP 6	Spruce non uniform shelterwood	N.A.	N.A.	>20	15%	>30	15%	80-120	95%
FMP 8	Beech timber shelterwood	N.A.	N.A.	>20	15%	>30	15%	80-120	95%
FMP 10	Oak timber provision	N.A.	N.A.	>20	20%	N.A.	N.A.	80-120	95%
FMP 12	Oak coppice	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	20-30	90%
FMP 13	Chestnut timber coppice	>10	15%	N.A.	N.A.	N.A.	N.A.	30-40	85%
FMP 14	Eucalyptus pulpwood	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	12-20	95%
FMP 15	No intervention	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
FMP 16	Nature conservation and biodiversity protection without management	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.
FMP 18	Soil protection	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	100-120	70%
FMP 19	Water purification	N.A.	N.A.	N.A.	N.A.	N.A.	N.A.	100-120	70%

\*percentage of standing biomass at the time of intervention

Table 17: Filled in example of Table 5

Forest management practice		Silvicultural operations without final harvesting	
Index	Name of practice	Years between operation (yrs.)	% biomass removals
FMP 20	Single tree selection	15-20	15%
FMP 21	Single tree selection and thinning	15-20	25%
FMP 22	Group selection	20-25	25%

Table 18: Filled in example of Table 6

Stratification of MFL			% distribution of forest management practices					Sum Total (%)
Ownership type	Main tree species	Productivity class	FMP Index 1	FMP Index 2	FMP Index 3	FMP Index 4	...	
Private commercial forest owners	Pine	I	12%	88%	0%	0%		100%
		II	16%	82%	0%	0%		100%
	Spruce	I	0%	0%	0%	0%		100%
		II	0%	0%	0%	0%		100%
	Birch	I	0%	0%	0%	0%		100%
		II	0%	0%	0%	0%		100%
	Aspen	I	0%	0%	0%	0%		100%
		II	0%	0%	0%	0%		100%
State owned forest	Pine	I	51%	44%	5%	0%		100%
		II	41%	54%	5%	0%		100%
	Spruce	I	0%	0%	0%	0%		100%
		II	0%	0%	0%	0%		100%
	Birch	I	0%	0%	0%	0%		100%
		II	0%	0%	0%	0%		100%
	Aspen	I	0%	0%	0%	0%		100%
		II	0%	0%	0%	0%		100%

## ANNEX IV

### Overview of implementation of the Kyoto Protocol in the EU Member States

Table 19, Table 20 and Table 21 give an overview of the reporting of LULUCF activities by the Member States under KP second commitment period.

Table 19. Voluntary KP-LULUCF activities elected by Member States in the second commitment period, and accounting timing selected.

Member State	Art 3.4 elected activities	Accounting frequency
Austria	---	end of CP
Belgium	---	end of CP
Bulgaria	---	end of CP
Croatia	---	end of CP
Cyprus	---	end of CP
Czech Republic	---	end of CP
Denmark	CM, GM	annual
Estonia	---	end of CP
Finland	---	end of CP
France	---	end of CP
Germany	CM, GM	end of CP
Greece	---	end of CP
Hungary	---	annual
Ireland	CM,GM	end of CP
Italy	CM, GM	end of CP
Latvia	---	end of CP
Lithuania	---	end of CP
Luxemburg	---	end of CP
Malta	---	end of CP
Netherlands	---	end of CP
Poland	---	end of CP
Portugal	CM, GM	end of CP
Romania	RV	end of CP
Slovakia	---	end of CP
Slovenia	---	end of CP
Spain	CM	end of CP
Sweden	---	end of CP
United Kingdom	CM, GM, WDR	end of CP
Iceland	RV	end of CP

Table 20. C pools for which estimates have been reported under each of the KP-LULUCF activities.

Member State	CHANGE IN CARBON POOL REPORTED							GREENHOUSE GAS SOURCES REPORTED							
	AGB	BGB	Litter	Dead wood	Soil		HWP	Fertilization	Drained, rewetted and other soils		Nitrogen mineralization in mineral soils	Indirect N <sub>2</sub> O emissions from managed soil	Biomass burning		
					Min	Org			N <sub>2</sub> O	CH <sub>4</sub>			N <sub>2</sub> O	N <sub>2</sub> O	CO <sub>2</sub>
<b>Afforestation/Reforestation</b>															
Austria	R	R	R	R	R	NO	R	NO	NO	NO	R	NO	NO	NO	NO
Belgium	R	R	R	R	R	NO	R	NO	NO	NO	R	NO	NO	NO	NO
Bulgaria	R	IE	R	NO	R	NO	R	NO	NO	NO	NO	NO	R	R	R
Croatia	R	R	R	NO	R	NO	NO	NO	NO	NO	NO	NO	R	R	R
Cyprus															
Czech Republic	R	R	R	R	R	R	R	NO	NO	NO	NO	NO	NO	NO	NO
Denmark	R	R	R	R	R	R	R	IE	R	R	NO	R	NO	NO	NO
Estonia	R	R	R	R	R	R	R	NO	NE	NE	NO	NO	IE	R	R
Finland	R	R	IE	IE	R	R	R	R	R	R	R	R	R	R	R
France	R	R	R	R	R	IE		NO	NO	NO	R		R	R	R
Germany	R	R	R	R	R	R	IE	NO	NO,R	NO,R	R	R	IE,NO	IE,NO	IE,NO
Greece	R	R	NR	NR	NR	NO	NO	NO	NO	NO	NO	NO	R	R	R
Hungary	R	R	NR	NR	NR	NO	IE	IE	NO	NO	NO	NO	IE	R	R
Ireland	R	R	R	R	NO	R	R	IE	R	R	NO	IE	R	R	R
Italy	R	R	R	R	R	NO	R	NO	NO	NO	R	R	R	R	R
Latvia	R	R	R	R	NO	R	NO	NO	R	R	NO	NO	NO	NO	NO
Lithuania	R	R	R	NO	R	R	IE	NO	R	R	NO	NO	R	R	R
Luxemburg	R	R	R	R	R	NO	IO	NO	NO	NO	NO	NO	NO	NO	NO
Malta	NR	NR	NR	NR	NR	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Netherlands	R	R	NR	R	R	R	IE	NO	NE	NE	R	NO	R	R	R
Poland	R	R	R	R	R	R	NO	NO	NO	NO	NO	NO	R	R	R

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Portugal	R	R	R	IE	R	NO	R	IE	NO	NO	R	IE	R	R	R
Romania	R	R	R	NO	R	NR	R	IE	NO	NO	R	R	R	R	R
Slovakia	R	R	R	NO,NR	R	NO,NR	NR	NO	NO	NO	NO	NO	R	R	R
Slovenia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Spain	R	IE	NR,R	NR,R	NR,R	NO	NR	NO	NO	NO	NE,R	IE,NE	IE,NO,R	NO,R	NO,R
Sweden	R	R	R	R	R	R	R	NO	R	R	R	R	NO	NO	NO
United Kingdom	R	IE	R	IE	R	R	R	R	NE	R	R	R	R	R	R
Iceland	R	R	R	NO	R	R	NO	R	R	R	NO	NO	NO	NO	NO
<b>Deforestation</b>															
Austria	R	R	R	R	R	NO	IO	NO	NO	NO	R	NO	NO	NO	NO
Belgium	R	R	R	R	R	NO	R	IE	NO	NO	R	NO	NO	NO	NO
Bulgaria	R	IE	R	R	R	NO	R	NO	NO	NO	NO	NO	NO	NO	NO
Croatia	R	R	R	IE	R	NO	R	NO	NO	NO	R	NO	NO	NO	NO
Cyprus															
Czech Republic	R	R	R	R	R	R	R	NO	NO	NO	R	NO	NO	NO	NO
Denmark	R	R	R	R	R	R	R	IE	R	R	R	IE	NO	NO	NO
Estonia	R	R	R	R	R	R	R	NO	NE	NE	NO	NO	NO	NO	NO
Finland	R	R	IE	IE,R	R	R	IO	IE	R	R	R	IE	R	R	R
France	R	R	R	R	R	IE		NO	NO	NO	R		R	R	R
Germany	R	R	R	R	R	R	NO	NO	NO,R	NO,R	R	R	NO	NO	NO
Greece	R	R	R	R	R	NO	NO	NO	NO	NO	R	NO	NO	NO	NO
Hungary	R	R	R	R	R	NO	IO	IE	NO	NO	R	R	IE	R	R
Ireland	R	R	R	R	R	R	IO	IE	R	R	R	IE	NO	NO	NO
Italy	R	R	R	R	R	NO	R	NO	NO	NO	NO	NO	NO	NO	NO
Latvia	R	R	R	R	R	R	R	IE	R	R	IE	IE	NO	NO	NO
Lithuania	R	R	R	R	R	R	IO	NO	NO	NO	R	NO	NO	NO	NO
Luxemburg	R	R	R	R	R	NO	IO	NO	NO	NO	R	NO	NO	NO	NO
Malta	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Netherlands	R	R	R	R	R	R	IO	IE	NE	NE	R	IE	R	R	R

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Poland	R	R	R	R	R	R	R	NO	NO	NO	NO	NO	NO	NO	NO	
Portugal	R	R	R	IE	R	NO	R	IE	NO	NO	R	IE	R	R	R	
Romania	R	R	R	NO	R	NR	R	IE	NO	NO	R	R	R	R	R	
Slovakia	R	R	R	R	R	NO,NR	NR	NO	NO	NO	NO	NO	NO	NO	NO	
Slovenia	R	R	R	R	R	NO	IO	NO	NO	NO	R	NO	NO	NO	NO	
Spain	NR,R	IE,NR	NR,R	NR,R	NR,R	NO	NR	NO	NO	NO	NE,R	IE,NE	NO,R	IE,NO,R	IE,NO,R	
Sweden	R	R	R	R	R	R	IO	NO	R	R	R	R	NO	NO	NO	
United Kingdom	R	IE	R	IE	R	IE	IO	NO	NO	NO	R	R	R	R	R	
Iceland	R	NO	NO	NO	R	R	NO	NO	R	R	NE	NO	NO	NO	NO	
<b>Forest Management</b>																
Austria	R	R	IE	R	R	NO	R	NO	NO	NO	NO	NO	IE	R	R	
Belgium	R	R	NO	NO	R	NO	R	NO	NO	NO	R	NO	NO	NO	NO	
Bulgaria	R	IE	R	R	R	NO	R	NO	NO	NO	NO	NO	R	R	R	
Croatia	R	R	NO	NO	NO	NO	R	NO	NO	NO	NO	NO	R	R	R	
Cyprus																
Czech Republic	R	R	IE	R	R	R	R	NO	NO	NO	NO	NO	R	R	R	
Denmark	R	R	R	R	R	R	R	IE	R	R	NO	IE	NO	NO	NO	
Estonia	R	R	R	R	R	R	R	NO	NA	NA	NO	NO	IE	R	R	
Finland	R	R	IE	IE	R	R	R	R	R	R	R	R	R	R	R	
France	R	R	R	R	R	IE		NO	NO	NO	R		R	R	R	
Germany	R	R	R	R	R	R	R	NO	NO,R	NO,R	R	R	IE,NO	NO,R	NO,R	
Greece	R	R	NR	NR	NR	NO	R	NO	NO	NO	NO	NO	R	R	R	
Hungary	R	R	NR	NR	NR	R	R	IE	NO	NO	NO	NO	IE	R	R	
Ireland	R	R	R	R	NA	R	R	IE	R	R	NO	IE	R	R	R	
Italy	R	R	R	R	NR	NR	R	NO	NO	NO	NO	NO	R	R	R	
Latvia	R	R	R	R	NO	R	R	NO	R	R	R	R	R	R	R	
Lithuania	R	R	R	R	NO	R	R	NO	R	R	NO	NO	R	R	R	
Luxemburg	R	R	R	R	R	NO	IO	NO	NO	NO	NO	NO	NO	NO	NO	
Malta	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	

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Netherlands	R	R	NO	R	NO	NO	R	NO	NE	NE	R	NO	R	R	R
Poland	R	R	R	R	R	R	R	NO	R	NO	NO	NO	R	R	R
Portugal	R	R	R	IE	R	NO	R	IE	NO	NO	R	IE	R	R	R
Romania	R	R	R	NO	R	NR	R	IE	NO	NO	R	R	R	R	R
Slovakia	R	R	NO,NR	NO,NR	NO,NR	NO,NR	R	NO	NO	NO	NO	NO	R	R	R
Slovenia	R	R	NR	R	NR	NO	R	NO	NO	NO	NO	NO	R	R	R
Spain	R	IE	NR	NR	NR	NO	R	NO	NO	NO	NE	NE	IE,R	R	R
Sweden	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
United Kingdom	R	IE	R	IE	R	R	R	NO	NE	R	R	NO	R	R	R
Iceland	R	R	R	NR	R	R	R	NO	R	R	NE	NE	NO	NO	NO
<b>Cropland Management</b>															
Denmark	R	R	NO	NO	R	R			R		IE		NO	NO	NO
Germany	R	R	IE	IE,NO	R	R			NO,R		R		NO	NO	NO
Ireland	R	IE	NO	NO	R	NO			NO		IE		NO	R	R
Italy	R	R	NO	NO	R	R			NO		NO		R	R	R
Portugal	R	R	R	NO	R	NO			NO		R		R	R	R
Spain	R	IE	NR,R	NR	R	NO			NO		NE,R		NO,R	IE,NO,R	IE,NO,R
United Kingdom	R	IE	NR	NR	R	R			NE		R		NE	R	R
<b>Grassland Management</b>															
Denmark	R	R	NO	NO	R	R			R		IE		NO	NO	NO
Germany	R	R	IE	IE,NO	R	R			NO,R		R		NO	NO	NO
Ireland	R	IE	NO	NO	R	NO			NO		IE		NO	R	R
Italy	R	R	NO	NO	R	R			NO		NO		R	R	R
Portugal	R	R	R	NO	R	NO			NO		R		R	R	R
United Kingdom	R	IE	NR	NR	R	R			NE		R		NE	R	R
<b>Revegetation Management</b>															
Romania	R	R	R	R	R	NO		R	NO	NO	R	R	R	R	R
Iceland	R	IE	IE	NO	R	NO		R	NO	NO	IE	IE	NE	R	R

**Wetlands Drainage and Rewetting**

United Kingdom	NR	NR	NR	NR		NR		NE	NE	NE		NE	NE	NE	NE
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Table 21. Values of FMRL and of its technical correction reported by the Member States, with information on the method applied to construct the FMRL.

Member State	Value inscribed in the Appendix to the annex to decision 2/CMP.7 (kt CO <sub>2</sub> eq/yr)	Technical correction	FMRL based on projections under a "Business-as-usual" scenario		
			Model-based projections using country-specific methodology	Model-based projections using JRC approach	Projections based on historical data assumed as proxy for a "business-as-usual"
Austria	-6516	5823	X		
Belgium	-2499	NA		X	
Bulgaria	-7950	23		X	
Croatia	-6289	905	X		
Cyprus	-157	NA			X
Czech Republic	-4686	NA		X	
Denmark	409	-83	X		
Estonia	-2741	NE		X	
Finland	-20466	-14545	X		
France	-67410	21795		X	
Germany	-22418	NE	X		
Greece	-1830	257			X
Hungary	-1000	-40		X	
Ireland	-142	-571	X		
Italy	-22166	-1680		X	
Latvia	-16302	11703		X	
Lithuania	-4552	-922		X	
Luxemburg	-418	182		X	
Malta	-49	49			X
Netherlands	-1425	NE		X	
Poland	-27133	NA	X		
Portugal	-6830	3286	X		
Romania	-15793	-3665		X	
Slovakia	-1084	-1214		X	
Slovenia	-3171	NE	X		
Spain	-23100	NO		X	
Sweden	-41336	9156	X		
UK	-8268	-14515	X		
EU	-315323	15943			
Iceland	-154	77	X		
EU+Iceland	-315476.5	16020			

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