MINISTRY OF THE ENVIRONMENT

National Forestry Accounting Plan (NFAP)

Developed by the Team for the elaboration of national plans related to accounting for greenhouse gas emissions and removals resulting from forestry activities

Warsaw 2018

Table of Contents

1. Introduction

1.1. Legal basis

In 2018, a new Regulation (EU) 2018/841 of the European Parliament and of the Council 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) (hereinafter referred to as "LULUCF Regulation") has entered into force.

According to the LULUCF Regulation, emissions and removals of greenhouse gases from managed forest land (MFL) in each EU Member State will be accounted for according to the forest reference level, which is the country-specific projected baseline of expected emissions and removals associated with forest land during the compliance period (CP), i.e. 2021-2030. National Forestry Accounting Plans (NFAP), including proposed forest reference levels (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 of the LULUCF Regulation). As set out in the LULUCF Regulation 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 of the LULUCF Regulation).

In view of the above, this document has been prepared in order to determine and characterise the FRL in accordance with the LULUCF Regulation as part of the fulfilment of the obligations of an EU Member State under the LULUCF Regulation. Up till now, the land use, land use change and forestry (LULUCF) sector has not been part of the EU climate and energy package and has not entered into reduction commitments towards EU emission reduction targets.

In order to limit the increase in the global average temperature, it is necessary to reduce anthropogenic (man-made) emissions of greenhouse gases. Parties to the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC), including the EU, have agreed to commit to the long-term objective of keeping global temperature increases below 2°C above pre-industrial levels; and to work towards preventing global temperature increases above 1.5°C above pre-industrial levels (UNFCCC, 2015). The Paris Agreement replaces the approach taken under the 1997 Kyoto Protocol (KP) which will not be continued beyond 2020.

The European Council, in its conclusions of 23-24 October 2014 on a climate and energy policy framework for 2030, endorsed a binding target of at least 40% reduction of internal greenhouse gas emissions in the whole economy by 2030 compared to 1990, and this objective was confirmed in the conclusions of the European Council of 17-18 March 2016.

In the Council conclusions of 23-24 October 2014 it was stated that the various objectives of the agricultural and land use sectors should be recognised, with their lesser potential for mitigating emissions, and the need to ensure coherence between the EU's food security and the climate change objectives. The European Council invited the Commission to examine the best means of encouraging the sustainable intensification of food production, while optimising the sector's contribution to greenhouse gas mitigation and sequestration, including through afforestation, and to establish a policy on how to include LULUCF into the 2030 greenhouse gas mitigation framework as soon as technical conditions allow and in any case before 2020. This gave the mandate to take action to develop legal solutions to include the LULUCF sector in the EU's emissions reduction target.

An attempt to fulfil above-mentioned obligation is the LULUCF Regulation.

The LULUCF Regulation sets out Member States' obligations with regard to accounting rules and the conformity of information relating to the LULUCF sector in order to implement the commitment submitted by the EU to the United Nations Framework Convention on Climate Change with regard to reducing greenhouse gas emissions for the period 2021-2030.

The greenhouse gas reduction targets agreed in Kyoto Protocol for existing commitment periods will cease to apply after 2020. With this in mind, the countries party to the UNFCCC are seeking to develop guidelines for accounting for emissions and removals from the LULUCF sector within the framework of the Paris Agreement. This agreement was settled and adopted in December 2015 at the 21st session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC). The Agreement contained a long-term objective and called on the State Parties to take action to protect and to increase the efficiency, as appropriate, of greenhouse gas sinks and tanks.

The LULUCF Regulation clarifies the accounting methodology for different land categories. Removals from managed forest land should be accounted for in relation to the forecasted FRL. According to the LULUCF Regulation, a new reference level for the category "managed forest land" should be created 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. Regulation also provides for maintaining the proportion between harvested wood used for production and bio-energy, which took place in the years 2000-2009. Forest reference levels should take into account the future impact of dynamic age-related forest characteristics in order to avoid excessive reduction of forest management intensity as an essential element of sustainable forest management practice with a view to maintaining or enhancing carbon sinks in the long term.

The LULUCF Regulation also establishes a compensation pool of CO_2 units per Member State in case they need additional units due to the reference period (i.e. 2000-2009) on which the reference level is based. The distribution key of the compensation pool is based on forest cover ratio and ranges from 2% of the sink to 32% of the sink in the period from 2000 to 2009.

1.2. General description of the forest reference level for Poland

The forest reference level (FRL) for Poland, as required by the LULUCF Regulation, is based on the continuation of sustainable forest management practices as documented during the reference period, 2000-2009. The forest reference level is a forecast of carbon stock changes over the period 2021-2025 for forest land taken into account for the accounting category known as 'managed forest land'. In accordance with Article 2 of Regulation (EU) 2018/841 , *managed forest land* is an area included in the reporting of Article 7(1)(c) of Regulation (EU) 525/2013 as forest land remaining forest land. For the definition of the category of *forest land remaining forest land*, see Section 2 of Part Four of the IPCC 2006 Guidelines.[1]

It has been assumed that the basic quantitative indicator of forest management practices applied in the reference period is the intensity of the harvest(i.e. harvesting, broken down by final felling and pre-final cuts). This intensity is defined as the quotient of the harvest during the reference period (broken down by final felling and pre-final cuts) and the volume of large and medium thick wood, expressed in m^3 of wood resources (hereinafter referred to as volume) by age classes and subclasses according to the state at the beginning of the reference period, i.e. 1 January 2000.

[1] IPCC 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published by IGES, Japan. Available under link: https://www.ipccnggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf;

Determination of forest resources and wood harvesting in the reference period was preceded by the division of forests in Poland into two categories (stratification layers -strata) based on the structure of forest land ownership:

1) forests under the management of the State Forests National Forest Holding (PGL Lasy Państwowe) - covering most of the area and wood resources of Poland (ca. 77%) and carried out according to uniform practices applied based on methods contained in the instructions and internal regulations concerning forest management in force in the State Forests National Forest Holding;

2) forests outside the management of the State Forests National Forest Holding (called - other forests) - including forests of other forms of ownership, whose total area and volume of resources is approximately 23%. Other forests include forests under private ownership, forests managed by national parks, the Agricultural Property Stock of the State Treasury, other forests of the State Treasury and municipalities forests. Forests under private ownership dominate in this group, while other properties account for a small percentage of Poland's forest area. This group is characterized by a different way of forest management, expressed, among others, by significantly lower ratios of main use in relation to group 1, i.e. forests managed by State Forests National Forest Holding .

The division of forests in Poland into the stratification layers mentioned above is justified by: differences in the intensity and structure of the harvest, as well as in the availability and reliability of data on the condition and management of forests.

Condition of forests in the reference period, in the form of a table of age classes as of 1 January 2000, has been estimated with a breakdown into the strata mentioned above. The basis for the preparation of such tables for forests managed by the State Forests National Forest Holding, as well as for the remaining forests, were the results of the National Forest Inventory(WISL) in Poland (for the period 2006-2010).

Volume of harvested wood in the reference period in the State Forests was determined on the basis of data of the Statistics Poland (identical to the data of the State Forests), while in the remaining forests - on the basis of data of the Statistics Poland (GUS) using the ratio of the volume of harvested wood according to WISL, to the volume of harvested wood according to GUS determined for the period 2010-2019 (the volume of harvested wood according to WISL turned out to be about 2.8 times higher than the values according to GUS - see Table 18). Volume of harvested wood in other forests due to lack of WISL data for the full reference period (in particular for the period 2000-2005), was adopted on the basis of WISL data reported from the first year of the second WISL cycle, i.e. 2010-2017. During this period, the harvest actually took place between 2006 and 2010, 2007 and 2011, etc. during the five-year cycle of the National Forest Inventory(WISL). Adopted WISL results are the first available data collected in a uniform way for forests in the country, and on their basis the relationship between the data from the Statistics Poland and the results obtained from the WISL was determined.

Total forest area (without shrub lands) for the two strata distinguished, as of January 1, 2000, was assumed on the basis of data from the Statistics Poland (GUS), while the total wood volume was determined by subtracting from the volume in 2010 the current increment of 9 m3/ha per year and adding the volume of harvested wood in the period 2000-2009.Increment of the current volume was assumed on the basis of data obtained within the second cycle of WISL, i.e. in the period 2010-2014. These are the first increment results developed for the country's forests.

The following can be stated with regard to the agreed main use rates:

- Final felling and pre-final cut indicators have been adjusted to the volume of harvesting in the reference period (2000-2009) in connection with the age classes table at the beginning of this

period, i.e. as of January 1, 2000; and are quantified forest management practices used to forecast the scenario according to the reference level in the periods: 2010-2015, 2016-2020, 2021-2025 and 2026-2030.

- Final felling and pre-final cut indicators were applied to the harvesting volume for the period 2000-2017 in relation to the table of age classes at the beginning of the period, i.e. as of 1 January 2017, and are quantified forest management practices - used to forecast the scenario at the current level in the periods: 2017–2020, 2021–2025.

1.3 Consideration to the criteria as set out in Regulation (EU) 2018/841 (LULUCF)

The manner in which the criteria set out in Regulation (EU) 2018/841 (LULUCF) are taken into account is set out in the Annex.

2. Preamble for the forest reference level

2.1 Introduction

Past challenges for EU Member States in the process of developing forest reference levels include lack of data and inconsistencies between different sets and sources of data. Estimation of catastrophic events, accounting of harvested wood products and the lack of documentation of forest management practices were equally frequently mentioned as problems that Member States expected in the process of estimating forest reference levels. Results of a study carried out in 2018 on behalf of the European Commission have clearly outlined the different natural conditions in each country: EU forests cover a wide range of tree species and structures, managed in different ways and for different purposes. Forests in the EU range from subtropical Mediterranean forests to boreal tundra, while forestry activities range from the highly industrial use of wood to the collection of firewood by households. Moreover, forest management is often multifunctional, while taking into account several objectives such as water protection, recreation, biodiversity protection and wood production. In this configuration, it is obvious that a single system of categorising and modelling forests and their relevance to carbon accounting would make no sense. Instead, the system should be flexible to take into account national differences in modelling reference levels for forests and the LULUCF sector itself, while ensuring transparency and completeness of reporting based on as consistent, comparable and accurate information as possible.

Forecasts carried out towards the establishment of a forest reference level aim to show what would happen to managed forest land if the historical management regime were to continue. Thus, the expected future impacts of policies and markets will not be taken into account when estimating the forest reference level, as in all other sectors responsible for greenhouse gas emissions this impact is accounted for in the form of credits or debits. The same management practices during the reference period, without any changes, shall be applied during the 2021-2025 period. Adopted assumption suggests that the forest reference level is the best possible estimate of the emission and removal value that would occur if policies and measures were not influenced, and any changes to such policies and measures or any new policy or measure implemented after the reference period.

However, the forest reference level must take into account the expected natural dynamics in terms of carbon stock accumulated in the forests of a given country, by combining expected changes in forest characteristics (e.g. changing age structure of forests, including biomass available for harvesting, growth, etc.) with a "Continuation of the practice of sustainable forest management" (Article 8(5) of Regulation (EU) 2018/841), which occurred during the reference period.

Article 5(4) of Regulation (EU) 2018/841 requires Member States to account for any changes in the carbon stock in above-ground biomass, below-ground biomass, forest litter, dead wood, organic carbon in soil matter and harvested wood products.

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. Nonetheless, there is no such possibility when accounting for land under the category "managed forest land" for above-ground biomass, dead wood and harvested wood products; with respect to these carbon pools, any changes in carbon stocks must be included in the settlements.

Although, according to Article 8(5), the forest reference level must 'avoid excessive reduction of forest management intensity as a core element of sustainable forest management practice', but estimation of the forest reference level must not contradict the first subparagraph of Article 8(5), which 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'. This part of the LULUCF Regulation can be understood as reflecting the need to model the development of age-related characteristics of forests over time, rather than fixating them at the level observed during the reference period. Section 3.2 of this document provides more detailed guidance on how these issues have been taken into account in the estimation of the forest reference level.

This section is intended to clarify certain general aspects of the forecasting of forest reference levels in accordance with the LULUCF Regulation.

2.2 Carbon pools and greenhouse gases included in the forest reference level

2.2.1 Carbon pools as referred to in Article 5(4) of Regulation (EU) 2018/841

Final estimates of the balance of greenhouse gas emissions and removals for CRF 4 A.1 category *forest land remaining forest land* have been estimated under two processes, i.e. by using CBM CFS 3 software to assess carbon stock changes in forest ecosystems and by using calculation methods and a model to assess the effect of carbon substitution as part of harvested wood products that are used as part of the national greenhouse gas inventory. Applied methodology is described in Tables 1, 2 and 3.

Table 1. Carbon pools and estimation tools used

No.	Carbon pool	Estimation tool
1	above-ground biomass	CBM CFS 3
2	below-ground biomass	CBM CFS 3
3	forest litter	CBM CFS 3
4	dead wood	CBM CFS 3
5	soil organic carbon	CBM CFS 3
6	harvested wood products from afforested land and managed forest land (total)	IPCC[2] method, using the first order decay function

[2] On the basis of the IPCC 2006 guidelines and the Supplement from KP.

Table 2. Elements of forest ecosystems included in the estimates of carbon stock changes under the CBM CFS 3 simulation

Aggregate III°	Aggregate II°	Aggregates I°	Basic Pools	Characteristics
Whole ecosystem	Biomass	Above-ground biomass	Round wood- conifers	Round wood with a diameter at the thinner end of at least 7 cm with the bark or 5 cm without bark from conifers: carbon in trunks and bark of conifers (without tops and stumps)
			Round wood- broadleaved trees	Round wood from broadleaved trees - carbon in trunks and bark of round wood from broadleaved trees (without tops and stumps)
			Other coniferous	Other biomass elements of coniferous trees - carbon in branches, tops and stumps of felled roundwood coniferous trees, and small trees with bark
			Other broadleaved	Other biomass elements of broadleaved trees - carbon in branches, tops and stumps of felled round wood broadleaved trees, and small trees with bark
			Assimilation apparatus of conifers	Assimilation apparatus of conifers - carbon in needles of living conifers
			Assimilation apparatus of broadleaved trees	Assimilation apparatus of broadleaved trees - carbon in leaves of living broadleaved trees
		Below-ground biomass	Thin roots of conifers	Thin roots of coniferous - carbon in the roots of thin coniferous of diameter < 5 mm
			Thin roots of broadleaved trees	Thin roots of broadleaved trees - carbon in the roots of thin broadleaved trees of diameter < 5 mm
			Thick roots of conifers	Thick roots of coniferous - carbon in the roots of thick coniferous of diameter >= 5 mm
			Thick roots of broadleaved trees	Thick roots of broadleaved trees - carbon in the roots of thick broadleaved trees of diameter >= 5 mm

	Soluble dead organic matter (DOM)	Above-ground organic matter	Forest litter	Forest Litter - carbon in very fast, fast and slow ground pool of dead organic matter
			Above-ground very fast soluble dead organic matter	Above-ground very fast soluble dead organic matter - carbon in dead organic matter from biomass leaves and thin roots in forest litter; very fast rate of circulation
			Above-ground fast soluble dead organic matter	Above-ground fast soluble dead organic matter - carbon in dead organic matter from branches, tops, stumps and small pieces of wood; fast rate of circulation
			Medium soluble dead organic matter	Medium soluble dead organic matter - carbon in dead organic matter from tree and/or trunk elements; medium rate of circulation
			Above-ground slowly soluble dead organic matter	Above-ground slowly soluble dead organic matter - carbon in dead organic matter from very fast, fast and medium pools of ground DOM; slow rate of circulation
			Dead coniferous tree trunks	Dead coniferous trunks - carbon in dead organic matter with the influence from the biomass round wood pool of coniferous trees; the default rate of decomposition is half of the rate of decomposition for the average pool to the pool of dead coniferous trunks
			Dead coniferous tree branches	Dead coniferous tree branches - carbon in dead organic matter with the influence of the biomass pool of other elements of coniferous trees; the default rate of decomposition is half of the rate of decomposition for the fast pool to the pool of dead branches of coniferous trees
			Dead broadleaved tree trunks	Dead broadleaved tree trunks - carbon in dead organic matter with the influence of the biomass pool of thick wood of broadleaved trees; the default rate of decomposition is half of the rate of decomposition for the average pool to the pool of dead broadleaved trees trunks
			Dead broadleaved tree branches	Dead broadleaved trees branches - carbon in dead organic matter with the influence of the biomass pool of other elements of broadleaved trees; the default rate of decomposition is half of the rate of decomposition for the fast pool to the pool of dead branches of

				broadleaved trees
			Dead wood	Dead wood - carbon in fast, medium, below-ground stock of dead organic matter from dead trunks of coniferous and broadleaved trees, and from dead branches of coniferous and broadleaved trees
		Below-ground DOM	Soil carbon	Soil carbon - carbon in a very fast below-ground, slow below-ground and in pool of black carbon in dead organic matter.
			Below-ground very fast soluble DOM	Below-ground very fast soluble dead organic matter - carbon in dead organic matter from the biomass of thin roots in mineral soil; very fast rate of circulation
			Below-ground fast soluble dead organic matter	Below-ground fast soluble dead organic matter - carbon in dead organic matter from thick roots in mineral soil; fast rate of circulation
			Below-ground slowly soluble dead organic matter	Below-ground slowly soluble dead organic matter - carbon in dead organic matter from very fast, fast below-ground pools of dead organic matter; slow rate of circulation

Table 3. Approach to estimates made using calculation methods applied in national greenhouse gas inventories

Source	Method	Data set	Comments
CO_2 emissions from forest fires	CBM CFS 3	Statistics Poland (GUS) "Forestry" 2001-2017	Area of fires for the years 2000-2016. For 2016-2020 average for the period 2000-2016. Data of the Central Headquarters of the State Fire Service and the National Forest Fire Information System
CH_4 emissions from forest fires	CBM CFS 3		
N_2O emissions from forest fires	IPCC 2006; Equation 2.27		
CO_2 emissions from organic soils	IPCC 2006; Equation 2.26	Studium krajowe Oświecimska-Piasko 2008 (National Study by Oświęcimska-Piasko 2008)	[7RR 2017, chapter 5.1].
Carbon substitution effect for products in the 'paper' category	IPCC 2006; Equations 12.1, 12.2, 12.6	FAOSTAT http://faostat.fao.org	Reference value of production in the period 2010-2025 was determined on the basis of adjustment factors
Carbon substitution effect for products in the 'wood based panels' category		FAOSTAT	
Carbon substitution effect for products in the category 'sawnwood'			

2.2.2 Greenhouse gases referred to in Article 2 of Regulation (EU) 2018/841

The main anthropogenic factor for the global temperature increase is the accumulation of greenhouse gases in the atmosphere. Processes releasing greenhouse gases into the atmosphere, such as the combustion of fuels, are referred to as "sources". Processes that remove greenhouse gases from the atmosphere are called "sinks". The most important sinks are oceans and biomass on land. The sum of sources and sinks results in net emissions. The main anthropogenic greenhouse gases include carbon dioxide (CO_2), methane (CH_4) and nitrogen oxide (N_2O). In the LULUCF Regulation, all greenhouse gases are expressed as CO_2 equivalent (an effect of the mass of CO_2 equivalent in the atmosphere on the extortion of solar radiation).

2.2.3 Demonstration of consistency between the carbon pools included in the forest reference level

Consistency between carbon pools is maintained by using CBM CFS 3 tool, which takes into account the relationship between the carbon pools listed in Table 1.

2.3 Description of the long-term forest strategy

2.3.1 Overall description of forests and forest management in Poland and the adopted national policies

The largest carbon sink in the LULUCF sector is forest land. The estimated amount of CO2 removal is mainly generated by the growth of living biomass. Definition of forest used in reporting to the Climate Convention is the same as the definition of forest used in the Forest Act 1991, which specifies that forest is:

- a compact area of at least 0.10 ha, covered with, or temporarily deprived of, forest vegetation (forest crops) - trees and shrubs and forest undergrowth:
    - which is intended for forestry production, or
    - constituting a nature reserve or being a part of a national park, or
    - entered in the register of monuments;
- associated with forest management, occupied for the purposes of forest management: buildings and structures, water reclamation facilities, forest spatial division lines, forest roads, areas under power lines, forest nurseries, wood storage areas, as well as used for forest parking lots and tourist facilities.

Forest area in Poland amounts to 9230 thousand ha (according to the Statistics Poland -GUS- as of 31.12.2016), excluding land related to forest management, which constitutes forest cover of 29.5%. Including land related to forest management, as of 31.12.2016, the forest area of Poland is 9435 thousand ha.

The ownership structure of forests in Poland is dominated by public forests - 80.8%, including forests managed by the State Forests National Forest Holding (PGL Lasy Państwowe) - 77.0%. This structure changed in the whole post-war period to a small extent. Between 1990 and 2016, the share of private forests increased by 2.2 percentage points to the current 19.2%. At the same time, the share of public forests decreased from 83% to 80.8%.

In the years 1945-2017, the species structure of Polish forests underwent significant changes, expressed, among other things, by increasing the share of forest stands with a predominance of broadleaved species. In the State Forests, where it is possible to trace this phenomenon on the basis of annual updates of the forest area and wood resources, the area of broadleaved stands increased from 13% to 23.8%.

The forest habitat structure is dominated by pinewood habitats, occurring on 50.5% of the forest area; habitats dominated by broadleaved trees cover 49.5%. In both groups there are also upland habitats occupying a total of 6.5% of the forest area and mountain habitats occurring on 8.7% of the area. Coniferous species dominate 68.5% of Poland's forest area. Pine, which according to the National Forest Inventory(WISL) occupies 58.2% of the forest area of all forms of ownership, 60.1% of the State Forests National Forest Holding and 55% of private forests, found in Poland the most favourable climatic and habitat conditions within its Eurasian range, thanks to which it managed to produce many valuable ecotypes (e.g. Taborska pine or Augustowska pine).

The age structure of the forest is dominated by forest stands of age class III and IV, occurring on 24.9% and 19.4% of the area respectively. In most forms of forest ownership, the third age class prevails, and in private forests its share amounts to 33.2%. Forest stands of over 100 years old together with restocking class (KO), class for restocking (KDO) and class with selection structure (BP) occupy 12.7% of the area of the State Forests National Forest Holding and 3.2% of private forests area. The share of non-afforested forest area in private forests is 6.1%, compared to 2.8% in the State Forests National Forest Holding.

According to WISL 2012-2016 data, the area of forest stands over 80 years old (without KO, KDO) increased from about 0.9 million ha in 1945 to over 2 million ha in 2016. In the same period the average age of forest stands in forests of all forms of ownership increased from 44 to 57 years (in State Forests - to 59 years, and in private forests - to 48 years). In 2016, forest renewal (without reforestation and introduction of the second floor) was carried out on an area of 56 095 ha of land of all ownership categories, of which 7912 ha (14.1%) were natural renewals. The area of renewals in 2016 was about 0.3 thousand ha smaller than in 2015.

During the last 40 years of the last century the area of renewals - and consequently the share of forest stands of the youngest age classes - has been decreasing in leaps. Since the beginning of the 21st century, a change in this trend can be observed. Activities aimed at the stabilization of forest ecosystems are carried out.

The increase in the share of natural renewals in the total renewal area, observed since the early 1980s, deserves additional attention. In the years 1976-1980 this share amounted to 3.4%, in the years 1991-1995 - 6.5%, in the years 1996-2010 - 10.5%, and in the last six years - 13.8%. Plants for renewal and afforestation work are grown in forest nurseries. The production area of forest nurseries in 2016 was 1966 ha, of which 1943 ha in State Forests, 15 ha in national parks and 8 ha in other public forests.

The basis for afforestation works in Poland is the "National Programme for Increasing the Forest Cover" (KPZL). At the initiative of and on behalf of the Ministry of Environmental Protection, Natural Resources and Forestry, the programme was developed by the Forest Research Institute and approved for implementation by the Council of Ministers on 23 June 1995. The main objective of KPZL is to increase the country's forest cover to 30% in 2020 and 33% in 2050 and to ensure optimal spatial and temporal distribution of afforestation activities, as well as to set ecological and economic priorities and implementation instruments.

Since 1967, when the first update of wood resources was carried out in the State Forests, a steady increase in wood resources has been recorded. A reliable source of data for the country in recent years, e.g. revealing private forest resources, are the results of WISL. According to WISL data for the periods 2005-2009 and 2013-2017, the total wood resources in the country increased on average by 35 million m^3 annually.

According to WISL measurements carried out in 2013-2017 and related to the forest area at the end of 2016, wood resources reached a volume of 2587 million m^3 of round wood including bark. More than a half (50.9%) of the resources are forest stands of the third and fourth age class. The share of forest stand volume with more than 100 years old trees together with KO, KDO and BP in the total volume is 18.1%.

According to WISL results from 2013-2017, the average growing stock of forests in Poland is 280 m^3/ha.

Poland carries out a number of activities aimed at protecting, maintaining and increasing carbon sinks in forest and agricultural areas. Most of the activities are of a continuous nature. These activities result from adopted policies or programming documents.

Document title	Description of the document
Act of 28 September 1991 on Forest (Journal of Laws of 2017, item 788, as amended).	The Act defines the principles of conservation, protection and enhancement of forest resources and the principles of forest management in connection with other elements of the environment and national economy.
State Forestry Policy (SFP), adopted by the Council of Ministers on 22 April 1997.	Document directs actions in the area of *Forestry* and indicates the link between forestry in cross-sectoral and international agreements.
National Programme for Increasing the Forest Cover (KPZL) adopted by the Council of Ministers in 1995.	The national programme for increasing the forest cover is a strategic study. It is an instrument of forest policy in the shaping of the country's natural space and contains general guidelines for drawing up regional spatial development plans in the field of increasing the forest cover. Methodological assumptions and criteria for determining afforestation preferences adopted in KPZL may be helpful in the creation of original regional and local solutions. The main objective of KPZL is to increase the country's forest cover to 30% in 2020 and 33% in 2050 and to ensure optimal spatial and temporal distribution of afforestation activities, as well as to set ecological and economic priorities and implementation instruments. New afforestation is an element of multifunctional and sustainable development of the country.
Act of 7 June 2001 on Forest Reproductive Material (Journal of Laws of 2017, item 116).	Act regulates the registration of forest basic material, marketing of forest reproductive material, control of forest basic material and forest reproductive material marketed, and seed regionalisation.
Act of 3 February 1995 on the protection of agricultural and forestry land (Journal of Laws of 2017, item 1161).	Act regulates the principles of protection of agricultural and forest land and the reclamation and improvement of land use value, as well as the possible transformation of forest areas for non-forestry purposes. Solutions contained there are intended to counteract irrational farming and forest production space management. This objective can be achieved through: - limiting of earmarking of land for non-

	agricultural or non-forest use, preventing agricultural land degradation and devastation processes and damage to agricultural production resulting from non-agricultural activities and mass movements of land, - re-cultivation and use of land for agricultural purposes, - preservation of peatbogs and ponds as natural water bodies, - limiting changes in the natural shape of the earth's surface.
Act of 16 April 2004 on Nature Conservation (Journal of Laws of 2018, item 142, as amended).	Act defines the scope of protection (necessary for effective conservation of Natura 2000 areas) - implementation of the obligation resulting from the Habitats Directive and the Birds Directive, and implementation to the appropriate extent of the objective of the Directives - maintenance or restoration of proper condition of the protected objects in the Natura 2000 network.

It should be noted that the current forest policy assumes the continuation of the objectives specified in the State Forestry Policy (SFP) of 1997, established on the basis of the Act of 28 September 1991 on Forest. The main objectives of the 1997 SFP include, among others, the following:

- Necessity of ensuring the sustainability of forests together with their multifunctionality, which will be achieved by increasing the country's forest resources, including:
    - improving the condition of forest resources and their comprehensive protection,
    - reorientation of forest management from the previous dominance of the raw material model to a pro-ecological and economically sustainable model of multifunctional forest management corresponding to the criteria formulated for Europe in the Helsinki process taking into account the specificity of Polish forestry.
- Increase in forest resources, which will follow through:
    - increasing the country's forest cover to 30% in 2020 and 33% in the middle of the 21st century by gradually afforestation of land unsuitable for agriculture and the spatially optimal forest structure in the landscape which will be achieved by protecting and full use of the productive potential of habitats,
    - restitution and rehabilitation of forest ecosystems, mainly by reconstruction (in suitable habitats) of forest stands of single species into forest stands of mixed species and by means of bio-melioration measures,
    - regeneration of devastated and neglected forest stands in private forests, and then their ecological rehabilitation.
- In order to improve the condition and protection of forests so that they can better and more broadly fulfil their various functions, account has been taken of the need to continue the following activities in the area of forest management:
    - increasing the health and resistance of forest stands to abiotic and biotic factors harmful by dissemination of biological and ecological methods of forest conservation,

- restriction the use of chemical substances to the essential needs (e.g. pesticides, mineral fertilisers)
- provision by forests of protective and social functions, so that these activities do not endanger the sustainability of forests and do not adversely affect the condition of forest stands,

- assumption that:
  - use of wood resources regulated by the forest use regime is derived from the needs arising from the objectives of forest breeding and conservation and is intended to ensure the continuity of production of as much wood of the best quality as possible,
  - volume of wood harvested in nursing treatments should not exceed the current growth, but should guarantee the accumulation of wood in forest stands, providing the basis for extended reproduction,
  - volume of wood harvested from mature forest stands should take into account the limitations resulting from the implementation of protective and social functions, the current and future forest species and age structure and the degree of its compatibility with the characteristics of the habitat, the level of achievement of the planned economic objective and the needs for restocking and reconstruction of forest stands,
  - condition of animals will be regulated to a level which does not jeopardise the objectives of breeding and forest protection,
  - regulation and targeting of recreation and tourism in forest areas will take place in a way that reconciles the social functions of forests with their protective and productive functions,
  - legal protection of all forest land will be improved.

National Forest Inventory (WISL)[3]

Since 2010, the National Forest Inventory(WISL) has been one of the main sources of information on forests of all forms of ownership for both national and international statistics. In 2015, the III cycle of WISL began, which will allow to better capture trends of change in forests. In case of observation of ecosystems with a life cycle of more than 100 years, only longer periods of time produce increasingly convincing results. The II inventory cycle, completed in 2014, provided the first information on the current growth of forest stands, relevant for the calculations related to determination of emissions/removals. The III cycle of WISL will provide better long-term observations on current forest stand growth, dead wood resources and forest use.

Data bank on forest resources and condition of forests - Forest data bank / FDB[4]

In order to improve the supervision of forest management in forests of all forms of ownership, work was undertaken on the construction of a forest data bank. Bank was launched in 2014. In order to ensure the proper functioning and development of FDB, work has been undertaken since 2015 to broaden the range of information collected and made available by FDB by including data from forest habitat and phytosociological studies and information on hunting management. Development activities for the FDB include also improvement of the processes of preparing forecasts of resource development and usage possibilities over a 10-30 year time horizon.

[3]According to Article 13a(2) of the Act of 28 September 1991 (Journal of Laws of 2018, item 2129)
[4]According to Article 13a(2) of the Act of 28 September 1991 (Journal of Laws of 2018, item 2129)

In 2016, the Forest Act was amended to introduce a financial subsidy mechanism for the preparation of simplified forest management plans (SFMP). Within the framework of FDB, the following were developed: guidelines for the preparation of SFMPs, standards for descriptive and spatial data and cartographic studies of SFMPs, as well as software supporting SFMP project contractors. These activities are aimed at improving the quality of management planning in non-state forests, increasing the level of their standardization and creating mechanisms to improve the timeliness and completeness of documentation for forests outside the State Forests National Forest Holding.

2.3.2 Description of future harvesting rates under different policy scenarios

2.3.2.1 Harvesting intensity indicators - reference level scenario

Harvesting intensity indicators in the reference level scenario - showing quantified forest management practices in the period 2000-2009 - have been determined according to age classes and subclasses as the ratio of harvesting by final felling and pre-final cuts to the total volume of wood resources.

Discussed harvesting intensity indicators for forest management in the reference level scenario have been estimated for the distinguished strata, i.e. for the forests managed by the State Forests National Forest Holding and for other forests. It has been assumed that within the distinguished categories of harvest(i.e. within final felling and pre-final cuts) the relations of harvesting intensity indicators in forests of the two distinguished layers are similar (i.e. final felling is more intensive in older than in younger age classes, while pre-final cuts are more intensive in younger than in older age classes). Differences between the layers occur, however, in the share of final felling and pre-final cuts in the total volume of harvest. Share of final felling in the reference period was higher in forests managed by the State Forests National Forest Holding and amounted to about 43%, while in the remaining forests (estimated on the basis of WISL data from the current period) this share was lower and constituted about 20% of the total amount of harvest.

However, the main difference between forests managed by the State Forests National Forest Holding and in other forests concerns mainly the values of indicators of the intensity of the final felling and pre-final cuts. The intensity indicators are much lower in the remaining forests than in the State Forests. Values of these intensities in the reference level scenario for age classes and subclasses are presented in Table 4.

Table 4. Indicators of intensity of final felling and pre-final cuts for age classes and subclasses in forests managed by the State Forests National Forest Holding and in other forests in the reference level scenario

No.	Age classes and subclasses	Indicators of intensity of harvest in the reference level scenario			
		Final felling	pre-final cuts	Final felling	pre-final cuts
		the State Forests National Forest Holding		other forests	
1	Ia (1-10 years)	0.0000	0.5550	0.0000	0.4657
2	Ib (11-20 years)	0.0007	0.5160	0.0004	0.4330
3	IIa (21-30 years)	0.0012	0.2274	0.0007	0.1908
4	IIb (31-40 years)	0.0033	0.2065	0.0019	0.1733
5	IIIa (41-50 years)	0.0043	0.1815	0.0025	0.1523
6	IIIb (51-60 years)	0.0058	0.1729	0.0034	0.1451
7	IVa (61-70 years)	0.0252	0.1389	0.0146	0.1165
8	IVb (71-80 years)	0.0449	0.1275	0.0260	0.1070
9	Va (81-90 years)	0.1743	0.0718	0.1011	0.0602
10	Vb (91-100 years)	0.2533	0.0477	0.1469	0.0400
11	VI (101-120 years)	0.2981	0.0259	0.1729	0.0217
12	VII and over (over 120 years old)	0.1990	0.0151	0.1155	0.0127
13	(KO - restocking class, KDO - class for restocking , BP - a forest stand with (which groups and clusters of trees of different ages and heights take part, permeating each other over the entire plot, which gives a total vertical closure, and not a floor system with a horizontal closure.)	0.5838	0.0004	0.3386	0.0003

Indicators of intensity of final felling and pre-final cuts according to age classes and subclasses translate into the following values of annual harvests in the strata. Volume of harvested wood (in m3 of round wood without bark) according to the reference level scenario in the subsequent periods covered by the analysis, i.e. in the years 2000-2030, is presented in Table No. 5.

Table 5. Volume of harvested wood in the years 2010-2030 in the reference level scenario

Forestry management scenario	Period	Harvest category	Volume of harvested wood		
			the State Forests National Forest Holding	other forests	Total
			thousands of m^3 of round wood without bark/year		
By reference level (2000–2009)	2010–2015	Total	33955	5865	39820
	2016–2020	Total	36996	6546	43542
	2021–2025	Total	39112	7099	46211
	2026–2030	Total	40946	7669	48615

In the reference level scenario, starting in 2010, the share of final felling in the total harvesting amount in the forests managed by the State Forest National Forest Holding was projected to be about 48%, while in the remaining forests - about 26%. Developed forecasts indicate that these shares may increase in subsequent periods - to about 58% in State Forests and to about 41% in the remaining forests in the period 2026-2030.

2.3.2.2 Harvesting intensity indicators - present level scenario

Current activities on forest land are still based on the policies described in chapter 2.3.1, but other harvesting indicators are now being implemented due to the need to further adapt forest ecosystems to progressive climate and environmental changes. Harvesting intensity indicators in the current scenario - showing quantified forest management practices in the period 2010-2019 - have been determined according to age classes and subclasses as the ratio of harvesting by final felling and pre-final cuts to the respective volume of the wood resources.

Discussed harvesting intensity indicators for forest management in the present period (2010-2019) have been estimated separately for the distinguished strata, i.e. for the forests managed by the State Forests National Forest Holding and for the remaining forests. It has been assumed that within the distinguished categories of harvest(i.e. final felling and pre-final cuts) - similarly as in the reference period - the relations of harvesting indicators between the age classes in the distinguished strata are similar (final felling is more intensive in older than in younger age classes, while pre-final cuts are more intensive in younger than in older age classes). Differences between the strata occur in the share of final felling and pre-final cuts. Share of final felling is higher in the forests managed by the

State Forests National Forest Holding (PGL Lasy Państwowe), whereas the share of pre-final cuts is higher in the remaining forests.

Values of these intensity indicators in the present level scenario for age classes and subclasses are presented in Table 6.

Table 6. Intensity indicators of final felling and pre-final cuts for age classes and subclasses in forests managed by the State Forests National Forest Holding and in other forests in the present level scenario.

No.	Age classes and subclasses	Indicators of intensity of use in the present level scenario			
		Final felling	pre-final cuts	Final felling	pre-final cuts
		the State Forests National Forest Holding		other forests	
1	Ia (1-10 years)	0.0000	0.5668	0.0000	0.4227
2	Ib (11-20 years)	0.0008	0.5271	0.0003	0.3931
3	IIa (21-30 years)	0.0014	0.2323	0.0005	0.1732
4	IIb (31-40 years)	0.0038	0.2109	0.0013	0.1573
5	IIIa (41-50 years)	0.0049	0.1854	0.0017	0.1382
6	IIIb (51-60 years)	0.0066	0.1766	0.0023	0.1317
7	IVa (61-70 years)	0.0285	0.1418	0.0099	0.1058
8	IVb (71-80 years)	0.0508	0.1302	0.0176	0.0971
9	Va (81-90 years)	0.1973	0.0733	0.0685	0.0547
10	Vb (91-100 years)	0.2868	0.0487	0.0995	0.0363
11	VI (101-120 years)	0.3376	0.0264	0.1171	0.0197
12	VII and over (over 120 years old)	0.2254	0.0154	0.0782	0.0115
13	(KO - renewal class, KDO - class to be renewed, BP - a forest stand in the construction of which groups and clusters of trees of different ages and heights take part, permeating each other over the entire plot, which gives a total vertical closure, and not a floor system with a horizontal closure.)	0.6610	0.0004	0.2293	0.0003

Indicators of intensity of final felling and pre-final cuts according to age classes and subclasses translate into the following volume of annual harvesting the distinguished strata. Volume of harvested wood (in m^3 of round wood without bark) according to the present period scenario in the subsequent periods covered by the analysis, i.e. in the years 2017-2030, is presented in Table No. 7.

Table 7. Volume of wood harvest in the years 2017-2030 in the present level scenario

Forestry management scenario	Period	Harvest category	Volume of harvested wood		
			the State Forests National Forest Holding	other forests	Total
			thousands of m^3 of round wood without bark/year		
By present level (2010–2019)	2017–2020	total	40504	5887	46391
	2021–2025	total	42104	6230	48334
	2026–2030	total	43880	6696	50576

In the present level scenario, starting in 2017, the share of harvesting in final felling in the forests managed by the State Forest National Forest Holding was about 54%, while in the remaining forests - about 23%. Developed forecasts indicate that these shares may increase in subsequent periods - to about 59% in State Forests and to about 30% in the remaining forests in the period 2026-2030.

2.3.3 Area of managed forest land

The forest area included under category *4.A.1 Forest land remaining in forest land* included in the projections for the reference level was taken as of 1 January 2010 (8685 thousand ha).

The formation of the area structure according to prevailing species was determined in a simplified manner, assuming - similarly as in the case of volume - that the structure according to prevailing species (the share of age classes resulting from the intersection of prevailing species and age classes in individual cells of the table of age classes) in the subsequent forecast periods, in the period 2010-2030, developed in the reference level scenario will not change in comparison to the structure from 2010.

The general area structure according to prevailing species in the starting years, i.e. in 2010 - in the baseline scenario and in 2017 - in the current level scenario is presented in Table 8.

Table 8. Evolution of the area structure of species in the starting years of the scenarios: according to the reference level (2010) and according to the current level (2017)

Dominant species	Reference level scenario (2010)			Current level scenario (2017)		
	forests managed by the State Forests National Forest Holding	**other forests**	**Total**	**forests managed by the State Forests National Forest Holding**	**other forests**	**Total**
	%			**%**		
Pine	62.57	55.00	60.93	60.27	51.16	58.17
Spruce	6.18	6.90	6.33	5.97	6.00	5.97
Fir	2.62	4.55	3.03	2.79	4.39	3.16
other coniferous	1.14	0.57	1.02	1.30	0.77	1.18
Total - coniferous	**72.51**	**67.01**	**71.32**	***70.33***	***62.32***	***68.49***
Beech	5.54	5.66	5.57	6.18	5.26	5.97
Oak	7.16	5.36	6.77	8.24	5.86	7.69
Hornbeam	0.98	2.22	1.25	1.25	2.82	1.61
Birch tree	6.74	7.83	6.98	6.66	9.12	7.23
Alder	4.65	7.51	5.27	4.85	8.34	5.65
Poplar	0.10	0.12	0.10	0.05	0.15	0.07
Aspen	0.41	1.67	0.69	0.39	2.20	0.81
other broadleaved trees	1.90	2.63	2.05	2.05	3.95	2.49
Total - broadleaved trees	**27.49**	**32.99**	**28.68**	***29.67***	***37.68***	***31.51***
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

2.3.4 Historical emissions and removals from harvested wood products

Table 9. Historical substitution effect of carbon in harvested wood products

Product	Substitution effect	Unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Paper	change in carbon stocks	[t CO2]	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4
Wood based panels	change in carbon stocks	[t CO2]	327.1	327.1	327.1	327.1	327.1	327.1	327.1	327.1	327.1	327.1	327.1	327.1	327.1	327.1
Sawn wood	change in carbon stocks	[t CO2]	186.1	-22.4	336.4	431.9	657.9	294.1	200.3	339.4	359.2	903.4	1016.9	686.2	686.6	824.5

Source: https://unfccc.int/sites/default/files/resource/pol-2018-crf-25may18.zip

Table 10. Historical substitution effect of carbon in harvested wood products (cont.)

Product	Substitution effect	Unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Paper	change in carbon stocks	[t CO2]	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4	-63.4
Wood based panels	change in carbon stocks	[t CO2]	327.1	327.1	327.1	327.1	327.1	327.1	327.1	327.1	327.1	327.1	327.1	327.1	327.1
Sawn wood	change in carbon stocks	[t CO2]	1240.7	855.2	984.2	1289.1	1030.8	979.9	1019.2	1057.1	981.2	998.2	1100.0	1097.5	1202.0

Source: https://unfccc.int/sites/default/files/resource/pol-2018-crf-25may18.zip

2.3.5 Description of forest characteristics (dynamic forest characteristics related to age, increment, rotation length and other information on forest management activities in a present management scenario)

For the information required, please refer to chapter 2.3.1.

2.3.6 Historical and future harvest rates, broken down into energy and non-energy usage

Harvest rates broken down by energy and non-energy usage in the reference level scenario were determined on the basis of the total volume of wood harvested in the reference period in the State Forests, which was determined on the basis of the Statistics Poland data (identical with the data of the State Forests National Forest Holding), while in the remaining forests - on the basis of the data of the Statistics Poland (GUS) using the relation of the volume of harvested wood according to WISL, to the volume of harvested wood determined for the present period. For the calculation of the above indicators, the proportions of the harvest reference value and industrial wood production reference value were calculated based on the data reported by the FAO reporting mechanism, in accordance with FAO 1866 and FAO 1867 codes. The value of predicted reference production was determined using the correction factors described in Chapter 3.2.2.

Table 11. Harvest by energy and non-energy usage in the reference level scenario

Reference level scenario			
Year	**Harvest**	**Wood products**	**Wood for energy purposes**
	(thousand m^3)		
2000-2009	32624	28226	4398
2016	42474	35626.6	6847.4
2017	43008	36398.0	6610.0
2018	43542	37418.5	6123.5
2019	44076	38488.3	5587.7
2020	44610	39080.6	5529.4
2021	45251	39674.8	5576.2
2022	45731	40256.0	5475.0
2023	46212	40824.2	5387.8
2024	46693	41379.2	5313.8
2025	47173	41921.2	5251.8

Table 12. Harvest indicators broken down by energy and non-energy usage in the reference level scenario

Reference level scenario			
Year	**Harvest**	**Wood products**	**Wood for energy purposes**
	(%)		
2000-2009	100.0	86.5	13.5
2016	100.0	83.9	16,1
2017	100.0	84.6	15.4
2018	100.0	85.9	14.1
2019	100.0	87.3	12.7
2020	100.0	87.6	12.4
2021	100.0	87.7	12.3
2022	100.0	88.0	12.0
2023	100.0	88.3	11.7
2024	100.0	88.6	11.4
2025	100.0	88.9	11.1

The value of harvest indicators broken down by energy and non-energy usage in the present level scenario was determined on the basis of the total value of wood harvested in the present period in the State Forests, which was determined on the basis of the Statistics Poland data (identical with the data of the State Forests National Forest Holding), while in the remaining forests - on the basis of the data of the Statistics Poland (GUS) using the relation of the volume of harvested wood according to WISL, to the volume of harvested wood determined for the present period. For the calculation of the above indicators, the proportion of the present value of harvest and the assumed total production of industrial wood, which was determined on the basis of forecasts for the development of the market for wood and wood products (production, export and import) until 2030, by the Wood Technology Institute, based on the data reported under the FAO reporting mechanism, in accordance with FAO 1866 and FAO 1867 codes .

Table 13. Harvest by energy and non-energy use in the present level scenario.

Present level scenario			
Year	**Harvest**	**Wood products**	**Wood for energy purposes**
	(thousand m^3)		
2017	45662	40384	5278
2018	46148	41223	4925
2019	46634	42061	4573
2020	47120	42900	4220
2021	47437	43360	4077
2022	47886	43820	4066
2023	48334	44280	4054
2024	48782	44740	4042
2025	49231	45200	4031

Table 14. Harvest indicators broken down by energy and non-energy use in the present level scenario

Present level scenario			
Year	**Harvest**	**Wood products**	**Wood for energy purposes**
	(%)		
2017	100.0	88.4	11.6
2018	100.0	89.3	10.7
2019	100.0	90.2	9.8
2020	100.0	91.0	9.0
2021	100.0	91.4	8.6
2022	100.0	91.5	8.5
2023	100.0	91.6	8.4
2024	100.0	91.7	8.3
2025	100.0	91.8	8.2

3. Description of the modelling approach

3.1 Description of the general approach applied for estimating the forest reference level

Forecasts carried out towards the establishment of a forest reference level aim to show what would happen to managed forest land if the historical management regime were to continue. Thus, the expected future impacts of policies and markets have not been taken into account when estimating the forest reference level.

In the guidelines for the development and reporting of forest reference levels under Regulation (EU) 2018/841, two alternatives are proposed for modelling the evolution of the managed forest land area over time, namely:

- assumption of a fixed area of managed forest land;
- assumption of dynamic formation of the managed forest land.

Irrespective of the alternative chosen for the development of the forest reference level, it is good practice to estimate and apply a technical correction to eliminate any mis-estimation of carbon balance developments due to differences between assumed land development and land development that actually took place during the compliance period.

The work on forecasting the forest reference level focused on alternative 1, with the result that the total area of managed forest land is assumed to remain constant over time. In other words, the area of land allocated to each strata has remained constant since the beginning of the forecasting year (thus there is no extrapolation of any possible historical trends for the future) and annual changes are not taken into account when forecasting forest reference level. Stratification of managed forest land (area of land allocated to each strata), documented for the year of the start of the forecasting, therefore, remains unchanged throughout the forecasting period.

Projections used unchanging values of quantified effects of management practices defined for the reference period. The adopted assumption suggests that the forest reference level is the best possible estimate of the emission and removal value that would occur if policy and measures were not influenced, and any changes to such policies and measures or any new policy or measure implemented after the reference period . At the same time, the same climatic conditions as for the historical period have been used for the forecasts for the establishment of the forest reference level. It has been assumed that climatic conditions will not change (i.e. they will remain constant over time).

3.1.1 Documentation of data sources applied for estimating the forest reference level

The description of the forest reference level as presented in Chapter 1., indicates that the basic quantitative indicator of forest management according to the reference level is the intensity of the harvest defined as the ratio of the harvest during the reference period (broken down by final felling and pre-final cuts) to the volume of the wood stock in age classes and subclasses as at the beginning of the reference period, i.e. 1 January 2000.

Source data for the estimation of the reference level shall include, on the one hand, the data needed to build an wood volume table divided by age classes and area as of 1 January 2000 and, on the other hand, the volume of harvested wood in the reference period (2000-2009). These values were established within the framework of two stratification layers, i.e. in forests managed by the State

Forests National Forest Holding and in forests outside the management of the State Forests National Forest Holding (i.e. in the remaining forests).

Construction of the wood volume table divided by age classes and area as of 1 January 2000 - using historical data based on the table of age classes as at 1 January 2010 - required, first of all, estimation of the harvest rates according to the current level, which was also connected with determination (within the stratification layers) of the amount of harvest in the period 2010-2019.

While in forests managed by the State Forests National Forest Holding the actual volume of harvesting coincides with the volume of harvesting as included in public statistics (according to GUS “Forestry"), in other forests, especially in private forests, the volume according to GUS - and according to the results of WISL - is much lower than the actual harvest. These relations are presented in Table no. 19. They indicate two important dependencies used in further analyses and forecasts concerning forests outside the management of the State Forests National Forest Holding, i.e. about 2.8 times higher harvesting according to WISL than according to GUS “Forestry" and the share in the amount of the total harvested wood: 20% of final felling and 80% of pre-final cuts.

Table 15. Wood volume table divided by age classes and area as of 1 January 2010 according to stratification layers of forests (based on WISL data from the period 2006-2010)

No.	Age classes and subclasses	Forests managed by the State Forests National Forest Holding		Other forests		Total	
		area	volume	area	volume	area	volume
		thousand ha	thousand m^3	thousand ha	thousand m^3	thousand ha	thousand m^3
1	Treeless forest area	203	4224	132	3293	334	7517
2	Stoppages	-	13771	-	4406	-	18177
3	Ia (1-10 years)	298	399	17	34	315	433
4	Ib (11-20 years)	328	12260	25	946	353	13205
5	IIa (21-30 years)	474	56537	163	19625	637	76162
6	IIb (31-40 years)	593	119395	226	43847	819	163242
7	IIIa (41-50 years)	917	240071	349	87534	1266	327605
8	IIIb (51-60 years)	848	254732	350	96802	1198	351534
9	IVa (61-70	617	198825	196	57085	813	255910

	years)						
10	IVb (71-80 years)	707	247392	147	47114	854	294506
11	Va (81-90 years)	600	223836	98	34065	697	257900
12	Vb (91-100 years)	409	159377	54	22192	463	181569
13	VI (101-120 years)	454	187534	62	25042	515	212576
14	VII and over (over 120 years old)	184	86949	34	15965	218	102914
15	(KO, KDO, BP)	173	54905	27	9443	200	64348
Total forested area		6602	1855983	1748	464098	8350	232 081
Total		6805	1860207	1880	467391	8685	2327598

Table 16. Volume of harvested wood in forests managed by the State Forests National Forest Holding

Year	Final felling		Pre-final cuts		Total	
	without bark	with bark	without bark	with bark	without bark	with bark
	thousand m3 of round wood					
2000	9014	11268	15083	18854	24097	30121
2001	8000	10000	15471	19339	23471	29339
2002	10266	12833	15329	19161	25595	31994
2003	11954	14943	15180	18975	27134	33918
2004	12911	16139	15788	19735	28699	35874
2005	12210	15263	15954	19943	28164	35205
2006	12694	15868	16006	20008	28700	35875
2007	13380	16725	18934	23668	32314	40393
2008	14140	17675	16555	20694	30695	38369
2009	15260	19075	15928	19910	31188	38985
Total	**119829**	**149786**	**160228**	**200285**	**280057**	**350071**

Table 17. Harvest of wood in forests managed by the State Forests National Forest Holding - present period

Year	Final felling		Pre-final cuts		Total	
	without bark	with bark	without bark	with bark	without bark	with bark
	thousand m3 of round wood					
2010	16621	20776	15261	19076	31882	39853
2011	15684	19605	17105	21381	32789	40986
2012	16017	20021	17195	21494	33212	41515
2013	16671	20839	17481	21851	34152	42690
2014	17716	22145	17964	22455	35680	44600
2015	18250	22813	18247	22809	36497	45621
2016	18819	23524	18586	23233	37405	46756
2017	21339	26674	19289	24111	40628	50785
2018	21503	26879	20605	25756	42108	52635
2019	21954	27443	20813	26016	42767	53459
Total	**184574**	**230718**	**182546**	**228183**	**367120**	**458900**

Table 18. Determination of the relation between the volume of wood harvested according to WISL in comparison to data of the Statistics Poland (GUS) "Forestry" in forests outside the State Forests National Forest Holding

Period (WISL)	Year (GUS)	According to WISL			According to GUS
		Final felling	pre-final cuts	Total	Total***
		thousand m^3 of round wood with bark			
2006–2010	2010	587	5194	5782	2108
2007–2011	2011	1233	5299	6532	2610
2008–2012	2012	1192	5360	6552	2208
2009–2013	2013	1231	5296	6527	2055
2010–2014	2014	1354	5131	6485	2476
2011–2015	2015	1456	5014	6470	2288
2012–2016	2016	1434	5125	6559	2155
2013–2017	2017	1398	4975	6373	**2583**

Total	**9885**	**41395**	**51279**	**15900**
Per 10 years	**12356**	**51743**	***64099**	****22713**
Percentage share	**19.3%**	**80.7%**	**100.0%**	**100.0%**

* of period 2010-2017

** of period 2010–2016

*** Data on harvested wood with bark results from multiplying the data according to the Statistics Poland (without bark) by a factor of 1.25.

Table 19. Volume of harvested wood in forests outside the State Forests National Forest Holding - reference period

Year	Harvested wood in thousand m^3 of round wood				
	according to GUS		according to WISL*		
	Total		Final felling	pre-final cuts	Total
	Without bark	With bark**	With bark		
2000	1928	2410	1350	5398	6748
2001	1546	1933	1082	4329	5411
2002	1542	1928	1079	4318	5397
2003	1603	2004	1122	4488	5611
2004	1727	2159	1210	4838	6048
2005	1561	1951	1093	4371	5464
2006	1528	1910	1070	4278	5348
2007	1832	2290	1282	5130	6412
2008	1712	2140	1198	4794	5992
2009	1513	1891	1059	4236	5296
Total	**16493**	**20616**	**11545**	**46180**	**57726**

*Conversion factor used is 2.8.

*** Data on harvested wood with bark results from multiplying the data according to the Statistics Poland (without bark) by a factor of 1.25.

Table 20. Volume of harvested wood in forests outside the State Forests National Forest Holding - present period

Year	Harvested in thousand m^3 of round wood				
	according to GUS		according to WISL**		
	Total		Final felling	pre-final cuts	Total
	without bark	with bark***	with bark		
2010	1686	2108	1180	4721	5901
2011	2088	2610	1462	5846	7308
2012	1766	2208	1236	4945	6181
2013	1644	2055	1151	4603	5754
2014	1981	2476	1387	5547	6934
2015	1830	2288	1281	5124	6405
2016	1725	2156	1207	4827	6034
*2017	**2067**	2271	1272	5088	6360
*2018	1817	2271	1272	5088	6360
*2019	1817	2271	1272	5088	6360
Total	**18170**	**22713**	**12719**	**50876**	**63595**

* average for the period 2010-2016

** data according to WISL are a result from the multiplication of data according to GUS by a factor of 2.8; the share of final felling was assumed at the level of 20%, and the share of pre-final cuts - 80%

*** Data on harvested wood with bark results from multiplying the data according to the Statistics Poland (without bark) by a factor of 1.25.

3.1.2 Documentation of stratification of the managed forest land

In the development of a reference level for forests in Poland, the available information on forest management practices, their characteristics, including the rules on forest use and the species-age structure of forests, was analysed. The division of forests in Poland into two stratification layers is justified by: the differences in the intensity and structure of the harvest, as well as in the availability and reliability of data on the condition and management of forests.

The main source of data on forests of all forms of ownership since 2010 is the National Forest Inventory(WISL). It provides, among other things, information on the structure and size of wood resources, and thanks to subsequent inventory cycles, it is also used to monitor changes in the forests in Poland. Based on the results of WISL and available more detailed data on forest management in the State Forests National Forest Holding, a division into two stratification layers (strata) was adopted:

- forests under management of the State Forests National Forest Holding - covering most of the area and wood resources of Poland (ca. 77%) and carried out according to uniform practices applied based on methods contained in the instructions and internal regulations concerning forest management in force in the State Forests National Forest Holding;
- forests outside the management of the State Forests National Forest Holding (called - other forests) - including forests of other forms of ownership, whose total area and volume of resources is approximately 23%. Other forests include forests under private ownership, forests managed by national parks, the Agricultural Property Stock of the State Treasury, other forests of the State Treasury and municipalities forests. Forests under private ownership dominate in this group, while other properties account for a small percentage of Poland's forest area. This group is characterized by a different way of forest management, expressed, among others, by significantly lower ratios of harvest relation to forests managed by the State Forests National Forest Holding.

The reference level is based on the forest area (without forest area used for forest management) as of 1 January 2010 (data from the WISL for the period 2006-2010) reduced - in Ia and Ib age subclasses - by land conversion (afforestation) from the previous 20 years (i.e. from the period 1990-2009 inclusive). It has also been assumed that the forest area of the reference level over the whole analysis period (2010-2030) will not change.

3.1.3 Documentation of sustainable forest management practices applied in the estimation of the forest reference level

In Poland in the reference period forest was managed in accordance with the Act of 28 September 1991 on Forest (Journal of Laws 1991, item 444, as amended). This management in individual forest units was carried out on the basis of forest management plans (in state forests), or on the basis of simplified forest management plans (in other forests) prepared for a period of 10 years. These plans were drawn up at the beginning of the reference period in accordance with the *Regulation of the Minister of Environmental Protection, Natural Resources and Forestry of 28 December 1998 on detailed rules for drawing up a forest management plan, a simplified management plan and a forest inventory*, and then - in accordance with the *Regulation of the Minister of the Environment of 20 December 2005 on detailed conditions and procedures for drawing up a forest management plan, a simplified forest management plan and a forest inventory*. According to the above-mentioned documents, the following have been taken into account when preparing the forest management plan or a simplified forest management plan:

1) requirements for breeding, protection, management, fire protection and forest use;
2) requirements for nature and landscape protection and biodiversity conservation;
3) the needs of national defence and security;
4) principles of forest management in protective forests;
5) existing and planned, according to the local rules, management systems for forest and its surrounding;
6) the need for rational shaping and protection of water resources.

The basic guidelines for forest management during the reference period were set out in particular in the forest management rules (issued in 1988 and 2003), the forest management manual (issued in 1994 and 2003) and the forest protection manual (issued in 1999 and 2004).

According to the provisions of the Act of 28 September 1991 on Forest, the main objective of forest management is to ensure forest sustainability and continuity of its multifunctional role in spatial development of the country.

The main objective of forest management was to preserve and enrich existing forests and to shape new ones with respect for natural conditions and processes. On the other hand, when formulating detailed management objectives, which are defined in the management plan for each forest stand and managed unit, the breeding objective shall be distinguished - by indicating the type of forest stand and the technical objective - by indicating the age of maturity of the stand's felling.

For the period of validity of the management plan (i.e. 10 years), economic indications shall be formulated in the harvest descriptions relating in particular to the tasks of forest management and harvest, the purpose of which is to use of forest resources and non-productive forest services as a public good and a source of resources for permanent, sustainable and multifunctional forest management. In all types of sanitation cuts - made during the forest stand growth period - the use of selective breeding method was obligatory in the reference period. Selection of felling in the early and late cleanings was mainly negative selection based on the removal of undesirable trees in given habitat conditions.

The selection direction in early and late thinning was positive and was based on the selection and promotion of an appropriate number of trees of the best quality from the upper layer of the forest stand and with high growth, distributed as evenly as possible throughout the forest stand, with the simultaneous support of bio groups of trees forming the skeleton of the forest stand and having a chance to survive until the felling age and beyond. It was carried out by systematic removal of trees hindering the proper development of the best trees, together with their protective surroundings, ensuring their stability.

Depending on the method of cutting, which created various possibilities of protecting the renewal by the old trees, two groups of cuttings were distinguished, i.e. clear-cutting marked with the symbol I and the complex felling marked with symbols II-V, including: Shelter wood method- symbol II, patch methods- symbol III, gradual felling - symbol IV, and selection system- symbol V.

Clear-cutting (I) - recommended for light-loving species - is characterized by a single removal of the entire stand from a defined area with the possible leaving of seedbeds, stoppages or bio groups of the felling stand. In the open harvest area, mostly artificial regeneration of light-loving species results in spatially differentiated contemporaneous crops.

Shelterwood method (II) is characterised by a regular distributed harvest of the forest stand on a given plot and is carried out by partial felling, with the medium or long time of regeneration.

Patch method (III) consists of a single or gradual implementation in a mature or reconstructed tree stand of patches of 5-20 acres in size, with or without top cover - depending on the ecological requirements of the renewed tree species. The natural or artificial regeneration, under side or top cover, which requires cover during adolescence, is basically a one-species clump higher by 1-3 m in height than the subsequent natural or artificial regeneration of light-loving species, occurring on the area between patches.

Gradual felling (IV) consists in the use of different types of regeneration felling in a forest stand on the same plot of land and the creation of regeneration centres, which are then widened by boundary felling during the usually long period of regeneration, leading to an uneven, time-spread thinning of the forest stand. Several seed years are used during such a felling. The effect of such felling is mixed forest stands of different ages with a complex spatial structure.

Selection system (V) is based on continuous felling in the entire forest stand area (control plot).

In the reference period (2000-2009), the management planning was governed by the regulation on final felling, assuming the maturity as the basic criterion of felling of forest stands in connection with the management methods (felling, clear-cutting, felling with clear cutting). The previously mentioned

felling were carried out in connection with habitat conditions and species composition of forest stands in a manner enabling the creation of the most favourable conditions for generation change.

In that period, a rule was in force that the sum of tasks for final felling and pre-final cuts specified in the forest management plan is the maximum value, which meant that in case of increased pre-final cut, final felling was limited.

The average felling ages/rotation periods (in years) for the most important tree species in the forests managed by the State Forests National Forest Holding were as follows: pine - 105, spruce - 95, beech - 115, oak - 140, birch - 80, alder - 75.

It should be noted that there is a significant difference between forests managed by the State Forests National Forest Holding and forests of other forms of ownership in terms of planning and implementation of management plans in force. While in the State Forests the size of the implemented harvest largely coincided with the size of the planned harvest, in the remaining forests - especially in private forests - the implementation of the planned tasks was (as now) much smaller (to a greater extent in relation to the GUS data than in relation to the WISL data).

It should also be emphasized that forest management methods in private forests are simplified and often implemented according to the needs of their owners within the framework of pre-final cuts. Therefore, in practice, the vast majority of harvested wood in private forests (estimated at about 80%) originates from pre-final cuts, and much smaller amount (about 20% of the harvested volume) originates from final felling.

The average felling ages/rotation periods (in years) for the most important tree species in forests outside the management of the State Forests National Forest Holding - defined as minimum years - are lower than those accepted in the State Forests and are as follows: pine - 80, spruce - 80, beech - 100, oak - 120, birch - 60, alder - 60. In practice, however, in forests outside the management of the State Forests National Forest Holding, higher felling ages are used, more similar to those used in the State Forests National Forest Holding.

Forest management carried out in forests of other (apart from private) forms of ownership (constituting only about 4% of the area and about 4.9% of total wood resources), i.e. in national parks, in the Agricultural Property Stock of the Treasury, in municipal forests and in other forests of the Treasury, has a much smaller impact on the intensity of forest management.

The above qualitative characteristics of practices applied in the reference period were reflected, among others, in the volume of wood harvested from final felling and pre-final cuts.

Data concerning these values for the 10-year period 2000-2009 - presented by the Statistics Poland (GUS) and the State Forests National Forest Holding (PGL Lasy Państwowe) and according to the results of WISL (used to verify data concerning forests outside the management of the PGL Lasy Państwowe) - are presented in Table 21.

Table 21. Wood harvested during final felling and pre-final cuts by stratification layer, period 2000-2009

Data source	VOLUME	Forests managed by the State Forests National Forest Holding	Other forests
		thousand m3 of round wood	
GUS	Without bark	280056	16493
	With bark***	350070	20616
WISL**	-	-	-
	With bark	-	57726*

* on the basis of the relationship between the volume of harvest according to WISL and the Statistics Poland (GUS), for the period 2010-2017.
**only for the needs of verification of GUS data for forests not under management of the State Forests National Forest Holding.
*** Data on harvested wood with bark results from multiplying the data according to the Statistics Poland (without bark) by a factor of 1.25.

Comparison of the volume of harvest according to WISL data as compared to GUS data for the period 2010-2017 indicates that the actual volume of harvest in forests not under management of the State Forests National Forest Holding is about 2.8 times higher than the volume provided by GUS, and the share in the amount of the total harvested wood: 20% of final felling and 80% of pre-final cuts.

Data adopted for the estimation of the intensity indicators for the reference level on the volume of final felling and pre-final cuts for the different stratification layers (together for the whole period, i.e. 2000-2009) are presented in Table 22.

Table 22. Harvest volume by stratification groups, 2000-2009 (in thousand m^3 with bark)

Stratification group	Category of harvest		Total
	Final felling	pre-final cuts	
Forests managed by the State Forests National Forest Holding	149786	200285	350071
Forests not managed by the State Forests National Forest Holding	11545	46180	57726

3.2 Detailed description of the modelling framework applied in the estimation of the forest reference level

This chapter provides information on how the framework for calculating CO_2 emissions and removals in forest ecosystems based on changes in carbon stocks in its different pools, was implemented.

Modelling of carbon emission and removal balances has been carried out with the use of CBM-CFS 3 software, the full documentation of which is available at https://www.nrcan.gc.ca/forests/climate-change/carbon-accounting/13107. In relation to the basic version of the software, a number of changes were introduced, partly using the parameters used by the JRC (Pilli et al. 2016 a 2016 a 2016 b, 2018) and partly using the data which is characteristic for Poland.

3.2.1 Modelling of carbon stock changes in forest ecosystems

Among other things, there have been taken into account:

1. Biomass expansion factors (BEFs) adapted to Polish conditions,
2. Densities of wood adapted to the conditions of Poland,
3. The division into natural-forest regions for Poland,
4. Growth curves based on WISL.

Modelling process itself is based on the following assumptions:

1. The modelling was carried out in accordance with the chapters described above, where each area unit represented a different age-grade group, taking into account the natural-forest regions.
2. Three main types of distortions were used to model the disturbances: pre-final cuts, final felling cuts and fires, the first two of which were based on the JRC methodology chosen for Poland. In case of final felling and pre-final cuts, a cut "from the oldest" was used, while in the case of fires, a random selection was used.
3. Modelling of disturbances was based on data on wood harvest in terms of volume, broken down by years and particular species-age groups, and natural-forest regions.
4. Due to the construction of the CBM CFS 3 itself, the modelling of fires was carried out in separate processes, but in such a way as to finally combine the results obtained.

It is worth noting that the data on the national volume of round wood, obtained by recalculating the values of carbon stocks obtained using the CBM CFS 3 software, show consistency with the data on the national volume of round wood by WISL. At the same time, consistency over the period 2010-2015 is also demonstrated by independent projections for Poland for the period 2000-2015, prepared by the Joint Research Centre (JRC) of the European Commission in Ispra on the basis of independent methodological assumptions.

3.2.2 Modelling of emissions from harvested wood products

This chapter provides information on how the framework for calculating the carbon substitution effect in harvested wood products based on changes in the carbon pool and some historical information on assumptions related to the principle of instantaneous oxidation, was implemented. According to the LULUCF Regulation, only carbon contained in wood products harvested in national forests (under category 4.A.1 forest land remaining forest land) should be included in the estimation of the forest reference level. As a consequence, time series of data reflecting the annual production of wood products have been allocated to the corresponding national forest land category.

This process consisted of three intermediate stages:

a) estimation of the share of carbon in harvested wood products from domestic forests. For this purpose, the share of the relevant categories of raw materials (which also originate from domestic forests) of harvested wood products, such as "industrial round wood", "wood pulp"

and "recovered paper" used (i.e. consumed) in the production process of the relevant wood products, such as "sawn timber", "wood-based panels" and "paper and board",was determined,

b) an estimate of the annual fraction of raw materials for the wood products categories 'sawn timber', 'wood-based panels' and 'paper and board' originating in land category 4.A.1 *forest land remaining forest land.* Importantly, in accordance with the requirements of the LULUCF Regulation, harvested wood from deforested areas in accordance with the practice included in the National Greenhouse Gas Inventory to the UNFCCC (in accordance with Decision 2/CMP.8) has been treated according to the principle of " instantaneous oxidation",

c) in order to obtain annual fractions of harvested wood products derived from the reporting category 4.A.1, forest land remaining forest land, to be included in the forest reference level, the information obtained in steps a and b has been combined using the correction factors included in Table 23.

It should be noted that the values of correction factors determined the rate of change in the forecasted harvesting, as compared to the average historical harvesting in the period from 2000 to 2009. The value of these indicators is the basic factor controlling the projected production of all groups of products from harvested wood in the period 2010-2025.

The estimation process itself uses the methodological guidelines contained in section 2.8.1.2 of the IPCC (2014)[5].

Table 23. Correction factors

Year	Acquisition by FRL 2000-2009 (thousand m^3)	Correction factor
2000	32624	NA
2001		NA
2002		NA
2003		NA
2004		NA
2005		NA
2006		NA
2007		NA
2008		NA
2009		NA
2010	38269	1.173
2011	38890	1.192
2012	39509	1.211

[5] The same information is expected to be included in section 12.5.2.1 ("Compilation of activity data on the production approach") of the IPCC 2019 amendment.

Year	Acquisition by FRL 2000-2009 (thousand m^3)	Correction factor
2013	40130	1.230
2014	40751	1.249
2015	41371	1.268
2016	42474	1.302
2017	43008	1.318
2018	43542	1.335
2019	44076	1.351
2020	44610	1.367
2021	45251	1.387
2022	45731	1.402
2023	46212	1.417
2024	46693	1.431
2025	47173	1.446

NA - not applicable

In the next step, the annual carbon inflow was calculated and taken into account for the estimation of the annual changes in carbon stocks by means of the first order decay function according to the rules set out in Annex V of the LULUCF Regulation.

It should be noted that section 2.8.4.1 of the IPCC 2013 Guidelines (2014) specifies possible data sets or sources that are also compatible with the LULUCF Regulation. These data include data on harvested wood products consistent with the HS international nomenclature and classification system (i.e. categories 'sawn timber', 'wood-based panels' and 'paper and board').

In order to meet IPCC requirements for estimating initial carbon stocks in annual reports and when calculating the contribution of harvested wood products to the forest reference level, the time series of activity data sources the period from 1900 onwards. Further information can be found in section 2.8.3 of IPCC (2014).

As a consequence of the application of the half-life function as a method for determining carbon stock changes in the pool of harvested wood products, emissions associated with the use of wood for energy purposes are implicitly taken into account in the estimates of forest carbon pools.

Importantly, according to criterion (e) of Annex IV.A to Regulation 2018/841, the calculation of the projected carbon substitution effect of harvested wood products in the forest reference level is based on the assumption of a *'a constant ratio between solid and energy use of forest biomass as documented in the period from 2000 to 2009*.

3.2.3 Identification of carbon pools and greenhouse gases included in the forest reference level

Member States should reflect in their estimates for each land-use category reported the broadest possible range of carbon stock changes in their pools. The list of required pools is contained in Section B of Annex I to Regulation (EU) 2018/841. However, some flexibility is left for Member States to decide not to include changes in carbon stocks for certain carbon pools in their accounting, as long as the carbon pool in question is not a source of GHG's emissions.

The decision not to include a pool shall not apply to a carbon pool of above-ground biomass, dead wood and harvested wood products under the land accounting category covering managed forest land. With a view to ensure the completeness and accuracy of the reported data, the projections for the determination of the reference level contained in this document take into account the broadest possible set of available data on the evolution of carbon stocks in its pools. The set of pools taken into account is shown in Table 24

Table 24. List of carbon pools and greenhouse gases included in the forest reference level

No.	Carbon pool	Y- taken into account N - omitted
1	**Above-ground biomass**	**Y**
2	**Below-ground biomass**	**Y**
3	**Forest litter**	**Y**
4	**Dead wood**	**Y**
5	**Soil organic carbon**	**Y**
6	**Harvested wood products from afforested and managed forest land (total)**	**Y**

3.2.4 Reasons for not including a carbon pool in the establishment of the forest reference level

Not applicable

4. Forest reference level (managed forests)

4.1 Forest reference level and detailed description of the development of the carbon pools

Reference level for managed forests for the period 2021-2025 means the average estimated level of projected annual emission and removals balances from forests over the period 2021-2025, estimated for CRF category 4.A.1 forest land remaining forest land. The reference level is expressed in tonnes of CO_2 equivalent per year and its determination method is included in Section A of Annex IV of Regulation (EU) 2018/841. Forecasted emission and removals balances for forests over the period 2021-2025 are shown in Table 25 and the forest reference level applicable for the period 2021-2026 is shown in Table 26.

Table 25. Summary estimates and projections of the balance of emissions and removals for category 4.a.1 'Forest land remaining forest land' according to the reference scenario

Scenario by reference level	Unit	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
	kt CO_2 eq.	-45449	-44919	-44095	-43541	-42443	-41287	-39734	-38305	-37069	-35803	-33296	-31229	-29329	-27595	-25717
Reference level	kt CO_2 eq.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-29433				

NA - not applicable

Table 26. Forest reference level in the reference scenario 2000-2009

Reference period	Unit	2021-2025	2026-2030
Reference level for managed forests (CRF category 4.A.1. forest land remaining forest land)	kt CO_2 eq.	-29433	NA

NA - not applicable

4.2 Consistency between the forest reference level and the latest national inventory report

In order to verify that the whole time series of estimates (i.e. historical and forecast estimates) is consistent, and where inconsistencies are identified, a consistency analysis has been carried out to adjust the forecast estimates.

Since the verification of results can only be carried out for historical periods, the model used to forecast the reference level for forests estimated the maximum long historical period for which methodically consistent source data were available. Historical data on forest area and carbon stocks (e.g. information on forest condition and age-related information), stratified according to the relevant carbon stock gain and loss variables used by the model for forecasting the 2010-2026 period, are closest to the data of 2000. The verification was carried out at the level of aggregated emissions and removals of greenhouse gases, and both the level of the time series data and their trend were analysed.

In order to verify the level, the sum of the time series of historical data was compared with the sum of the results obtained within the model. Results obtained, within the range of one standard deviation (i.e. 68% confidence interval) from the set of historical data included in the National Greenhouse Gas Inventory, indicate the correctness of the modelling process.

Inconsistencies in the time series were identified as follows:

- an iterative process has been applied to the historical (2010-2016) and projected (2017-2025) time series to exclude outliers (if any) that are larger than the median of the data in the time series, taking into account twice the standard deviation in each subsequent iteration. On the basis of the remaining values of the time series, a set of data on annual changes was determined.
- the mean and standard deviation for the data set have been calculated.
- possible inaccuracies were identified in the time series between the last historical year and the first year of forecasting which are not affected by catastrophic events, by checking whether the annual change value is greater than the average value plus twice the standard deviation. No deviations above these values were found.

In the absence of possible inconsistencies, the calibration techniques listed in chapter 5.3.3 of Volume 1 of the IPCC 2006 Guidelines to ensure the consistency of the different time series, were not implemented.

Fig 1. Compatibility of data included in the forest reference level with the data contained in the National Inventory Report 2018

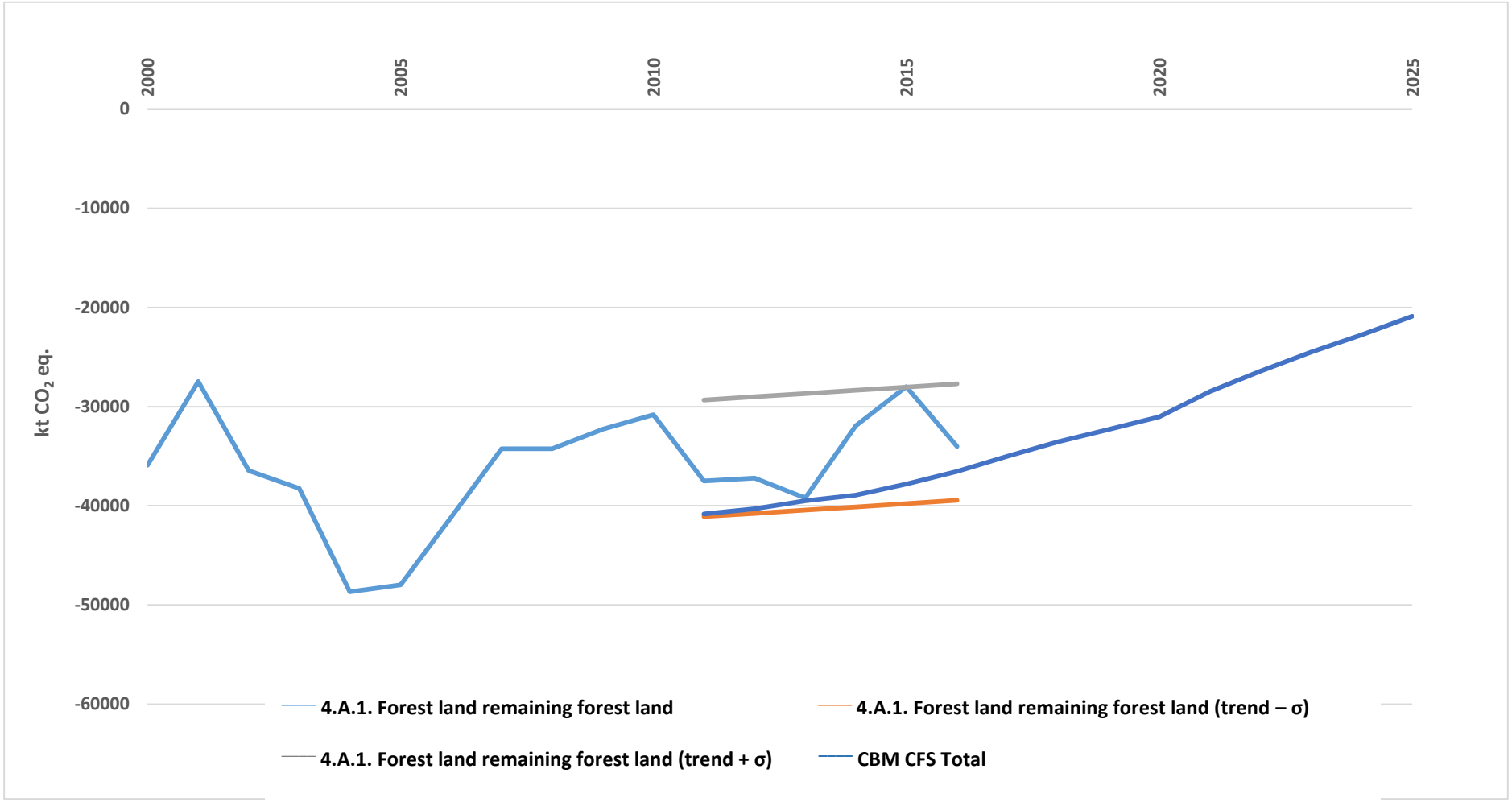

Table 27. Summary estimates and projections of the balance of emissions and removals for category 4.A.1 'Forest land remaining forest land' in the reference level scenario

Inventory	Unit	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
4.A.1. Forest land remaining forest land	**kt CO_2**	-35903	-27456	-36450	-38250	-48656	-47956	-41169	-34251	-34235	-32283	-30828	-37507	-37222	-39204	-31934	-27992	-34005
CBM CFS	**kt CO_2**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-40834	-40315	-39490	-38925	-37812	-36546
Regression line	**kt CO_2**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-35214	-34887	-34559	-34232	-33905	-33578
Standard deviation (σ)	**kt CO_2**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	5878	5878	5878	5878	5878	5878
Regression line + σ	**kt CO_2**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-41092	-40765	-40438	-40111	-39783	-39456
Regression line - σ	**kt CO_2**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-29335	-29008	-28681	-28354	-28027	-27699
Compliance test	**True/ False**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**True**	**True**	**True**	**True**	**True**	**True**

4.3 Estimated changes in the carbon pools and greenhouse gases for the forest reference level

The following table indicates the evolution of carbon stocks in its pools and greenhouse gases for the forest reference level.

Table 28. Modelling effect of carbon stock changes in its pools for category 4.A.1 Forest land remaining in forest land

Carbon pool	Unit	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Living biomass	kt C	-11044	-10594	-10226	-9847	-9467	-9084	-8509	-8160	-7812	-7457	-6540	-5988	-5490	-5104	-4620
Forest litter	kt C	-521	-668	-741	-774	-782	-778	-782	-755	-726	-700	-722	-697	-669	-624	-593
Dead wood	kt C	170	95	28	-35	-90	-145	-213	-237	-258	-279	-467	-469	-473	-426	-422
Mineral soils	kt C	185	88	24	-22	-56	-83	-104	-121	-135	-147	-160	-168	-175	-178	-183
Organic soils	kt CO_2 eq.	158	159	161	162	163	165	166	167	169	170	172	173	174	176	177
Total	kt CO_2 eq.	-40834	-40315	-39490	-38925	-37812	-36546	-34990	-33555	-32308	-31029	-28488	-26416	-24510	-22767	-20880

Table 29. Estimates and projections of emissions resulting from forest fires (natural disasters)

Kind of emission	Unit	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
CO_2	kt	98	131	335	59	128	259	65	251	243	243	236	231	249	249	249
CH_4	kt CO_2 eq.	10	13	33	6	13	26	6	25	24	24	23	23	24	24	25
N_2O	kt CO_2 eq.	1	2	4	1	1	3	1	3	3	3	3	3	3	3	3
Total	kt CO_2 eq.	109	146	372	66	142	288	73	279	270	270	262	256	276	276	277

Table 30. Historical and projected reference carbon substitution effect of harvested wood products

Type of product	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Paper	kt C	-108	-90	-77	-67	-59	-53	-52	-47	-42	-39	-36	-35	-33	-31	-29	-28
Wood based panels	kt C	-778	-782	-786	-791	-795	-799	-815	-817	-818	-820	-822	-826	-826	-827	-827	-827
Sawn wood	kt C	-380	-386	-393	-399	-405	-412	-426	-430	-435	-439	-444	-450	-454	-457	-460	-464
Total	kt CO_2	-4641	-4614	-4604	-4606	-4616	-4631	-4741	-4744	-4751	-4761	-4774	-4808	-4813	-4820	-4828	-4837

5. Bibliography

1. GUS (1991-2016). Forestry. Statistics Poland. Warszawa, 1991-2017.
2. GUS (1988-2016). Environmental protection 1988-2016. Statistics Poland. Warszawa, 1988-2017.
3. Forsell N, Korosuo A, Federici S, Gusti M, Rincón-Cristóbal J-J, Rüter S, Sánchez-Jiménez B, Dore C, Brajterman O and Gardiner J. (2018). Guidelines for the development and reporting of forest reference levels according to Regulation (EU) 2018/841. Available online at: https://ec.europa.eu/clima/policies/forests/lulucf_en.
4. IOŚ-PIB (2012). National Quality Assurance and Control Programme (QA/QC) for the inventory of greenhouse gases, ver. 3. National Centre for Balancing and Emission Management, Institute for Environmental Protection, National Research Institute. Warszawa, September 2012.
5. IOŚ-PIB (2018) National Inventory Report. Warszawa, 2018
6. IPCC (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories.
7. Kozakiewicz P., Daglezja zielona (Pseudotsuga menziesii (Mirb.) WTD SGGW Library in Warszawa.
8. Kraszkiewicz A., Kachel-Jakubowska M., Szpryngiel M., Niedziółka I., 1994. Assessment of physical properties of robinia dendromass, in Inżynieria Rolnicza 6(131)/2011.
9. Pilli R., Kull S.J., Blujdea V.N.B, Grassi G., 2018, The Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3): customization of the Archive Index Database for European Union countries, Annals of Forest Science, 75:71 https://doi.org/10.1007/s13595-018-0743-5
10. Pilli R., Grassi G., Kurz W.A., Viñas R.A., Guerrero N.H., 2016 a, Modelling forest carbon stock changes as affected by harvest and natural disturbances. I. Comparison with countries' estimates for forest management, Carbon Balance and Management 11(1) DOI: 10.1186/s13021-016-0047-8
11. Pilli R., Grassi G., Kurz W.A., Viñas R.A., Guerrero N.H., 2016 b. Modelling forest carbon stock changes as affected by harvest and natural disturbances. II. EU-level analysis, 2016, Carbon Balance Manage (2016) 11:20 DOI 10.1186/s13021-016-0059-4
12. Seventh Government Report and Third Biennial Report to the Conference of the Parties to the UN Framework Convention on Climate Change. 2017.

6. List of tables

Annex

The way in which the criteria set out in Annex IV to Regulation (EU) No 2018/841 are taken into account

Point of Annex 4 of Regulation (EU) No 2018/841	Element of Annex 4 of Regulation (EU) No 2018/841	Chapter of National Forestry Accounting Plan (NFAP)
(a)	General description of the forest reference level	1.2
(a)	Consideration to the criteria as set in Annex IV of the LULUCF Regulation	annex
(b)	Identification of carbon pools and greenhouse gases included in the forest reference level	2.2.1, 2.2.2
(b)	Reasons for not including a carbon pool in the establishment of the forest reference level	3.2.4
(b)	Demonstration of consistency between the carbon pools included in the forest reference level	2.2.3
(c)	Description of the approach, methods and models, including quantitative data, used for establishing the reference level for forests, consistent with the most recently submitted national inventory report	3.1
(c)	Description of documentation on sustainable forest management practices and their intensity as well as national policies adopted	3.1.3
(c)	Description of national policies adopted	2.3.1
(d)	Information on how harvest indicators will develop under different policy scenarios;	2.3.2
(e)	Description of how each of the following elements has been taken into account when setting the forest reference level:	
(i)	area under forest management;	2.3.3
(ii)	emissions and removals from forests and harvested wood products as shown in greenhouse gas inventories and relevant historical data,	2.3.4
(iii)	description of forest characteristics (dynamic forest characteristics related to age, growths, rotation length and other information on forest management activities in a present management scenario)	2.3.5
(iv)	historical and future harvest indicators, broken down into energy and non-energy use	2.3.6