MINISTRY
OF CLIMATE

National Forestry Accounting Plan

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

Warsaw, 2019

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1. Introduction

1.1. Legal basis

In 2018, a new *Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU (Text with EEA relevance*) (hereinafter referred to as "LULUCF Regulation") entered into force.

In accordance with the LULUCF Regulation, the 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 (FRL), 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 (NFAPs), including proposed FRL, should 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 accordance with Article 8(7), Member States should communicate their revised FRLs to the European Commission by 31 December 2019 for the period from 2021 to 2025.

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. To date, the land use, the land use change and forestry (LULUCF) sector has not been part of the EU climate and energy package and has not been included in 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) greenhouse gas emissions. The Parties to the Paris Agreement adopted 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 has replaced 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 the 2030 climate and energy policy framework endorsed a binding target of at least a 40 % domestic reduction in economy-wide greenhouse gas emissions by 2030 compared to 1990, and that target was reaffirmed in the European Council's conclusions of 17-18 March 2016.

The European Council conclusions of 23-24 October 2014 stated that the multiple objectives of the agriculture and land use sector, with their lower mitigation potential as well as the need to ensure coherence between the Union food security and climate change objectives, should be acknowledged. 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 the abovementioned obligation is the LULUCF Regulation, which 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 from 2021 to 2030.

The national greenhouse gas reduction targets agreed in the Kyoto Protocol for existing commitment periods will cease to apply after 2020. With this in mind, the Parties 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 reached 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 conserve and enhance, as appropriate, sinks and reservoirs of greenhouse gases.

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

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 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 from 2000 to 2009. The FRL is a projection of carbon stock changes over the period from 2021 to 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 reported as forest land remaining forest land pursuant to Article 7(1)(c) of *Regulation (EU) 525/2013 of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC (Text with EEA relevance*) (hereinafter

referred to as “Regulation (EU) 2018/841”). 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. wood harvesting, broken down by final felling and pre-final cuts). This intensity is defined as the quotient of the main use (wood harvesting) during the reference period (broken down into final felling and pre-final cuts) and the volume of round wood by age classes and subclasses according to the state at the beginning of the reference period, i.e. on 1 January 2000. The harvesting intensity indicators are described in greater detail in section 2.3.2.2.

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

1) forests managed by the State Forests National Forest Holding (PGL Lasy Państwowe) - covering most of the forest area and wood resources of Poland (ca. 77%) and managed 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 other than those managed by the State Forests National Forest Holding (also referred to as “the other forests”) - including forests under other forms of ownership, whose total forest area and volume of resources are approximately 23%. The 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 municipal 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 manner of forest management, expressed, among others, by significantly lower harvesting indicators than in group 1, i.e. the forests managed by State Forests National Forest Holding.

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

The state of forests in the reference period, in the form of a surface and volume-based 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 for the other forests, were the results of the National Forest Inventory (WISL) in Poland (for the period from 2006 to 2010).

The volume of harvested wood in the reference period in forests managed by the State Forests National Forest Holding was determined on the basis of data from Statistics Poland (GUS) (identical to the data of the State Forests National Forest Holding), whereas the harvested volume in the other forests - on the basis of data from GUS using the ratio of the volume of harvested wood according to WISL to the volume of harvested wood according to GUS as determined for the period from 2010 to 2019 (the volume of harvested wood according to WISL turned out to be about 2.8 times greater than the values according to GUS - see Table 18). Due to the lack of WISL data for the full reference period (in particular, for the period from 2000 to 2005), the volume of harvested wood in the other

[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: IGES, Japan. Available at: https://www.ipccnggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf;

forests was adopted on the basis of WISL data reported starting from the first year of the second WISL cycle, i.e. 2010-2017. During this period, the harvest which actually took place from 2006 to 2010, from 2007 to 2011, etc. during the five-year cycle of WISL was recorded. These 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 GUS and the results obtained from WISL was determined.

The total forest area (without shrub lands) for the two strata distinguished, as of 1 January 2000, was adopted on the basis of data from the GUS, while the total wood volume as of that date was determined by subtracting the current increment of 9 m^3/ha per year from the volume in 2010 and adding the volume of harvested wood in the period from 2000 to 2009 . The current increment of the volume was adopted on the basis of data obtained within the second of WISL cycle, i.e. in the period from 2010 to 2014. These are the first increment results developed for forests in Poland.

The following can be stated with regard to the determined harvesting intensity indicators:

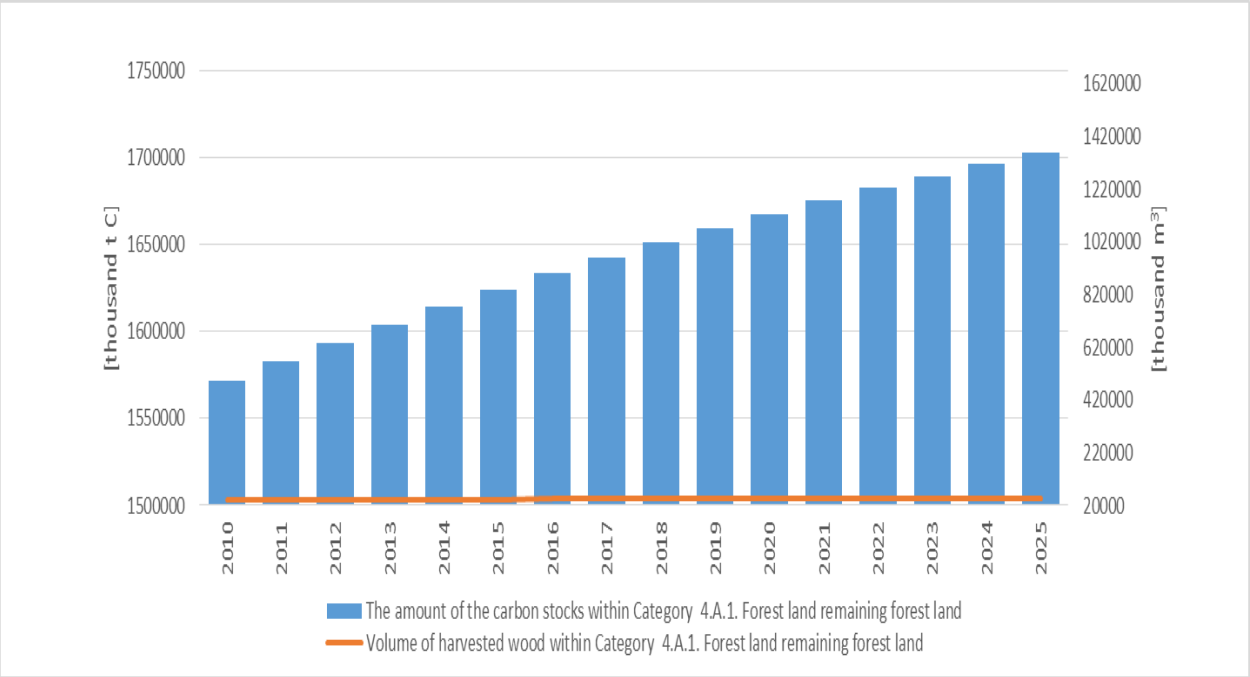
- Final felling and pre-final cut indicators have been adjusted to the volume of harvested wood in the reference period (2000-2009) in relation to the volume-based table of age classes at the beginning of this period, i.e. as of 1 January 2000; they are quantified forest management practices used to project the reference level scenario in the periods: 2010–2015, 2016–2020, 2021–2025 and 2026–2030.
- Final felling and pre-final cut indicators have been adjusted to the volume of harvested wood in the period from 2000 to 2017 in relation to the volume-based table of age classes at the beginning of the period, i.e. as of 1 January 2017; they are quantified forest management practices - used to project the present level scenario in the periods: 2017–2020, 2021–2025 and 2026-2030.

The FRL was based on the continuation of sustainable forest management practices, as documented in the period from 2000 to 2009. The period from 2021 to 2025 as a whole is characterised by that the volume of harvested wood will not exceed the annual stand increment, even though the alternative scenarios provide for a significant increase in the volume of harvested wood (Tables 4, 5, 25 and 26). The main factor responsible for the increase of the volume of harvested wood is the need to shape a correct age structure of forests, as this structure is unbalanced due to a large share of stands in age classes III and IV. If these stands are allowed to age excessively, this will pose a risk for their stability and the implementation of the idea of sustainability of forests. In this context, commercial and protective measures to prevent degradation of habitats and stands, as well as measures intended to generate such a structure that would limit the adverse impacts of the external environment on forest ecosystems, are key and indispensable elements. It is believed that forests should be mainly shaped with consideration given e.g. to the appropriate species composition, internal construction, shape and structure of stands, while, at the same time, these elements should be regarded as stability drivers which are subject to periodic inspections during forest management works.

It is important to emphasise the essence of the idea of preserving the sustainability of a forest, which does not apply to a single stand, but rather to a forest regarded as a whole, which is formed by stands of different tree thickness and of different ages subject to different management methods in an extensive area. The sustainability of a forest is a biological concept which is supreme with respect to the sustainability of use and the maintenance of different functions and it is often defined as a state of dynamic equilibrium between the processes of regeneration, survival and loss of trees and stands at forest holding level. In practice, this means that a forest holding occupies an extensive forest area and is represented by stands in practically all the age classes. Therefore, the preservation

of the sustainability of a forest requires the appropriate control of its development, consisting of establishing the dependence between the intensity of the survival process and the intensity of the depletion process considered in quite an extensive forest area. A number of emphasised dependencies, including the aspect of the long-term growth of wood resources (carbon stocks), most certainly make it possible to demonstrate that the FRL is consistent with the objectives of reaching in the second part of this century a balance between anthropogenic emissions from individual sources and the removals of greenhouse gases by sinks, thus, sustainably contributing to increasing the resources.

Fig. 1. Changes in carbon stocks and volume of harvested wood in the FRL scenario (2010-2025)



1.3 Consideration of 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) (Section B of Annex IV) are taken into account is shown in Annex II.

2. Preamble to the forest reference level

2.1 Introduction

Past challenges for EU Member States in the process of developing FRL include the lack of data and inconsistencies between different sets and sources of data. The estimation of natural disturbances, accounting for harvested wood products and the lack of documentation on forest management practices were equally frequently mentioned as problems which Member States expected in the process of estimating their FRLs. The results of a study carried out in 2018 on behalf of the European Commission 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 the national differences in modelling FRLs and the LULUCF sector itself, while ensuring transparency and completeness of reporting based on as consistent, comparable and accurate information as possible.

Projections carried out to develop the FRL 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 FRL, 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, will be applied during the 2021-2025 period. This assumption suggests that the FRL is the best possible estimate of the emission and removal levels which would occur if the policies pursued, and the measures undertaken or any changes to such policies and measures, or any new policy or measure implemented after the reference period had no impacts.

However, the FRL 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. the changing age structure of forests, including biomass available for harvesting, increment etc.) with “the continuation of sustainable forest management practice" (Article 8(5) of Regulation (EU) 2018/841) which occurred in the reference period.

Article 5(4) of the LULUCF 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 of "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 accounts.

Although, according to Article 8(5), the FRL must not “unduly constrain forest management intensity as a core element of sustainable forest management practice”, but the estimation of the FRL 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 to reflect 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 information on how these issues have been taken into account in the estimation of the FRL.

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

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

The 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 by two processes, i.e. by using CBM-CFS3 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 which are used in national greenhouse gas inventories.

The methodology which has been applied 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-CFS3
2	Below-ground biomass	CBM-CFS3
3	Forest litter	CBM-CFS3
4	Dead wood	CBM-CFS3
5	Soil organic carbon	CBM-CFS3
6	Harvested wood products in the land accounting categories of afforested land and managed forest land (total)	IPCC[2] method, using the first order decay function

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

Table 2. Elements of forest ecosystems included in the estimates of carbon stock changes under the CBM-CFS3 simulation

Aggregate III°	Aggregate II°	Aggregate 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 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 round wood 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 thin roots of conifers of diameter < 5 mm
			Thin roots of broadleaved trees	Thin roots of broadleaved trees - carbon in the thin roots of broadleaved trees of diameter < 5 mm
			Thick roots of conifers	Thick roots of coniferous - carbon in the roots of thick conifers of diameter >= 5 mm
			Thick roots of broadleaved trees	Thick roots of broadleaved trees - carbon in the thick roots of 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 foliage biomass 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 inflow from the biomass pool of round wood of coniferous trees; the default rate of decomposition is half 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 inflow from the biomass pool of the round wood of coniferous trees; the default rate of decomposition is half 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 inflow from the biomass pool of round wood of broadleaved trees; the default rate of decomposition is half the rate of decomposition for the average pool to the pool of dead broadleaved tree trunks
			Dead broadleaved tree branches	Dead broadleaved trees branches - carbon in dead organic matter with the inflow from the biomass pool of other elements of broadleaved trees; the default rate of decomposition is half 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 pool 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 very fast below-ground, slow below-ground and black carbon pools 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 and 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-CFS3	Statistics Poland (GUS) "Forestry" 2001-2017	Area of fires in the period from 2000 to 2016. For the period from 2016 to 2020, the average from the period from 2000 to 2016. Data of the National Headquarters of the State Fire Service and the National Forest Fire Information System
CH_4 emissions from forest fires	CBM-CFS3		
N_2O emissions from forest fires	IPCC 2006; Equation 2.27		
CO_2 emissions from organic soils	IPCC 2006; Equation 2.26	National Study by Oświęcimska-Piasko 2008	[7RR 2017, Section 5.1].
Carbon substitution effect for products in the "paper" category	IPCC 2006; Equations 12.1, 12.2 and 12.6	FAOSTAT http://faostat.fao.org FAOSTAT	The reference value of production in the period from 2010 to 2025 was determined on the basis of correction factors
Carbon substitution effect for products in the "wood panels" category			
Carbon substitution effect for products in the "sawn wood" category			

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

The main anthropogenic driver of the global temperature increase is the accumulation of greenhouse gases in the atmosphere. The processes releasing greenhouse gases into the atmosphere, such as the combustion of fuels, are referred to as "sources". The processes removing 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 dioxide (N_2O). In the LULUCF Regulation, all greenhouse gases are expressed as CO_2 equivalent (the effect of the mass of CO_2 equivalent in the atmosphere on the solar radiative forcing).

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

The consistency between the carbon pools is maintained by using the CBM-CFS3 tool, which takes into account the relationships 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

Forest land is the largest carbon sink in the LULUCF sector. The estimated amount of CO_2 removal is mainly generated by the increment of living biomass. The definition of a forest used in reporting to the Climate Convention is the same as the definition of a forest used in the Forest Act of 1991, which specifies that a forest is:

- a compact area of at least 0.10 ha, covered with, or temporarily deprived of, forest vegetation (forest crops) - trees and shrubs and forest undergrowth which:
  - is intended for forestry production, or
  - constitutes a nature reserve or a part of a national park, or
  - has been entered into the register of monuments;

- is associated with forest management, occupied for the purposes of forest management: buildings and structures, water amelioration 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.

The forest area in Poland is 9,230,000 ha (according to GUS- as of 31.12.2016), excluding the land related to forest management, which represents a forest cover of 29.5%. Including the land related to forest management, as of 31.12.2016, the forest area in Poland is 9,435,000 ha.

The ownership structure of forests in Poland is dominated by public forests - 80.8%, including the forests managed by the State Forests National Forest Holding - 77.0%. This structure has hardly changed in the whole post-war period. From 1990 to 2016, the share of private forests increased by 2.2% to the current 19.2%. At the same time, the share of public forests decreased from 83% to 80.8%.

In the period from 1945 to 2017, the species structure of Polish forests underwent significant changes, manifested, among other things, by an increasing share of forest stands with a predominance of broadleaved species. On the land managed by the State Forests National Forest Holding, 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 coniferous habitats, occurring in 50.5% of the forest area, while the broadleaved habitats cover 49.5%. In both groups, there are also upland habitats occupying as a total 6.5% of the forest area and mountain habitats occurring in 8.7% of the forest area. Coniferous species dominate in 68.5% of Poland's forest area. Pine, which according to the WISL occupies 58.2% of the forest area under all forms of ownership, i.e. 60.1% of the State Forests National Forest Holding and 55% of private forests, has found in Poland the most favourable climatic

and habitat conditions within its Eurasian range and as a result of this it has managed to produce many valuable ecotypes (e.g. the Taborska pine or the Augustowska pine).

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

According to WISL 2012-2016 data, the area of forest stands aged over 80 years (without KO and 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 under 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 regeneration (without reforestation and introduction of the second floor) was carried out in an area of 56,095 ha of land under all the ownership categories, including natural regeneration in 7,912 ha (14.1%). The area regenerated in 2016 was smaller by about 300 ha than in 2015.

Over the last 40 years of the 20th century, there was a has been a step-like decrease in the area of regeneration and, in consequence, in the share of forest stands of the youngest age classes. Since the beginning of the 21st century this trend can be seen to have changed. Measures are taken to stabilise forest ecosystems.

In addition, an increase in the share of natural regeneration in the total area of regeneration, to be seen since the early 1980s, should be noted. In the period from 1976 to 1980, this share was 3.4%, then 6.5% in the period from 1991 to and 1995, 10.5% in the period from 1996 to 2010 and 13.8% in the last six years. In forest nurseries, seedlings are grown for the purposes of regeneration and afforestation works. The production area of forest nurseries in 2016 was 1,966 ha, including 1,943 ha in State Forests, 15 ha in national parks and 8 ha in the other public forests.

The basis for afforestation works in Poland is the "National Programme for the Augmentation of the Forest Cover" (KPZL). At the initiative of, and on commission from, 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 the optimal spatial and temporal distribution of afforestation activities, as well as to establish environmental and economic priorities and implementing tools.

A steady increase in wood resources has been recorded since 1967 when the first update of wood resources was carried out in the State Forests. A reliable source of data for the country in recent years, e.g. revealing private forest resources, are the WISL results. According to the 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 the WISL measurements carried out in the period from 2013 to 2017 and referred to the forest area at the end of 2016, wood resources reached a volume of 2,587 million m^3 of round wood with bark. More than half (50.9%) of the resources are forest stands in age classes III and IV. Together with KO, KDO and BP, the share of the volume of the forest stands aged over 100 years in the total volume is 18.1%.

According to the WISL results from the period from 2013 to 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
Forest Act of 28 September 1991 (Official Journal of the Laws of 2018, Item 2129, as amended)	The Act defines the principles of conservation, protection and enhancement of forest resources and the principles of forest management in relation to other elements of the environment and national economy.
National Forest Policy (NFP), adopted by the Council of Ministers on 22 April 1997	The document gives direction to actions in the area of *Forestry* and indicates the linkages of forestry in cross-sectoral and international agreements.
National Programme for the Augmentation of the Forest Cover (KPZL) adopted by the Council of Ministers in 1995	The National Programme for the Augmentation of the Forest Cover is a strategic study. It is a forest policy instrument for shaping the country's natural space and contains general guidelines for drawing up regional spatial development plans with a view to increasing the forest cover. The methodological assumptions and criteria for determining afforestation preferences adopted in KPZL may be helpful in the creation of original regional and local solutions. The objective of KPZL is to increase the country's forest cover to 30% by 2020 and 33% after 2050 and to ensure the optimal spatial and temporal distribution of afforestation activities, as well as to set the environmental and economic priorities and to adapt implementing tools. New afforestation is an element of the multifunctional and sustainable development of the country.
Act of 7 June 2001 on Forest Reproductive Material (Official Journal of the Laws of 2019, Item 1097).	The Act regulates the registration of basic forest material, the marketing of forest reproductive material, the control of basic forest material and the forest reproductive material marketed, and seed regionalisation.
Act of 3 February 1995 on the Protection of Agricultural and Forest Land (Official Journal of the Laws of 2017, item 1161)	The Act regulates the principles of the protection of agricultural and forest land and the reclamation and improvement of the utility value of the land, as well as lays down the possible conversion of forest areas for non-forestry purposes. The solutions contained in the Act are intended to counteract irrational farming and forest production space management. This objective can be achieved through: • limiting agricultural land uses other than agriculture and forestry, preventing agricultural land degradation and devastation processes and damage to agricultural production resulting from non-agricultural activities and mass earth movements, • reclamation and use of land for agricultural purposes, • preservation of peatbogs and ponds as natural water reservoirs, • limiting changes in the natural shape of the earth surface.

Act of 16 April 2004 on Nature Conservation (Official Journal of the Laws of 2018, Item 1614, as amended)	The Act lays down the scope of protection (necessary for the effective conservation of Natura 2000 sites) – the implementation of the obligation under the Habitats and Birds Directives, and the achievement to the appropriate extent of the objective of the Directives – the maintenance or restoration of a favourable status of the objects of conservation in the Natura 2000 network.

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

- The need to ensure the sustainability of forests, *inter alia*, their multifunctionality, which will be achieved by increasing the country's forest resources, including:
    - an improvement in the condition of forest resources and their comprehensive protection,
    - the reorientation of forest management from the previous dominance of the raw material model to an environmentally friendly 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.
- Forest resources will be increased through:
    - the augmentation of the country's forest cover to 30% in 2020 and 33% in the middle of the 21st century by gradual afforestation of land unsuitable for agriculture and the implementation of a spatially optimal forest structure in the landscape which will be achieved by the protection and full use of the productive potential of habitats,
    - the restitution and rehabilitation of forest ecosystems, mainly by reconstruction (in suitable habitats) of single-species forest stands into mixed forest stands and by means of bio-melioration measures,
    - the regeneration of devastated and neglected forest stands in private forests, followed by 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:
    - improving the health and resilience of forest stands to harmful abiotic and biotic factors by the dissemination of biological and ecological methods of forest conservation,
    - restricting the use of chemical substances (e.g. pesticides, mineral fertilisers) to the essential needs,
    - the provision of protective and social functions by forests in such a manner that these activities may not endanger the sustainability of forests and do not adversely affect the condition of forest stands.
- The assumption has been made that:
    - the use of wood resources regulated by the harvest limit results from the needs arising from the objectives of silviculture and conservation and is intended to ensure the continuity of production of as much wood of the best quality as possible,
    - the volume of wood harvested in sanitary cuts should not exceed the current increment, but should guarantee the accumulation of wood in forest stands, providing the basis for extended reproduction,
    - the 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,

- the management of game will be regulated to a level which does not jeopardise the objectives of breeding and forest protection,
- the recreation and tourism in forest areas will be regulated and targeted in a manner which reconciles the social functions of forests with their protective and productive functions,
- the legal protection of all forest land will be improved.

National Forest Inventory (WISL)[3]

Since 2010 WISL has been one of the main sources of information on forests under all forms of ownership for both national and international statistics. In 2015, the third WISL cycle began, which will make it possible to better capture trends of change in forests. In the case of observations of ecosystems with a life cycle of more than 100 years, only longer periods of time produce increasingly convincing results. The second inventory cycle, which was completed in 2014, provided the first information on the current increment of forest stands, which is relevant for calculations to determine emissions/removals. The third WISL cycle will provide better, long-term observations on the current forest stand increment, dead wood resources and forest use.

Data bank on forest resources and state of forests - Forest Data Bank (FDB)[4]

In order to improve the implementation and state supervision of forest management in forests under all forms of ownership , work was undertaken to establish a forest data bank. The bank was launched in 2014. In order to ensure the proper functioning and development of the FDB, work was undertaken in 2015 to broaden the range of information collected and made available by the FDB by including data from forest habitat and phytosociological studies and information on hunting management. The development activities at the FDB also include improvements in the processes of preparing projections of resource development and use possibilities on a macro scale over a 10-30 year time horizon.

In 2016, the Forest Act of 28 September 1991 was amended to introduce a financial subsidy mechanism for the preparation of simplified forest management plans (SFMP). Within the framework of the FDB, the following was developed: the 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 aim 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 on forests other than those managed by the State Forests National Forest Holding.

2.3.2 Reference level scenario

2.3.2.1 Felling residue and bark fractions

The conversion factors for recalculating the volume “with bark” into the volume “without bark” which are used in the practice of Polish forestry have been assented in successive forest

[3] In accordance with Article 13a(2) of the Forest Act of 28 September 1991.
[4] In accordance with Article 13a(3) of the Forest Act of 28 September 1991.

management instructions. In this document, in order to account for bark and felling residues, 20% has been detracted from round wood "with bark" (wood with a diameter of more than 7 cm). For the purposes of the National Forestry Accounting Plan, this fraction has been called the fraction "without bark".

The conversion factors for recalculating the stand volume "with bark" into the harvested volume "without bark" have been applied by multiplying the wood resources by a factor of 0.8. In turn, a factor of 1.25 is applied to recalculate the harvested volume "without bark" into the stand volume "with bark"[5].

These values result from a generalisation of the factors laid down in successive forest management instructions, i.e. those adopted in 1980 (§ 197.1), 1994 (§ 193.1) and 2003 r. (§ 93.1 and 95.3), which applied the same conversion factors for final felling. In the 2003 Forest Management Instruction, the conversion factors for recalculating the gross volume ("with bark") into the net volume ("without bark") in final felling and pre-final cuts were set out as reduction factors (§ 93(1) of the Instructions), designed to recalculate the gross volume ("with bark") into the net volume ("without bark") (in final felling).

Table 2. Conversion factors

	Age class			
Tree species group	II	III	IV	V and higher, as well as KO, KDO and, BP
Pine, larch	0.72	0.75	0.77	0.79
Spruce, fir, Douglas fir	0.78	0.80	0.82	0.83
Oak, ash, maple, sycamore, elm and other hard broadleaved trees	0.70	0.72	0.73	0.75
Beech, hornbeam	0.81	0.84	0.86	0.87
Birch, alder	0.73	0.75	0.77	0.79
Aspen, poplar, willow, lime	0.74	0.77	0.79	0.80

In accordance with § 95(3) of the Instructions, the indicative volume limit for pre-final cuts is defined in the net volume of round wood ("without bark"). For comparison with wood resources or increment, expressed in the gross volume of round wood ("with bark"), the gross volume ("with bark") is calculated by multiplying the net volume ("without bark") by a factor of 1.25 (a factor of 0.8 is applied to recalculate the gross volume into the net volume)[6].

2.3.2.2 Harvest intensity indicators

The harvest intensity indicators in the reference level scenario - showing quantified forest management practices in the period from 2000 to 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 round wood resources (Table 5).

This intensity can thus be expressed with the formula: $W_i = U_i/V_i$, where:

W_i – the harvesting intensity indicator (in final felling or pre-final cuts) in the *i*-th age class,

[5] Directorate General of State Forests. 2003. Forest Management Instructions, Part 1 [in Polish]. CILP: Warsaw.
Ministry of Forestry and Timber Industry. 1980. Forest Management Instructions. 1 Management Works [in Polish]. State Agricultural and Foresry Publishing House (PWRiL): Warsaw.
Ministry of Environmental Protection, Natural Resources and Forestry. 1994. Forest Management Instructions, General Part [in Polish]. Forest Research Institute: Warsaw.

[6] Directorate General of State Forests 2003; Ministry of Forestry and Timber Industry 1980; Ministry of Environmental Protection, Natural Resources and Forestry 1994.

U_i – volume of harvested round wood (in final felling or pre-final cuts) in the *i*-th age class,

V_i – volume of round wood in the *i*-th age class at the beginning of the period.

The harvesting intensity indicators for forest management in the reference level scenario have been estimated for the chosen strata, i.e. for the forests managed by the State Forests National Forest Holding and for the other forests. Their determination was based on indicators by age classes and subclasses as defined in the State Forests National Forest Holding on the basis of data contained in forest management plans. Subsequently, indicators were adjusted to the total volume of harvested wood in the reference period (separately for final felling or pre-final cuts) for the wood resources in place at the beginning of the reference period, i.e. in 2000. It has been assumed that within the distinguished categories of harvest (i.e. within final felling and pre-final cuts) there are similar relationships between the harvesting intensity indicators in forests for the two distinguished layers (i.e. final felling is more intensive in older rather than in younger age classes, while pre-final cuts are more intensive in younger age classes than in older age classes). There are differences between the strata, however, in the share of final felling and pre-final cuts in the total volume of harvest. The share of final felling in the reference period was higher in the forests managed by the State Forests National Forest Holding and amounted to about 43%, while in the other forests (estimated on the basis of the WISL data from the present period) this share was lower and represented about 20% of the total volume of harvested wood.

However, the main difference between the forests managed by the State Forests National Forest Holding and the other forests concerns mainly the values of the intensity indicators of final felling and pre-final cuts. The intensity indicators are much lower in the other forests than in the State Forests. Table 5 shows the values of these intensity indicators as adopted in the reference level scenario for age classes and subclasses.

The intensity indicators of final felling and pre-final cuts illustrate quantitatively how forests are managed in the reference period and reflect the then forest management model. The high values of the indicators of pre-final cuts result from a small growing stock of round wood in forest stands in these age classes (a low value of the denominator). In light of their growing stock, even a very small amount of wood planned to be harvested in the youngest age classes produces a high value of the indicator of pre-final cuts. In pre-final cuts, the cutting of trees in the youngest age classes mostly results from their bad health condition, incorrect breeding parameters and the removal of those trees that have remained from the previous forest generation (so-called residual trees).

Table 3. Intensity indicators of final felling and pre-final cuts in age classes and subclasses in the forests managed by the State Forests National Forest Holding and in the other forests in the reference level scenario

No	**Age classes and subclasses**	**Harvesting intensity indicators in the reference level scenario**			
		Final felling	**Pre-final cuts**	**Final felling**	**Pre-final cuts**
		State Forests		**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 older (more than 120 years)	0.1990	0.0151	0.1155	0.0127
13	KO - restocking class, KDO - class for restocking , BP - a forest stand with groups and clusters of trees of different ages and heights, 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

In order to convert the intensity indicators into volume of harvested wood in cubic metres, account should be taken of the average growing stock in a given class age and its surface area. For example, the value of the harvesting intensity indicator of pre-final cuts in the forests managed by the State Forests National Forest Holding in age class Ia (0.5550) is very low, since the average growing stock in this class is relatively low. In turn, a much lower indicator in class IIIb (0.1729) corresponds to a higher volume of harvested wood in absolute numbers, irrespective of the larger growing stock and surface area of this age class. The intensity Indicators of final felling and pre-final cuts by age classes and subclasses translate into the following annual volumes of harvested wood in the forest strata distinguished. The volume of harvested wood (in m^3 of round wood without bark) in the reference level scenario in the successive periods covered by the analysis, i.e. 2017-2030, is presented in Table 6.

Table 4. Volume of harvested wood in the period from 2017 to 2030 in the reference level scenario

Forest management scenario	**Period**	**Harvest category**	**Volume of harvested wood**		
			State Forests National Forest Holding	**Other forests**	**Total**
			Thousand m^3 of round wood without bark/year		

Reference level scenario (2000–2009)	**2000-2009**	**Total**	**28,006**	**4,618***	**32,624**
	2010–2015	Total	33,955	5,801	39,756
	2016–2020	Total	36,996	6,475	43,471
	2021–2025	Total	39,112	7,022	46,124
	2026–2030	Total	40,946	7,585	48,531

*The value of 5,772,500 m^3 (from Table 15 according to WISL after recalculation for one year) has been multiplied by 0.8 to account for bark and felling residues.

It can be seen that Table 6 projects an increase in the volume of harvested wood in the period from 2010 to 2030. This is related to a change in the age class structures and the aging of forest stands (their movement to the oldest age classes) rather than a change in forest management practices. This is presented in greater detail in Fig. 2. In the FRL scenario, starting in 2010, the share of final felling in the forests managed by the State Forest National Forest Holding was about 48%, while in the other forests it was about 26%. Projections indicate that these shares may increase in subsequent periods - to about 58% in State Forests and to about 41% in the other forests in the period from 2026 to 2030.

2.3.3 Area of managed forest land

The forest area of 8,684,000 ha was included in the projections of the reference level (as of 1 January 2001) under category *4.A.1 Forest land remaining forest land*, including 6,805,000 ha managed by the State Forest National Forest Holding and 1,859,000 ha in forests other than those managed by the State Forest National Forest Holding (Table 13).

The formation of the area structure according to dominant species was determined in a simplified manner, assuming - similarly as in the case of volume - that the structure according to dominant species in the period from 2010 to 2030, developed in the reference level scenario, will not change in relation to the structure in 2010.

The general area structure according to prevailing species in the starting year of the projection, i.e. in 2010, in the reference level scenario is presented in Table 7.

Table 5. Formation of the area structure of species in the starting year of the reference level scenario (2010)

Dominant species	**Reference level scenario (2010)**		
	Forests managed by the State Forests National Forest Holding	**Other forests**	**Total**
	%		
Pine	62.57	55.00	60.93
Spruce	6.18	6.90	6.33
Fir	2.62	4.55	3.03
Other coniferous	1.14	0.57	1.02
Total coniferous	**72.51**	**67.01**	**71.32**

Beech	5.54	5.66	5.57
Oak	7.16	5.36	6.77
Hornbeam	0.98	2.22	1.25
Birch	6.74	7.83	6.98
Alder	4.65	7.51	5.27
Poplar	0.10	0.12	0.10
Aspen	0.41	1.67	0.69
Other broadleaved	1.90	2.63	2.05
Total broadleaved	**27.49**	**32.99**	**28.68**
Grand total	**100.00**	**100.00**	**100.00**

2.3.4 Historical emissions and removals from harvested wood products

Table 6. Historical carbon substitution effect in harvested wood products

Product	Substitution effect	Unit	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Paper	Change in carbon stocks	[kt CO_2]	67.7	46.4	-56.8	-16.6	8.4	144.8	170.3	47.6	32.1	45.7	161.6
Wood panels	Change in carbon stocks	[kt CO_2]	530.3	434.7	327.1	356.9	320.8	343.5	423.8	606.3	652.1	839.0	1,090.2
Sawn wood	Change in carbon stocks	[kt CO_2]	609.6	374.8	186.1	-22.4	336.4	431.9	657.9	294.1	200.3	339.4	359.2

Source: https://unfccc.int/sites/default/files/resource/pol-2019-crf-23May19.zip

Table 7. Historical carbon substitution effect in harvested wood products

Product	Substitution effect	Unit	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Paper	Change in carbon stocks	[kt CO_2]	161.6	177.7	190.3	224.5	340.8	286.9	272.4	248.3	209.1	197.8	159.0
Wood panels	Change in carbon stocks	[kt CO_2]	1,090.2	1,212.1	1,438.5	1,454.0	1,540.9	1,893.9	2,145.3	2,212.2	2,287.4	2,633.5	2,477.0
Sawn wood	Change in carbon stocks	[kt CO_2]	359.2	903.4	1,016.9	686.2	686.6	824.5	1,240.7	855.2	984.2	1,289.1	1,030.8

Source: https://unfccc.int/sites/default/files/resource/pol-2019-crf-23May19.zip

Table 8. Historical carbon substitution effect in harvested wood products (continued)

Product	Substitution effect	Unit	2009	2010	2011	2012	2013	2014	2015	2016	2017
Paper	Change in carbon stocks	[kt CO_2]	252.3	445.0	305.1	309.0	256.9	148.7	178.8	180.2	193.4
Wood panels	Change in carbon stocks	[kt CO_2]	2,247.5	2,394.1	2,413.6	2,471.9	2,593.5	2,639.8	2,819.2	3,051.3	3,232.6
Sawn wood	Change in carbon stocks	[kt CO_2]	979.9	1,019.2	1,057.1	981.2	998.2	1,100.0	1,080.2	1,189.3	1297.2

Source: https://unfccc.int/sites/default/files/resource/pol-2019-crf-23May19.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 the present management scenario)

The required information is given in Section 5.

2.3.6 Historical and future harvest indicators, broken down into energy and non-energy uses

Historical and future harvest indicators, broken down into energy and non-energy uses, in the reference level scenario were determined on the basis of the total volume of wood harvested in the reference period in the forests managed by the State Forests National Forest Holding, which was drawn from GUS data (identical with the data of the State Forests National Forest Holding), while those for the other forests were calculated on the basis of the GUS data, using the ratio between the volume of harvested wood according to WISL and the volume of harvested wood determined by GUS for the present period. In order to calculate the above indicators, the proportions of the harvest reference value (the net volume of large- and medium-sized round wood) and the reference value of the production of sawn wood, wood panels and paper were calculated using the correction factors estimated in Section 3.2.2. The size of the production of sawn wood and wood panels, as values expressed in comparable units with harvest, were compared directly. In turn, for paper the wood consumption value related to its production was determined indirectly. In this specific case, the default carbon content factor for paper was used, i.e. [0.46] tC/t and so was the default wood density index unified for species, i.e. [0.45] t dry matter/m^3.

Table *9. Harvest broken down into energy and non-energy uses in the reference level scenario*

Reference level scenario			
Year	**Harvest**	**Group of wood materials**	**Wood for energy purposes**
	(thousand m^3)		
2000-2009	32,624	25,256	7,368
2010	38,207	29,578	8,629
2011	38,828	30,059	8,769
2012	39,446	30,537	8,909
2013	40,065	31,016	9,049
2014	40,686	31,497	9,189
2015	41,304	31,976	9,328
2016	42,406	32,829	9,577
2017	42,939	33,241	9,698
2018	43,471	33,653	9,818
2019	44,003	34,065	9,938
2020	44,536	34,478	10,058
2021	45,176	34,973	10,203
2022	45,654	35,343	10,311
2023	46,134	35,715	10,419
2024	46,614	36,086	10,528
2025	47,092	36,456	10,636

Table 10. Harvesting indicators broken down into energy and non-energy uses in the reference level scenario

Reference level scenario			
Year	**Harvest**	**Group of wood materials**	**Wood for energy purposes**
	(%)		
2000-2009	100	77.4	22.6
2010	100	77.4	22.6
2011	100	77.4	22.6
2012	100	77.4	22.6
2013	100	77.4	22.6
2014	100	77.4	22.6
2015	100	77.4	22.6
2016	100	77.4	22.6
2017	100	77.4	22.6
2018	100	77.4	22.6
2019	100	77.4	22.6
2020	100	77.4	22.6
2021	100	77.4	22.6
2022	100	77.4	22.6
2023	100	77.4	22.6
2024	100	77.4	22.6
2025	100	77.4	22.6

3. Description of the modelling approach

3.1 Description of the general approach applied to estimate the forest reference level

The projections carried out to estimate the FRL 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 FRL.

In the guidelines for the development and reporting of FRLs under the LULUCF regulation, two alternatives are proposed for modelling the evolution of the managed forest land area over time, namely:

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

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

The work to project the FRL focused on alternative 1 and, as a result, it is assumed that the area of managed forest land in each stratum remained constant throughout the period covered by the projection (thus, there was no extrapolation of any possible historical trends to the future) when projecting the FRL. This also means that annual area changes are not taken into account when projecting the FRL.

The projections used constant values of quantified effects of management practices defined for the reference period. This ensures that the FRL is the best possible estimate of the alternative emissions and removals which would occur if the policies pursued and the measures undertaken or any changes to such policies and measures, or any new policy or measure implemented after the reference period had no impact. At the same time, the same climatic conditions as those in the historical period were used in the projections to determine the FRL. It was assumed that the climatic conditions would not change (i.e. they would remain constant over time).

3.1.1 Documentation on data sources used to estimate the forest reference level

The description of the FRL presented in Section 1.2 indicates that the basic quantitative indicator of forest management according to the reference level is the harvesting intensity defined as the ratio between the volume of harvested wood in the reference period (broken down into final felling and pre-final cuts) and the volume of round wood in wood resources by age classes and subclasses at the beginning of the reference period, i.e. as of 1 January 2000.

In order to correctly estimate the FRL, it was necessary to construct an area- and volume-based table of age classes as of 1 January 2000 and to the determine the volume of harvested wood in the reference period (2000–2009). These values were determined within the two strata, i.e. the forests managed by the State Forests National Forest Holding and the forests other than those managed by the State Forests National Forest Holding (i.e. the other forests).

The construction of an area- and volume-based table of age classes as of 1 January 2000 required the use of historical data based on the table of age classes as of 1 January 2010.

The determination of the total volume of harvested wood in the reference period for the strata "forests managed by the State Forests National Forest Holding" posed no problem since the data on the harvest in the State Forests National Forest Holding provided in public statistics (according to GUS "Forestry") were complete, reliable and close to the WISL results.

In contrast, in the case of the strata "the other forests" a problem in the correct determination of the volume of harvested wood was posed by a large discrepancy between the statistical data published by GUS and the WISL results. These relationships are presented in Table 18. They indicate that in the strata "the other forests" the volume of harvested wood according to WISL is about 2.8 times larger than the volume of harvested wood in the forests other than those managed by the State Forests National Forest Holding according to GUS. Therefore, the GUS data multiplied by a factor of 2.8 were used in the calculations.

The data on the wood harvest structure (broken down into final felling and pre-final cuts) in the "forests managed by the State Forests National Forest Holding" are also reliable and available in public statistics. In contrast, such data are lacking for "the other forests". Therefore, this structure for "the other forests" was estimated from the WISL data, assuming that the share of final felling in the reference period was about 20%, while that of pre-final cuts was about 80% of the total volume of harvested wood (Table 15).

Table 11. Area- and volume-based table of age classes as of 1 January 2000 according to the strata of forests (based on WISL data from the period from 2006 to 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	4,224	130	3,257	333	7,481
2	Residual trees	-	13,771	-	4,358	-	18,129
3	Ia (1–10 years)	298	399	17	33	315	432
4	Ib (11-20 years)	328	12,260	25	935	353	13,195
5	IIa (21-30 l years)	474	56,537	161	19,412	635	75,949
6	IIb (31–40 years)	593	119,395	223	43,371	816	162,766
7	IIIa (41-50 years)	917	240,071	346	86,584	1,263	326,655
8	IIIb (51–60 years)	848	254,732	346	95,751	1,194	350,483
9	IVa (61–70 years)	617	198,825	194	56,466	811	255,291
10	IVb (71–80 years)	707	247,392	145	46,602	852	293,994
11	Va (81–90 years)	600	223,836	97	33,695	697	257,531
12	Vb (91–100 years)	409	159,377	54	21,951	463	181,328
13	VI (101–120 years)	454	187,534	61	24,770	515	212,304
14	VII and older (more than 120 years)	184	86,949	34	15,792	218	102,741
15	(KO, KDO, BP)	173	54,905	26	9,340	199	64,245
Total treeless forest area		6 602	1,855,983	1,729	459,060	8,331	2,315,043
Grand total		6 805	1,860,207	1,859	462,317	8,664	2,322,524

Table 12. Volume of harvested wood in the forests managed by the State Forests National Forest Holding in the reference period

Year	Final felling		Pre-final cuts		Total	
	Without bark	With bark	Without bark	With bark	Without bark	With bark *
	Thousand m^3 of round wood					
2000	9,014	11,268	15,083	18,854	24,097	30,122
2001	8,000	10,000	15,471	19,339	23,471	29,339
2002	10,266	12,832	15,329	19,161	25,595	31,993
2003	11,954	14,942	15,180	18,975	27,134	33,917
2004	12,911	16,139	15,788	19,735	28,699	35,874
2005	12,210	15,262	15,954	19,942	28,164	35,204
2006	12,694	15,868	16,006	20,008	28,700	35,876
2007	13,380	16,725	18,934	23,667	32,314	40,392
2008	14,140	17,675	16,555	20,694	30,695	38,369
2009	15,260	19,075	15,928	19,910	31,188	38,985
Grand total	**119,829**	**149,786**	**160,228**	**200,285**	**280,057**	**350,071**

*A factor of 1.25 accounts for bark and felling residues.

Table 13 . Determination of the relationship between the volume of harvested wood according to WISL and the data of the Statistics Poland (GUS) "Forestry" in forests other than those managed by 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	5,194	5,781	2,108
2007–2011	2011	1,233	5,299	6,532	2,610
2008–2012	2012	1,192	5,360	6,552	2,208
2009–2013	2013	1,231	5,296	6,527	2,055
2010–2014	2014	1,354	5,131	6,485	2,476
2011–2015	2015	1,456	5,014	6,470	2,288
2012–2016	2016	1,434	5,125	6,559	2,156
2013–2017	2017	1,398	4,975	6,373	-
Grand total		**9,885**	**41,394**	**51,279**	**15,900**
Recalculated for 10 years		**12,356**	**51,743**	**64,099***	**22,713****
Percentage share		**19.3%**	**80.7%**	**100.0%**	**100.0%**

* In the period from 2010 to 2017

** In the period from 2010 to 2016

*** The data on the volume of harvested wood with bark have been calculated by multiplying the GUS data (without bark and felling residues) by a factor of 1.25.

Table 14. Volume of harvested wood in the forests other than those managed by the State Forests National Forest Holding in the reference period

Year	Volume of 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	1,928	2,410	1,350	5,398	6,748
2001	1,546	1,933	1,082	4,329	5,411
2002	1,542	1,928	1,079	4,318	5,397
2003	1,603	2,004	1,122	4,488	5,610
2004	1,727	2,159	1,210	4,838	6,048
2005	1,561	1,951	1,093	4,371	5,464
2006	1,528	1,911	1,070	4,278	5,348
2007	1,832	2,290	1,282	5,130	6,412
2008	1,712	2,140	1,198	4,794	5,992
2009	1,513	1,892	1,059	4,236	5,295
Grand total	**16,493**	**20,616**	**11,545**	**46,180**	**57,725**

*A factor of 2.8 has been used.
** The data on the volume of harvested wood with bark have been calculated by multiplying the GUS data (without bark and felling residues) by a factor of 1.25.

Table 15. Total volume of harvested wood in the reference period in both strata

Year	State Forests National Forest Holding	Other forests	Total
	Volume of harvested wood in thousand m^3 of round wood (with bark)		
2000	30,122	6,748	36,870
2001	29,339	5,411	34,750
2002	31,993	5,397	37,390
2003	33,917	5,610	39,527
2004	35,874	6,048	41,922
2005	35,204	5,464	40,668
2006	35,876	5,348	41,224
2007	40,392	6,412	46,804
2008	38,369	5,992	44,361
2009	38,985	5,295	44,280
Grand total	350,071	57,725	407,796

3.1.2 Documentation on stratification of the managed forest land

In the development of the FRL for forests in Poland, the available information on forest management practices, their characteristics, including the rules for forest use and the species and age structure of forests, was analysed. The division of forests in Poland into two strata is justified, in particular, by: the differences in the intensity and structure of their harvest, as well as in the availability and reliability of data on the state and management of forests.

Since 2010 the main source of data on forests under all forms of ownership has been the WISL. It provides, among other things, information on the structure and size of wood resources. Due to successive inventory cycles, it is also used to monitor changes in the forests in Poland. Based on the WISL results and more detailed data available on the forest management in the State Forests National Forest Holding, a division into two strata was adopted:

- the forests managed by the State Forests National Forest Holding - covering most of the forest area and wood resources of Poland (ca. 77%), where uniform practices based on the methods laid down in the instructions and internal regulations on forest management in force in the State Forests National Forest Holding are applied:

- the forests other than those managed by the State Forests National Forest Holding (also called "the other forests"), including forests under other forms of ownership, whose total forest area and volume of resources represent approximately 23% of the total forest area in Poland. The 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 municipal forests. The forests under private ownership dominate in this group, while other properties represent a small percentage of Poland's forest area. This group is characterized by a different manner of forest management, expressed, among others, by significantly lower harvest indicators than those in strata 1, i.e. the forests managed by the State Forests National Forest Holding.

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

3.1.3 Documentation of sustainable forest management practices used to estimate the forest reference level

In Poland, in the reference period forests were managed in accordance with the forest management principles laid down in the Forest Act of 28 September 1991. In individual forest units, these principles were reflected in forest management plans (in State Forests), or in simplified forest management plans (in the 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, subsequently, 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 these documents, the following had to

be taken into account when preparing a forest management plan or a simplified forest management plan:

1) the requirements of silviculture, as well forest protection, management, fire protection and use;
2) the requirements of nature and landscape protection and biodiversity conservation;
3) the needs of national defence and security;
4) the principles of forest management in protective forests;
5) the existing and planned, in acts of local law, methods for the development of forests and their surroundings;
6) the need for the rational development and protection of water resources.

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

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

The main objective of silviculture was to preserve and enrich the existing forests and to shape new ones, with respect for the natural conditions and processes. In turn, when formulating detailed management objectives, which are defined in the management plan for each forest stand and managed unit, the silviculture objective is distinguished, by indicating the type of forest stand, and so is the technical objective, by indicating the age of felling maturity of the stand.

For the validity period of the management plan (i.e. 10 years), economic indications are formulated in the stand descriptions, relating, in particular, to the tasks of forest management and harvest, the purpose of which is to use forest resources and non-productive forest services as a public good and a source of resources for sustained, sustainable and multifunctional forest management.

In all types of sanitary cuts - made during the forest stand growth period - the use of the selective breeding method was obligatory in the reference period. The purpose of the selection in the early and late cleanings was mainly a negative one, consisting in the removal of undesirable trees in given habitat conditions.

The purpose of the selection with early and late thinnings was a positive one and was based on the selection and promotion of an appropriate number of trees of the best quality from the upper storey of the forest stand and with a large increment, distributed as evenly as possible throughout the forest stand, while simultaneously supporting biogroups of trees forming the backbone of the forest stand and likely to survive until the felling age and beyond. It was implemented by the systematic removal of trees impeding the proper development of the best trees, together with their protective surroundings ensuring their stability.

Depending on the method of cutting, which offered the different possibilities of the regeneration being sheltered by the old trees, two groups of cuttings were distinguished, i.e. clear-cuttings marked with the symbol I and the complex felling marked with symbols II-V, including: the shelterwood method – the symbol II, the patch methods – the symbol III, the gradual felling – the symbol IV and the selection system – the symbol V.

Clear-cutting (I) - recommended for light-loving species - is characterized by a single removal of the entire stand from a specific area, possibly leaving seedbeds, residual trees or biogroups of the felled stand. In the open harvest area, the mostly artificial regeneration of light-loving species results in spatially separated crops of the same age.

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

The 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 tree species regenerated. 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 than the subsequent natural or artificial regeneration of light-loving species, occurring in the area between patches.

The 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 are mixed forest stands of different age with a complex spatial structure.

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

In the reference period (2000-2009), the management planning was governed by the regulation on final felling, assuming maturity as the basic criterion for felling of forest stands, coupled with the management methods (felling, clear-cutting, felling with clear cutting). The previously mentioned fellings were carried out with consideration given to the habitat conditions and the species composition of forest stands in a manner enabling the creation of the most favourable conditions for the change of a generation.

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 was the maximum value, which meant that in case of increased pre-final cut, final felling was limited.

The input data to the CBM included the harvest volumes in the individual age classes as provided by WISL – adjusted to the total (real) harvest volume in a given period – as shown in Table 14. This harvest volume results from the implementation of forest management plans (taking into account random factors). At the same time, this harvest volume reflects the felling ages/rotation periods (in years) for the most important tree species in the forests other than those managed by the State Forests National Forest Holding. These were approximately as follows: pine - 105, spruce - 95, beech - 115, oak - 140, birch – 80 and alder - 75. Moreover, when processing the data in the CBM, unified felling ages were used for the individual nature and forest regions.

It should be noted that there is a significant difference between the forests managed by the State Forests National Forest Holding and the forests under other forms of ownership in terms of the planning and implementation of management plans in force. Whereas in the State Forests the size of the implemented total harvest volume largely coincided with the size of the planned harvest volume, in the other forests - especially in private forests - the implementation of the planned tasks was (and is 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 the forest management methods in private forests are simplified and often implemented to meet 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 a much smaller amount (about 20% of the harvested volume) comes from final felling.

The input data to the CBM included the harvest volume in the individual age classes as provided by WISL – adjusted to the total (real) harvest volume in a given period – as shown in Table 16. The average felling ages/rotation periods (in years) for the most important tree species in the forests

other than those managed by the State Forests National Forest Holding – in accordance with the applicable regulations[7] - could be defined as the minimum numbers of years, i.e. as follows: pine - 80, spruce - 80, beech - 100, oak - 120, birch - 60, alder - 60. In practice, however, in the forests other than those managed by the State Forests National Forest Holding higher felling ages are used, closer to those used in the State Forests National Forest Holding. When processing the data in the CBM, unified felling ages were used for the individual nature and forest regions.

Forest management carried out in the forests under other forms of ownership (excluding private ones), constituting only about 4% of the forest 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 in final felling and pre-final cuts.

The data on these values for the 10-year period 2000-2009 - presented by the GUS and the State Forests National Forest Holding and according to the WISL results (used to verify the data on the forests other than those managed by the State Forests National Forest Holding) - are presented in Table 18.

Table 16. Volume of wood harvested in final felling and pre-final cuts by the strata, 2000-2009

Data source	Volume of round wood	Forests managed by the State Forests National Forest Holding	Other forests
		Thousand m^3 of round wood	
GUS	Without bark	280,056	16,493
	With bark***	350,070	20,616
WISL**	-	-	-
	With bark	-	57,725*

* On the basis of the relationship between the harvest volumes according to WISL and the Statistics Poland (GUS), for the period from 2010 to 2017.

** Only for the purposes of verifying the GUS data on the forests other than those managed by the State Forests National Forest. Holding.

*** The data on harvested wood with bark have been calculated by multiplying the GUS data (without bark and felling residues) by a factor of 1.25.

Comparison of the harvest volume according to the WISL data and the GUS data for the period from 2010 to 2017 indicates that the actual harvest volume in the forests other than those managed by the State Forests National Forest Holding is about 2.8 times higher than the volume provided by GUS, while the share of final felling is 20% and the share of pre-final cuts is 80% in the amount of the total harvested wood.

The data used to estimate the intensity indicators for the FRL concerning the volume of final felling and pre-final cuts in the individual strata (as a total for the whole period, i.e. 2000-2009) are presented in Table 19.

[7] 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.

Table 17. Harvest volume by stratification groups, 2000-2009 (in thousand m^3 of round wood with bark)

Stratification group	Category of harvest		Total
	Final felling	Pre-final cuts	
Forests managed by the State Forests National Forest Holding	149,786	200,285	350,071
Forests other than those managed by the State Forests National Forest Holding	11,545	46,180	57,725

3.2 Detailed description of the modelling framework used to estimate the forest reference level

This chapter provides information on the manner of implementation of the framework for calculating CO_2 emissions and removals in forest ecosystems based on changes in carbon stocks in its different pools. The modelling of carbon emission and removal balances was carried out using CBM-CFS3 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 applied by the JRC (Pilli et al. 2016 a, 2016 a 2016 b, 2018) and partly using the data which are characteristic of Poland.

The Carbon Budget Model (CBM) is a model based on yield data which simulates the carbon dynamics in above-ground and below-ground biomass, dead organic matter (DOM) and soil (Kurz et al., 2009). Its spatial framework is conceptually consistent with IPPC Reporting Method 1 (IPCC 2003), where the spatial units are defined by their geographic boundaries and each forest stand is assigned to a spatial unit. Each forest stand is characterised by area, age, soil class and up to 10 classifiers based on administrative and ecological information and the forest management parameters (such as the forest composition and the management strategy).

A library with yield tables (assigned to forest stands according to the value of the classifier which is a nature and forest region) defines gross round wood volume production by age class for each species. Species-specific, stand-level models allometric equations (Boudewyn et al., 2007) convert the round wood volume into above-ground biomass, divided into stem wood, other wood (tops, branches and small pieces of wood) and foliage.

Since an annual change in carbon stocks from one age class to the next one is used to estimate the annual carbon increment in above-ground biomass, the model assumes that the input data to yield tables include the net increment, excluding the increment of dead trees (UNECE/FAO, 2000). The increment of below-ground biomass (thin and trick roots) is calculated using the equations proposed by Li et al. (2003).

The CBM-CFS3 model assumes that the values given in yield tables represent gross round wood volume (including bark and residues thicker than 7 cm arising in the course of the wood harvesting operations) (Kurz et al., 2009). In order to select the appropriate set of yield tables to meet the input requirements of the model, the WISL data on the current annual increment (CAI) and the average volume for each forest type and region, understood in Poland as a nature and forest region, were used.

The standing volume (SV) given in yield tables is close to the average growing stock per hectare as reported in WISL. The creation of the model required two independent sets of yield tables. The first table, called "the historical library" here, was based on the volume reported by the National Inventory of Forests and Carbon Stocks (INFC, Italy). It is used in the initialisation procedure of the simulation to show the above-ground volume and biomass of each stand resulting from past management practices and disturbance events. The other set of tables, called "the "current library", is based on the current annual increment reported by WISL. It was applied in the development of the model to estimate the current gross volume increment of each stand. During the model run, this volume increment as envisaged under the current library was reduced by management activities and natural events.

The historical library comes from a large, species-independent database, containing about 1,460 equations, originating from a large database of forest yield tables (the AFOLU database, Teobaldelli et al., 2007) and a review of Italian literature (Castellani, 1982). All the original data given by yield tables were extrapolated using the Chapman-Richard function (Richards, 1959). The parameters were estimated using the Marquardt method (Motulsky and Ransnas, 1987) provided by SAS® software in order to estimate the round wood volume for 21 age classes from 10 to 210 years. A species-independent database of general equations was created (which was called UBALD) and the average volume was calculated for each equation. The equation with a minimum relative difference from the average volume reported by the WISL for each forest type and (if possible) region was selected. These equations were subsequently used to compile the historical library.

"The current yield tables" are based on the original current annual increment reported by the WISL, corrected with the number of young plants which exceed the minimum diameter at breast height in a year (Tomter et al., 2012). The change in the current annual increment (CAI_t) was estimated as a function of time using the following combined exponential and power function (Sit, 1994):

$$CAI_t = at^b c^t,$$

where t is the average age reported by the INFC for each age class, the parameter a controls the maximum increment gained by the current annual increment and the parameters b and c (assuming for the present study that b> 0 and 0 ≤ c ≤ 1, in accordance with the values proposed by Sit, 1994) control the shape of the curve. The yield tables used in the current library were derived directly from the value of CAI_t, avoiding the use of any empirical table.

3.2.1 Modelling of carbon stock changes in forest ecosystems

In the modelling process, among other things, the following was taken into account:

- Biomass expansion factors (BEFs) adapted to Polish conditions
- Wood densities adapted to Polish conditions
- The division into nature and forest regions in place in Poland
- Growth curves based on WISL data

Moreover:

- Modelling was carried out using forest stand groups aggregated in accordance with their area and representing different species and age groups, taking into account the nature and forest regions.

- Three main types of distortions were used to model the disturbances: pre-final cuts, final felling cuts and fires. The first two were based on the JRC methodology chosen for Poland. In the 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.
- Volume data on wood harvest were used, broken down by years and particular species and age groups, as well as by nature and forest regions.
- The modelling of fires was carried out in separate processes, but in such a way as to finally combine the results obtained.
- The modelling used the felling ages applied in Polish forest management, in accordance with forest management planning[8].

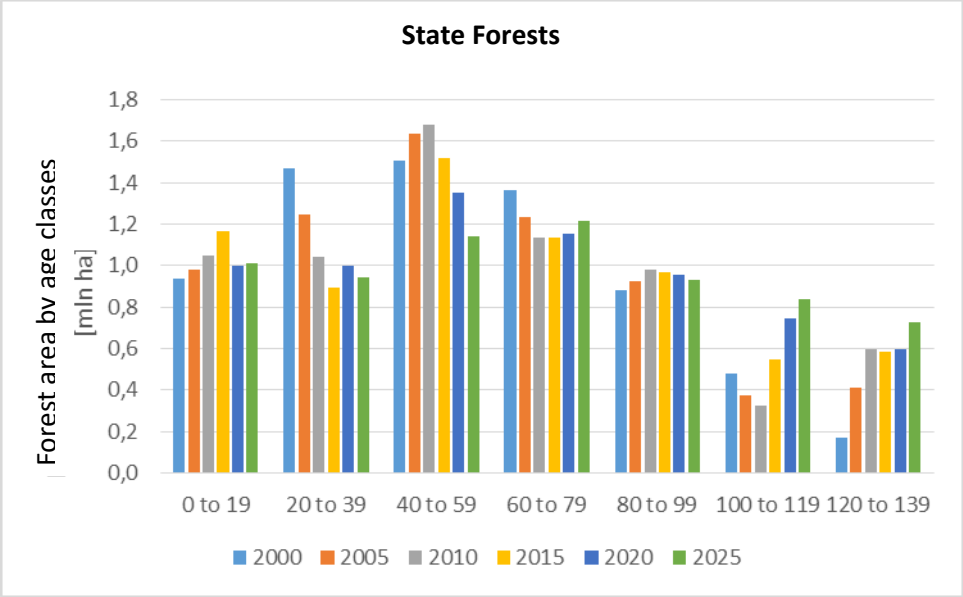
It should be emphasised that the data on the national volume of round wood, obtained by recalculating the values of carbon stocks obtained using the CBM-CFS3 software, show consistency with the WISL data on the national volume of round wood. At the same time, the consistency over the period from 2010 to 2015 is also demonstrated by independent projections for Poland for the period from 2000 to 2015, prepared by the Joint Research Centre (JRC) of the European Commission in Ispra on the basis of independent methodological assumptions.

The harvest data for the historical period from 2000 to 2009 as used in the CBM are consistent with Table 17, which shows the total harvest volume in the reference period in both strata. The input data to the CBM are disaggregated values of the total presented in Table 17.

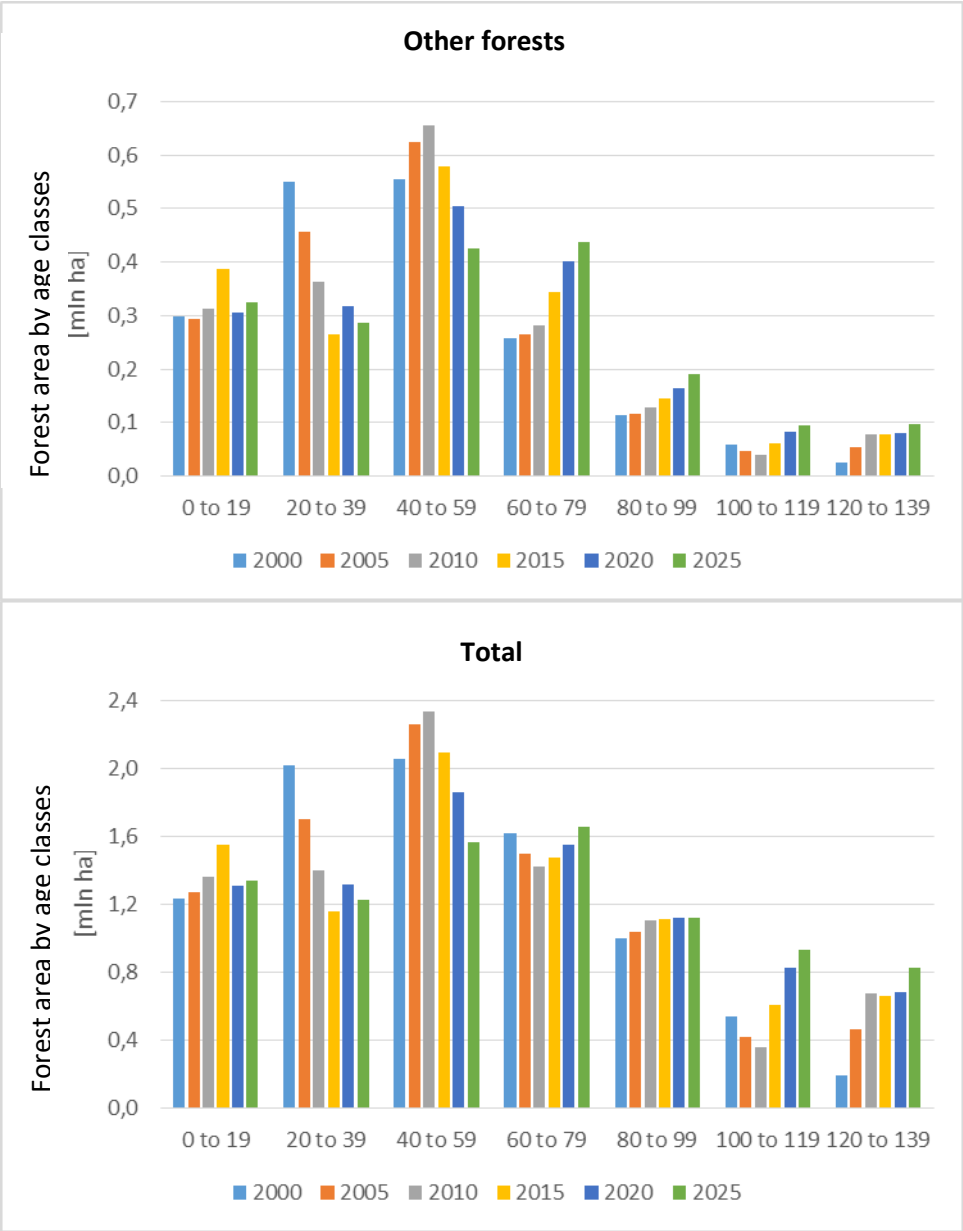
Annex 1 shows the growth curves developed on the basis of WISL data.

Fig. 2 below shows a hypothetical age structure of forest stands which would arise if the reference period practices were applied.

Fig. 2. Changes in the area-based age structure of forest stands by ownership categories in the period from 2000 to 2025 as calculated using CBM-CFS 3



[8] Forest Management Instructions, State Forests National Forest Holding, 2003.
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.



The age class structure of forest stands in the stratification groups by ownership category is diversified. In the forests managed by the State Forests National Forest Holding, there is a smaller share of the youngest age classes and a larger share of the oldest age classes than in the other forests. In the projection period, the adoption of forest management practices from the period from 2000 to 2009 will contribute to a gradual equalisation of the area shares of forest stands in the individual age groups, which will make it easier to pursue sustained and sustainable forest management. In the successive projection periods, it can be expected that the age structures in both stratification groups will come closer to each other.

The CBM-CFS3 model adopted the same felling ages, irrespective of the ownership category. Specifically, the following felling ages were adopted for the species: beech – 110 years, oak - 140 years, pine – 100 years, spruce – 80 years, birch – 80 years, alder – 80 years, the other broadleaved species – 60 years and the other coniferous species – 100 years.

In the process of modeling the individual components of the forest ecosystem, bark was included in the growth curves (developed on the basis of the WISL) and, as a result, its values (in tonnes of carbon) are included in the calculated biomass value. A library with yield tables (assigned to forest stands according to the value of the classifier) defines gross round wood volume production by age class for each species. Species-specific, stand-level allometric equations (Boudewyn et al., 2007) provide, among others, information on the conversion factor for the share of bark.

Forest management causes a change in the species structure of forest stands (Table 20). As a result of the implementation of sustainable forest management, e.g. by adapting the species compositions of forest stands to the optimum habitat conditions, the species structure of forest stands changes. These activities enhance the sustainability of forests and, thereby, the carbon stocks stored in forest ecosystems.

Table 18.Species structure of forest stands in 2000 and 2010 in the stratification groups

	State Forests	Other	Total	State Forests	Other	Total
Species structure [%]	2000			2010		
Pine	61.7	53.5	59.9	62.6	55.0	60.9
Beech	6.1	5.8	6.0	6.4	6.7	6.5
Birch	7.6	10.6	8.3	7.0	8.7	7.4
Oak	8.1	7.6	8.0	8.2	7.7	8.1
White fir	2.5	3.9	2.8	2.6	4.6	3.1
Ash	0.6	0.4	0.6	0.6	0.5	0.6
Larch	1.3	0.8	1.2	1.1	0.6	1.0
Alder	5.0	7.8	5.6	4.7	7.5	5.3
Aspen	0.6	2.5	1.0	0.5	1.9	0.8
Spruce	6.5	7.0	6.6	6.2	6.9	6.3

An analysis of the projection of the carbon stock accumulated in a forest ecosystem indicates a growing trend with decreasing dynamics (Fig. 3). In the case of the delta of the ecosystem, there is a falling trend with constant dynamics (Fig. 4).

Fig. 3. Changes in carbon stocks accumulated in forest ecosystems, broken down into the State Forests and the forests under the other forms of ownership, as calculated using CBM-CFS3 in the period from 2000 to 2025

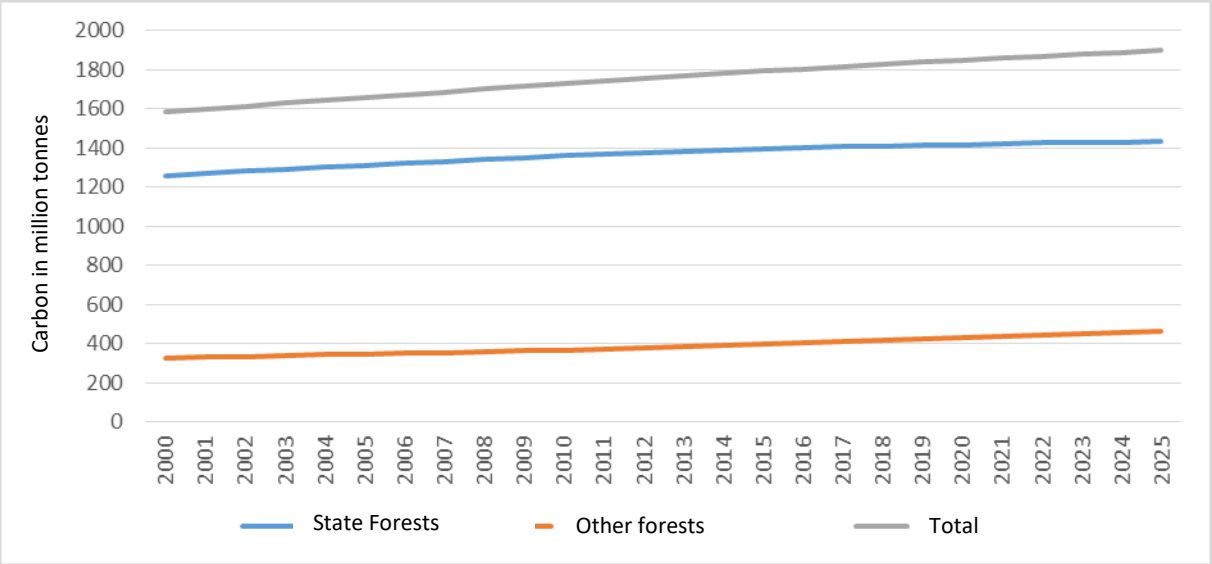
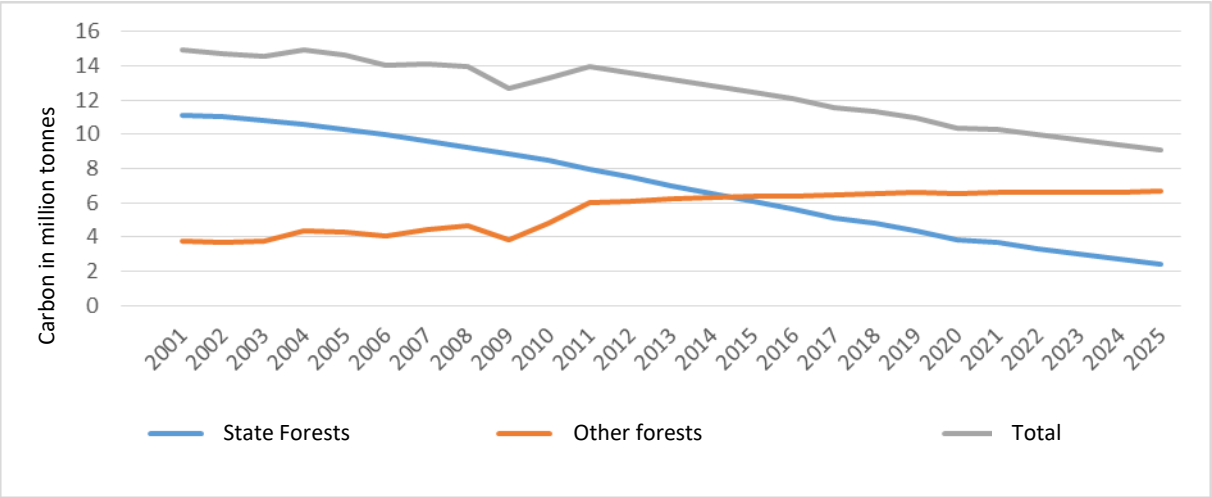


Fig. 4. Changes in the increment (delta) of carbon stocks accumulated in forest ecosystems, broken down into the State Forests and the forests under the other forms of ownership, as calculated using CBM-CFS3 in the period from 2000 to 2025



3.2.2 Modelling of emissions from harvested wood products

This Section provides information on the manner of implementation of the framework for calculating the carbon substitution effect in harvested wood products based on changes in the carbon pool and some historical information on the assumptions related to the principle of instantaneous oxidation.

In accordance with the LULUCF Regulation, only the carbon contained in harvested wood prdocuts from national forests (under category 4.A.1 *Forest land remaining forest land*) should be included in the estimation of the FRL. As a consequence, the time series of data reflecting the annual production of harvested wood products were been allocated to the corresponding national forest land category.

This process consisted of three intermediate stages:

a) The estimation of the share of carbon in harvested wood products from domestic forests. For this purpose, the shares of the relevant categories of raw materials (which also originated from domestic forests) of harvested wood products, such as "industrial round wood", "wood pulp" and " and "recovered paper", used (i.e. consumed) in the production process of the relevant wood products, such as "sawn timber", "wood panels" and "paper and board", were determined.
b) The estimation of the annual fraction of raw materials for the harvested wood product categories "sawn wood", "wood panels" and "paper and board" originating from land category 4.A.1 *Forest land remaining forest land.* Importantly, in accordance with the requirements of the LULUCF Regulation, the harvested wood from deforested areas, was treated in accordance with the principle of "instantaneous oxidation, in line with the practice included in the National Greenhouse Gas Inventories submitted to the UNFCCC (pursuant to Decision 2/CMP.8) ".
c) In order to obtain the annual fractions of harvested wood products originating from the national harvest in category 4.A.1 Forest land remaining forest land, to be included in the FRL, the information obtained in steps a) and b) has been combined using the correction factors included in Table 21. In addition, it should be noted that the values of the correction factors determined the rate of change in the projected volume of harvested wood, as compared with the average historical volume of harvested wood in the period from 2000 to 2009. The value of these indicators is the basic factor controlling the projected production of all the groups of harvested wood products in the period from 2010 to 2025.

The estimation process itself followed the methodological guidelines contained in Section 2.8.1.2 of IPCC (2014).

Table 19. Correction factors

Year	Harvest volume acc. to FRL: 2000-2009 (thousand m^3)	Correction factor
2000	32,624	NA
2001		NA
2002		NA
2003		NA
2004		NA
2005		NA
2006		NA
2007		NA
2008		NA
2009		NA
2010	38,207	1.17
2011	38,828	1.19
2012	39,446	1.21

Year	Harvest volume acc. to FRL: 2000-2009 (thousand m^3)	Correction factor
2013	40,065	1.23
2014	40,686	1.25
2015	41,304	1.27
2016	42,406	1.30
2017	42,939	1.32
2018	43,471	1.33
2019	44,003	1.35
2020	44,536	1.37
2021	45,176	1.38
2022	45,654	1.40
2023	46,134	1.41
2024	46,614	1.43
2025	47,092	1.44

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, in accordance with the rules set out in Annex V to the LULUCF Regulation.

It should be noted that Section 2.8.4.1 of the 2013 IPCC Guidelines (2014) specifies possible data sets or sources which 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. the categories "sawn wood", "wood 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 FRL projection, the time series of activity data sources includes 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, the 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 the LULUCF Regulation, the calculation of the projected carbon substitution effect of harvested wood products in the FRL level is based on the assumption of "*a constant ratio between solid and energy use of forest biomass as documented in the period from 2000 to 2009"*.

Irrespective of the possibly available information on the development and/or changes of patterns of the consumption or production of relevant commodities manufactured from harvested wood products, the above criterion for establishing the FRL implies that the ratio between harvested wood and specific intermediate wood products representing harvested wood products for material use or to be used as solid wood remains the same and that so does the share of harvested wood products in their production in the reference period from 2000 to 2009.

In order to carry out a projection for harvested wood products in the FRL, the projected volume of harvested wood as estimated using the methodology taking into account the harvest intensity indicators described in Section 2.3.2.1 was used as the starting point of the calculations. Just as in the

example described in Section 2.8.5 of IPCC (IPCC 2014), the stages described below were implemented to calculate the projected carbon inflow into the pool of harvested wood products:

1) The calculation of the rate of change in the projected volume of harvested wood compared with the average historical volume of harvested wood in the period from 2000 to 2009 (table 17), representing the ratio between the projected volume of harvested wood and average historical volume of harvested wood in the period from 2000 to 2009. These values were defined as correction factors.

2) The use of the annual values of correction factors to determine the carbon inflow into the pool of harvested wood products in the period modelled (i.e. 2011-2026)

   A numerical example:

   (i) the sawn wood production in the period from 2000 to 2009: 7.55 Mm^3 $year^{-1}$

   (ii) the projected sawn wood production (in Mm^3 $year^{-1}$): in 2021 = 10.46 (7.55*1.38), in 2022 = 10.57 and in 2023 = 10.68.

In the above methodology, it is assumed that the same average proportion of harvested wood used as a raw material for the future production of specific harvested wood products (i.e. sawn wood, wooden panels and paper and board, reflecting their use as solid wood) in the specific period from 2000 to 2009 will also be valid in the projection period. For the projection of the future development of emissions and removals, the annual carbon inflow into the pool of harvested wood products was calculated from 1900, taking into account the most recent activity data acquired from the FAO statistical data.

Poland does not possess data which would make it possible to differentiate between harvested wood products in the land accounting categories of afforested land and managed forest land, therefore, in accordance with Annex V to the LULUCF Regulation, Poland accounts for harvested wood products assuming that all emissions and removals occurred on managed forest land.

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 the LULUCF Regulation. 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 emissions. The decision not to include a pool should not apply to a carbon pool of above-ground biomass, dead wood and harvested wood products under the land accounting category of 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 changes in carbon stocks in its pools. The set of pools which has been taken into account is shown in Table 22.

Table 20. 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 in the land accounting categories of afforested land and managed forest land (as a total)**	**Y**

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

Not applicable

4 Forest reference level (managed forests)

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

The FRL for managed forests for the period from 2021 to 2025 means the average estimated level of the projected annual emission and removal balance from forests over the period from 2021 to 2025, estimated for CRF category 4.A.1 *Forest land remaining forest land*. The FRL is expressed in tonnes of CO_2 equivalent per year and the method for its determination is included in Section A of Annex IV to the LULUCF Regulation. The projected emission and removal balance for forests over the period from 2021 to 2025 is shown in Table 23, while the FRL for managed forests in the period from 2021 to 2025 is shown in Table 24.

Table 21. 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*

	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Reference level scenario (instantaneous oxidation of carbon in harvested wood products)	kt CO_2 eq.	-39,229	-38,604	-37,631	-36,907	-35,568	-34,168	-32,414	-30,749	-29,099	-28,50	-27,417	-26,052	-24,602	-24,418	-22,846	-21,443
Reference level scenario (the half-life value of carbon stocks in harvested wood)	kt CO_2 eq.	-42,886	-42,283	-41,334	-40,638	-39,328	-37,957	-36,311	-34,660	-33,024	-32,193	-31,377	-30,047	-28,607	-28,433	-26,873	-25,481
Reference level	kt CO_2 eq.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-23,872				
Reference level	kt CO_2 eq.	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	-27,888				

NA – not applicable

Table 22. Forest reference level in the reference scenario 2000-2009

Settlement period	Unit	2021-2025	2026-2030
The reference level for managed forests (CRF category 4.A.1. Forest land remaining forest land), taking into account the instantaneous oxidation of carbon in harvested wood products [9]	kt CO_2 eq.	-23,872	NA
The reference level for managed forests (CRF category 4.A.1. Forest land remaining forest land), taking into account the half-life value of carbon in harvested wood products [10]	kt CO_2 eq.	-27,888	NA

NA – not applicable

[9] *Instantaneous oxidation*
[10] *Half- life value*

4.2 Consistency between the simulated historical data and the data contained in the national greenhouse gas inventory reports

A consistency analysis has been carried out to verify whether the whole time series of estimates (i.e. historical and projected estimates) is consistent and, where inconsistencies are identified, to adjust the projected estimates.
Since the verification of results can only be carried out for historical periods, the model used to project the forest reference level estimated the longest historical period for which methodically consistent source data were available. The historical data on the forest area and carbon stocks (e.g. information on the forest condition and age), stratified according to the relevant carbon stock gain and loss variables used by the model for projecting the period from 2010 to 2026 period, are closest to the 2000 data. The verification was carried out at the level of aggregated greenhouse gas emissions and removals, 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. The results which fell within the range of one standard deviation (i.e. a 68% confidence interval) from the set of historical data included in the national greenhouse gas inventory reports indicate the correctness of the modelling process.

The 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) which 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 were calculated,
- possible inaccuracies were identified in the time series between the last historical year and the first projection year which are not affected by natural disturbances, by checking whether the annual change value was 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 Section 5.3.3 of Volume 1 of the 2006IPCC Guidelines, designed to ensure the consistency of the different time series, were not implemented.

Fig. 5. Compatibility of data included in the forest reference level with the data contained in the 2018 National Inventory Report

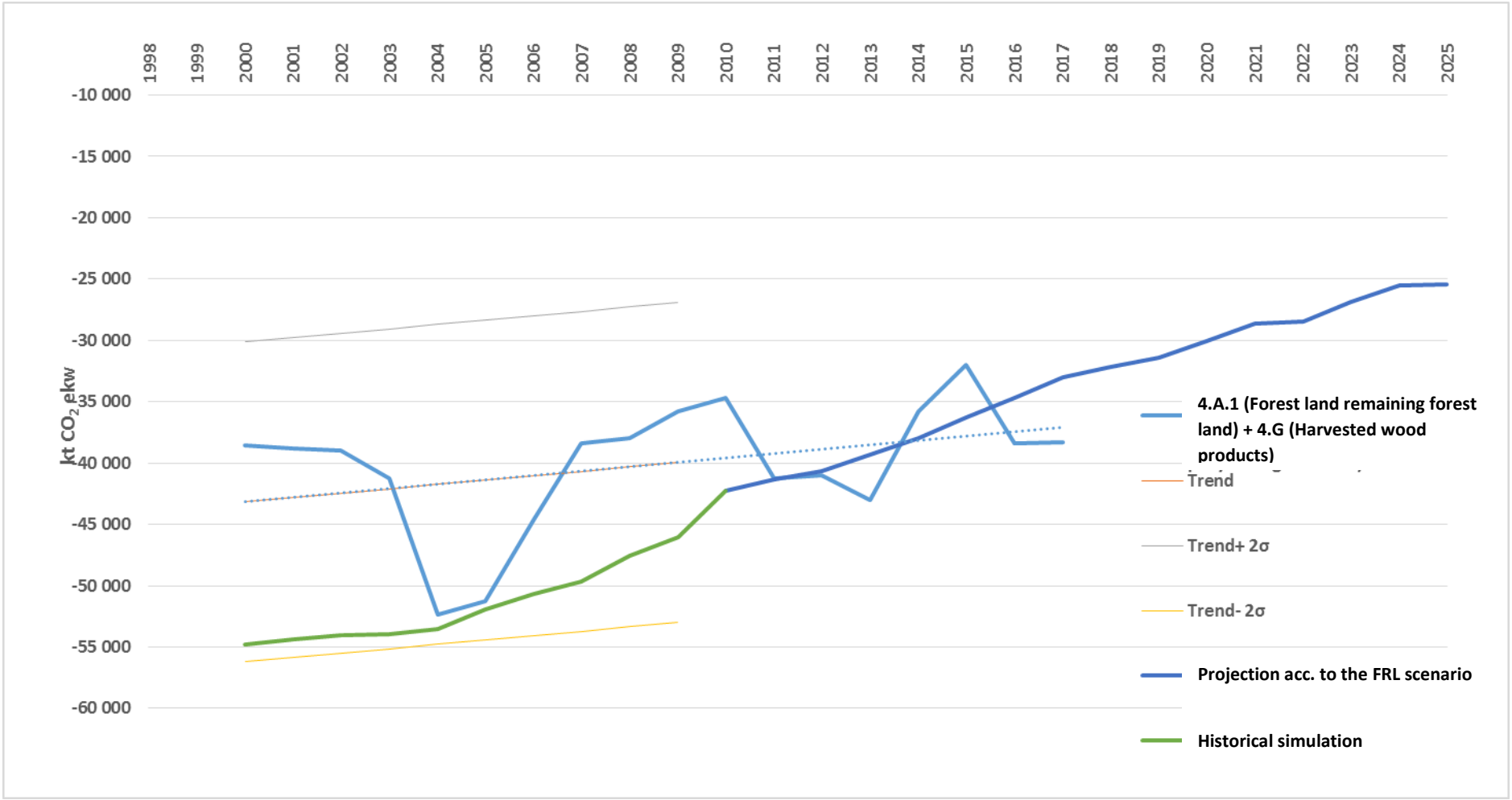


Table 23. Summary estimates and projections of the balance of emissions and removals for category 4.A.1 Forest land remaining forest land *in the reference level scenario 4.A.1*

GHG inventory	**Unit**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
4.A.1 Forest land remaining forest land + 4.G Harvested wood products	kt CO_2 eq.	-38 ,49	-29,820	-39,019	-41,256	-52,315	-51,272	-44,650	-38,371	-37,989	-35,763	-34,687	-41,282	-40,984	-43,052	-35,822	-32,028	-38,421	-38,307
Historical simulation	kt CO_2 eq.	-54,777	-54,414	-54,029	-53,977	-53,547	-51,914	-50,641	-49,703	-47,558	-46,011	NA	NA	NA	NA	NA	NA	NA	NA
Regression line	kt CO_2 eq.	-43,166	-42,809	-42,452	-42,096	-41,739	-41,382	-41,025	-40,669	-40,312	-39,955	NA	NA	NA	NA	NA	NA	NA	NA
Standard deviation (σ)	kt CO_2 eq.	**6,520**	**6 520**	**6,520**	**6,520**	**6,520**	**6,520**	**6,520**	**6,520**	**6 520**	**6,520**	NA	NA	NA	NA	NA	NA	NA	NA
Regression line + σ	kt CO_2 eq.	-30,125	-29,769	-29 412	-29,055	-28,698	-28,341	-27,985	-27,628	-27,271	-26,914	-26,558	-26,201	-25,844	-25,487	-25,131	-24,774	-24,417	-24,060
Regression line - σ	kt CO_2 eq.	-56,207	-55,850	-55,493	-55,136	-54,780	-54,423	-54,066	-53,709	-53,353	-52,996	-52,639	-52,282	-51 925	-51,569	-51,212	-50,855	-50,498	-50,142
Compliance test	True/ False	**True**	**True**	**True**	**True**	**True**	**True**	**True**	**True**	**True**	**True**	NA	NA	NA	NA	NA	NA	NA	NA

NA – not applicable

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

The following table indicates the changes in carbon stocks in its pools and greenhouse gases for the FRL.

Table 24.Effect of the modelling of carbon stock changes in its pools for category 4.A.1 Forest land remaining in forest land

Carbon pool	**Unit**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
Living biomass	**kt C**	-10,885	-10,726	-10,523	-10,244	-9,901	-9,560	-9,024	-8,628	-8,177	-7,947	-7,719	-7,346	-6,958	-6,909	-6,482	-6,100
Forest litter	**kt C**	-387	-562	-646	-688	-704	-703	-718	-697	-673	-651	-630	-603	-571	-494	-475	-456
Dead wood	**kt C**	665	500	389	293	210	136	29	-15	-54	-88	-115	-114	-117	26	-10	-39
Mineral soils	**kt C**	203	100	36	-6	-33	-51	-65	-73	-78	-82	-85	-83	-82	-79	-76	-74
Organic soils	**kt CO_2 eq.**	575	579	584	588	593	598	603	608	613	618	623	628	633	638	643	648
Total	**kt CO_2 eq.**	-39,229	-38,604	-37,631	-36,907	- 35,568	-34,168	-32,414	-30,749	-29,099	-28,250	-27,417	-26,052	-24,602	-24,418	-22,846	-21,443

Table 25. Estimates and projections of emissions resulting from forest fires (natural disturbances)

Emission type	Unit	2010	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	249
CH_4	**kt CO_2 eq.**	10	13	33	6	13	26	6	25	24	24	23	23	24	24	25	25
N_2O	**kt CO_2 eq.**	1	2	4	1	1	3	1	3	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	277

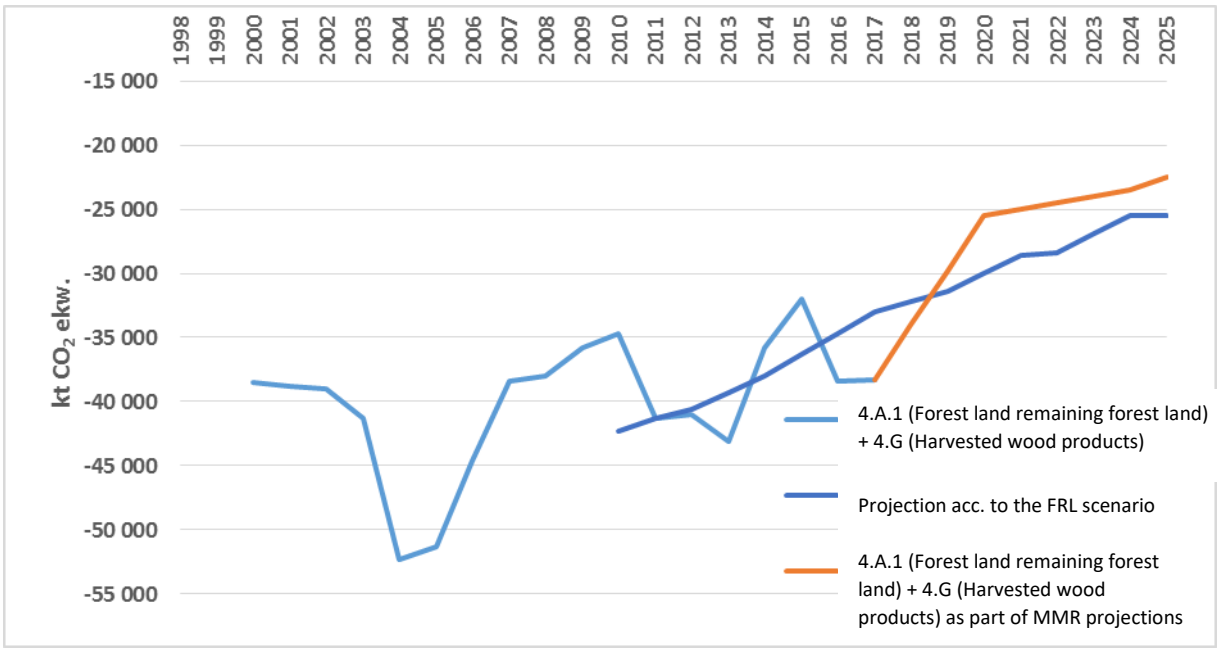
Table 26. Historical and projected reference carbon substitution effect of harvested wood products

Product type	Unit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Paper	**kt C**	-44	-39	-36	-33	-31	-30	-32	-30	-28	-26	-25	-25	-24	-22	-22	-21
Panels	**kt C**	-622	-626	-630	-634	-637	-641	-655	-657	-658	-660	-662	-666	-666	-667	-667	-668
Sawn wood	**kt C**	-332	-338	-344	-350	-356	-362	-376	-380	-385	-389	-393	-399	-402	-406	-409	-412
Total	**kt CO_2**	-3,657	-3,679	-3,703	-3,731	-3,760	-3,789	-3,897	-3,910	-3,926	-3,942	-3,960	-3,996	-4,005	-4,015	-4,026	-4,038

4.4 Consistency between the reference level and the national projections of anthropogenic greenhouse gas emissions from the individual sources and removals by sinks as reported under Regulation (EU) 525/2013

Section A of Annex IV to the LULUCF Regulation sets out the criteria for determining the FRL. At this point, it is important to emphasise the criterion laid down in the LULUCF Regulation which relates the FRL presented under the LULUCF Regulation to general policies and requirements set out in the earlier Regulation (EU) 525/2013. The trends identified in the data time series demonstrate consistency in terms of both the value and behaviour of the trend. It is important to note that the projections for the LULUCF sector submitted by Poland in the reports under Article 14 of Regulation (EU) 525/2013 (MMR) were prepared in 2017 and since then they have not been updated. Bearing this in mind, it should be noted that the behaviour of the trend in the projected time series reflects the scope of the assumptions available, adopted as a result of analyses of data available, reflecting the continuation of forest management activities which took place until 2015 inclusive.

Fig. 6. Consistency between the data taken into account in the forest reference level and the data reported under Article 14 of Regulation 525/2013 (MMR)



5 Present level scenario

5.1 Harvest intensity indicators

The present activities on forest land continue to be carried out under the policies described in Section 2.3.1, but different harvest indicators are now implemented, given the need to further adapt forest ecosystems to the unfolding climate and environmental change. The harvest intensity indicators in the current scenario – representing quantified forest management practices in the period from 2010 to 2019 – have been determined according to age classes and subclasses as the ratio of harvesting by final felling and pre-final cuts to the relevant volume of round wood resources.

The harvesting intensity indicators for forest management in the present period (2010–2019) have been estimated for the strata distinguished, i.e. for the forests managed by the State Forests

National Forest Holding and for the other forests. It has been assumed that within the distinguished categories of harvest (i.e. within final felling and pre-final cuts) – just as in the reference period - there are similar relationships between the harvest intensity indicators for age classes in forests in the two distinguished strata (i.e. final felling is more intensive in older rather than in younger age classes, while pre-final cuts are more intensive in younger rather than in older age classes). There are differences between the strata, however, in the share of final felling and pre-final cuts. The share of final felling is larger in the forests managed by the State Forests National Forest Holding, while the share of pre-final cuts is greater in the other forests.

The values of these intensity indicators in the present level scenarios for age classes and subclasses are given in Table 29.

Table 27. Intensity indicators of final felling and pre-final cuts for age classes and subclasses in the forests managed by the State Forests National Forest Holding and in the other forests in the present level scenario

No.	Age classes and subclasses	Harvesting intensity indicators in the present level scenario			
		Final felling	Pre-final cuts	Final felling	Pre-final cuts
		State Forests		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 older (more than 120 years)	0.2254	0.0154	0.0782	0.0115
13	KO - restocking class, KDO - class for restocking , BP - a forest stand with groups and clusters of trees of different ages and heights, 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

Table 28. Formation of the area structure of species in the starting year of the present level scenario (2017)

Dominant species	Present level scenario (2017)		
	Forests managed by the State Forests National Forest Holding	**Other forests**	**Total**
	%		
Pine	60,27	51,16	58,17
Spruce	5.97	6.00	5.97
Fir	2.79	4.39	3.16
Other coniferous	1.30	0.77	1.18
Total coniferous	***70.33***	***62.32***	***68.49***
Beech	6.18	5.26	5.97
Oak	8.24	5.86	7.69
Hornbeam	1.25	2.82	1.61
Birch	6.66	9.12	7.23
Alder	4.85	8.34	5.65
Poplar	0.05	0.15	0.07
Aspen	0.39	2.20	0.81
Other broadleaved	2.05	3.95	2.49
Total broadleaved	***29.67***	***37.68***	***31.51***
Grand total	**100.00**	**100.00**	**100.00**

The intensity indicators of final felling and pre-final cuts by age classes and subclasses translate into the following annual volumes of harvested wood in the forest strata distinguished. The volume of harvested wood (in m^3 of round wood without bark) in the present level scenario in the successive periods covered by the analysis, i.e. 2017-2030, is presented in Table 31.

Table 29. Volume of harvested wood in the period from 2017 to 2030 in the present level scenario

Forest management scenario	Period	Harvest category	Volume of harvested wood		
			State Forests National Forest Holding	Other forests	Total
			Thousand m^3 of round wood without bark/year		
Present level scenario (2010–2019)	2017–2020	Total	40,504	5,887	46,391
	2021–2025	Total	42,104	6,230	48,334
	2026–2030	Total	43,880	6,696	50,576

In the present level scenario, starting in 2017, the share of final felling in the forests managed by the State Forests National Forest Holding was about 54%, whereas it was about 23% in the other forests. The projections which have been prepared indicate that these shares can grow in successive periods - to about 59% in the State Forests and to about 30% in the other forests in the period from 2026 to 2030.

Table 30. *Volume of harvested wood in the forests managed by the State Forests National Forest Holding in the present period*

Year	Final felling		Pre-final cuts		Total	
	Without bark	With bark	Without bark	With bark	Without bark	With bark*
	Thousand m^3 of round wood					
2010	16,621	20,776	15,261	19,076	31,882	39,852
2011	15,684	19,605	17,105	21,381	32,789	40,986
2012	16,017	20,021	17,195	21,494	33,212	41,515
2013	16,671	20,839	17,481	21,851	34,152	42,690
2014	17,716	22,145	17,964	22,455	35,680	44,600
2015	18,250	22,812	18,247	22,809	36,497	45,621
2016	18,819	23,524	18,586	23,233	37,405	46,757
2017	21,339	26,674	19,289	24,111	40,628	50,785
2018	21,503	26,879	20,605	25,756	42,108	52,635
2019	21,954	27,443	20,813	26,016	42,767	53,459
Grand total	**184,574**	**230,718**	**182,546**	**228,182**	**367,120**	**458,900**

* A factor of 1.25 accounts for bark and felling residues.

Table 31. Volume of harvested wood in the forests other than those managed by the State Forests National Forest Holding in the current period

Year	Volume of 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		
2010	1,686	2,108	1,180	4,721	5,901
2011	2,088	2,610	1,461	5,846	7,307
2012	1,766	2,208	1,236	4,945	6,181
2013	1,644	2,055	1,151	4,603	5,754
2014	1,981	2,476	1,387	5,546	6,933
2015	1,830	2,288	1,281	5,124	6,405
2016	1,725	2,156	1,207	4,827	6,034
*2017	1,817	2,271	1,272	5,088	6,360
*2018	1,817	2,271	1,272	5,088	6,360
*2019	1,817	2,271	1,272	5,088	6,360
Grand total	**18,170**	**22,713**	**12,719**	**50,876**	**63,595**

* The average from the period from 2010 to 2016.
** The WISL data have been calculated by multiplying the GUS data by a factor of 2.8; the share of final felling has been adopted as 20%, while the share of pre-final cuts as 80%.
*** The data on the volume of harvested wood with bark have been calculated by multiplying the GUS data (without bark and felling residues) by a factor of 1.25.

5.2 Harvest by energy and non-energy uses in the present level scenario

The projected harvest indicators, broken down into energy and non-energy uses, in the present level scenario were determined on the basis of the total volume of wood harvested in the present period in the forests managed by the State Forests National Forest Holding and the GUS data (identical with the data of the State Forests National Forest Holding), while those for the other forests were calculated on the basis of the data of the GUS, using the ratio between the volume of harvested wood according to WISL and the volume of harvested wood according to GUS as determined for the present period. In order to calculate the above indicators, the ratio between of the present harvest value (the net volume of large- and medium-sized round wood) and the assumed total value of the production of sawn wood, wood panels and paper, determined on the basis of the projections of the development of the market of wood and harvested wood products (production, export and import) until 2030 as performed by the Wood Technology Institute, were used. The size of the production of sawn wood and wood panels, as values expressed in comparable units with harvest, were compared directly. In turn, for paper the wood consumption value related to its production was determined

indirectly. In this specific case, the default carbon content factor for paper was used, i.e. [0.45] tC/t and so was the default wood density index unified for species, i.e. [0.45] t dry matter/m^3.

Table 32. Harvest broken down into energy and non-energy uses in the present level scenario

Present level scenario			
Year	**Harvest**	**Group of raw wood materials**	**Wood for energy purposes**
	(Thousand m^3)		
2017	45,662	39,879	5,783
2018	46,148	41,476	4,672
2019	46,634	43,073	3,561
2020	47,120	44,670	2,450
2021	47,437	45,657	1,780
2022	47,886	46,644	1,242
2023	48,334	47,631	703
2024	48,782	48,618	164
2025	49,231	49,231	0

Table 33. Harvest indicators broken down into energy and non-energy uses in the present level scenario

Present level scenario			
Year	**Harvest**	**Group of raw wood materials**	**Wood for energy purposes**
	(%)		
2017	100.0	87.3	12.7
2018	100.0	89.9	10.1
2019	100.0	92.4	7.6
2020	100.0	94.8	5.2
2021	100.0	96.2	3.8
2022	100.0	97.4	2.6
2023	100.0	98.5	1.5
2024	100.0	99.7	0.3
2025	100.0	100.0	0.0

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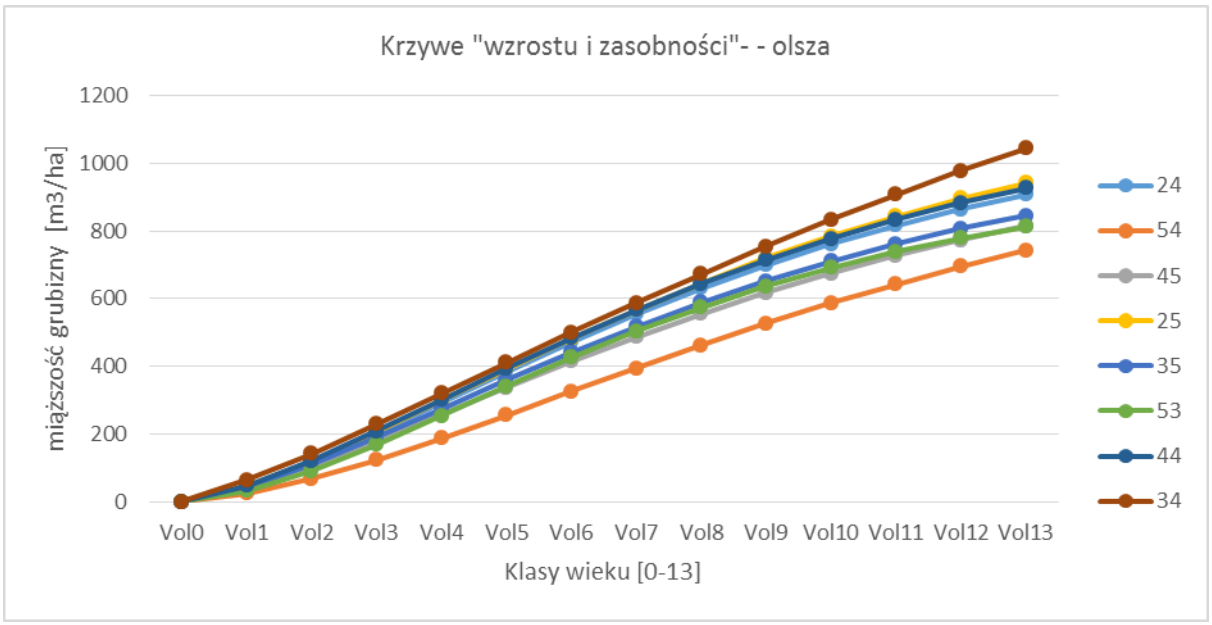
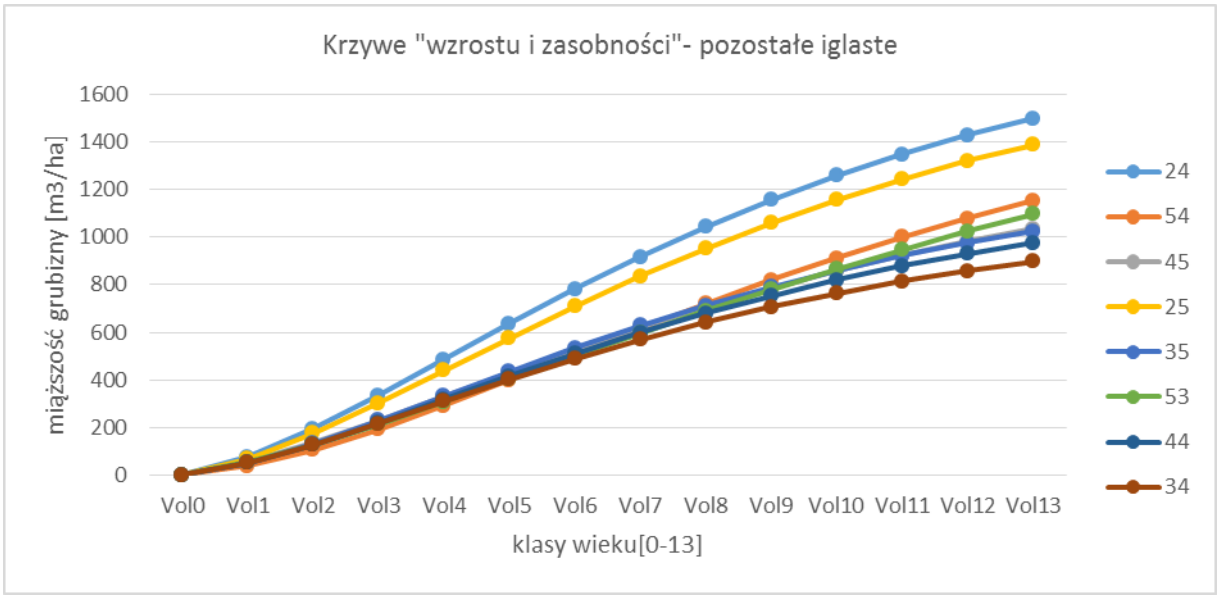
7. List of Tables

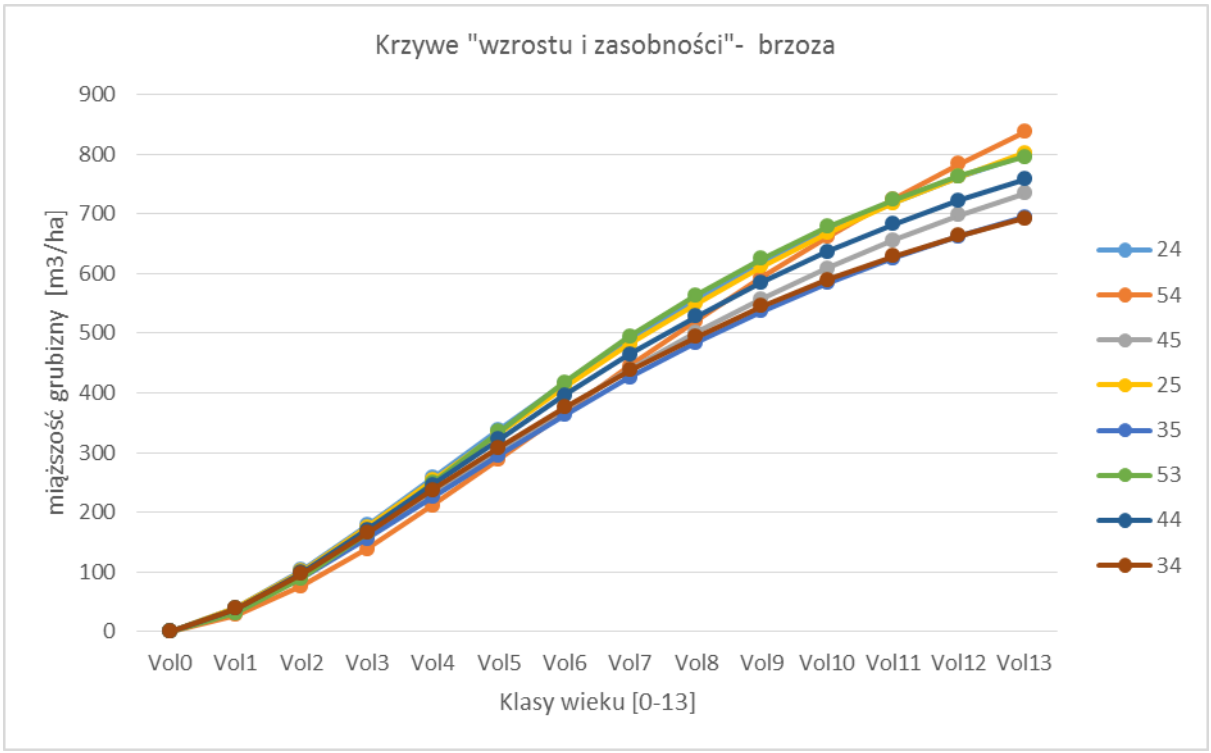
Annex I - Growth curves determined on the basis of the WISL data

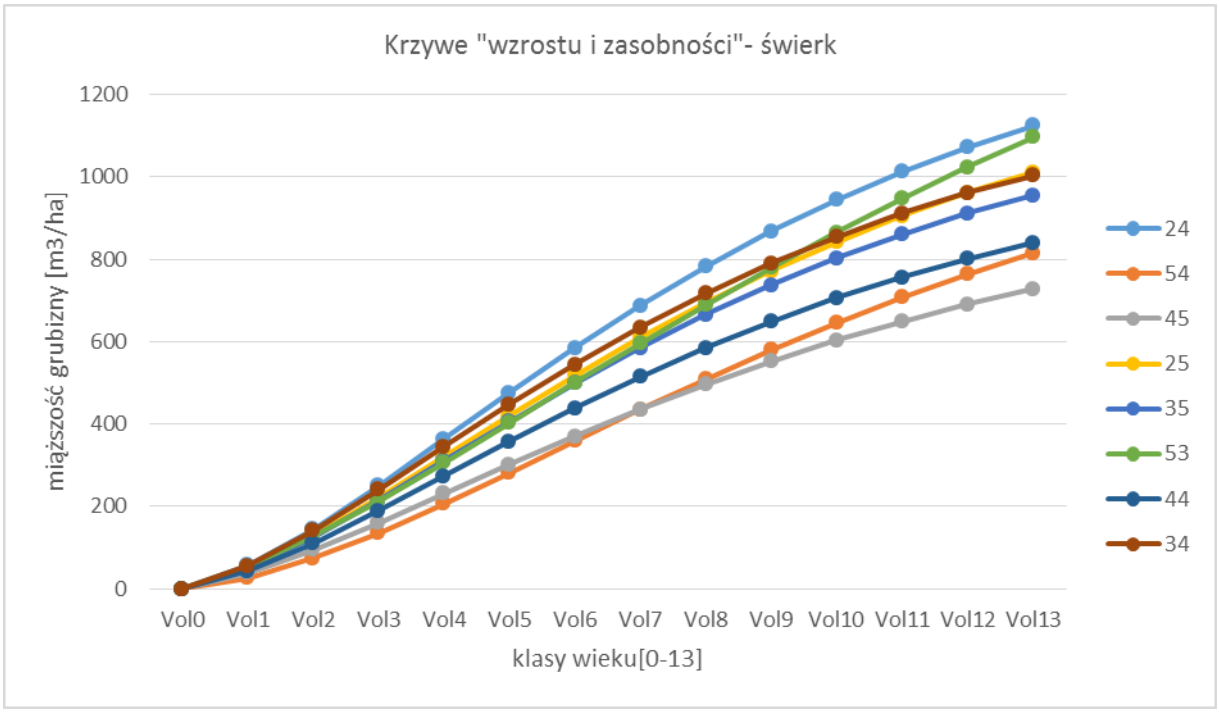
Division by species

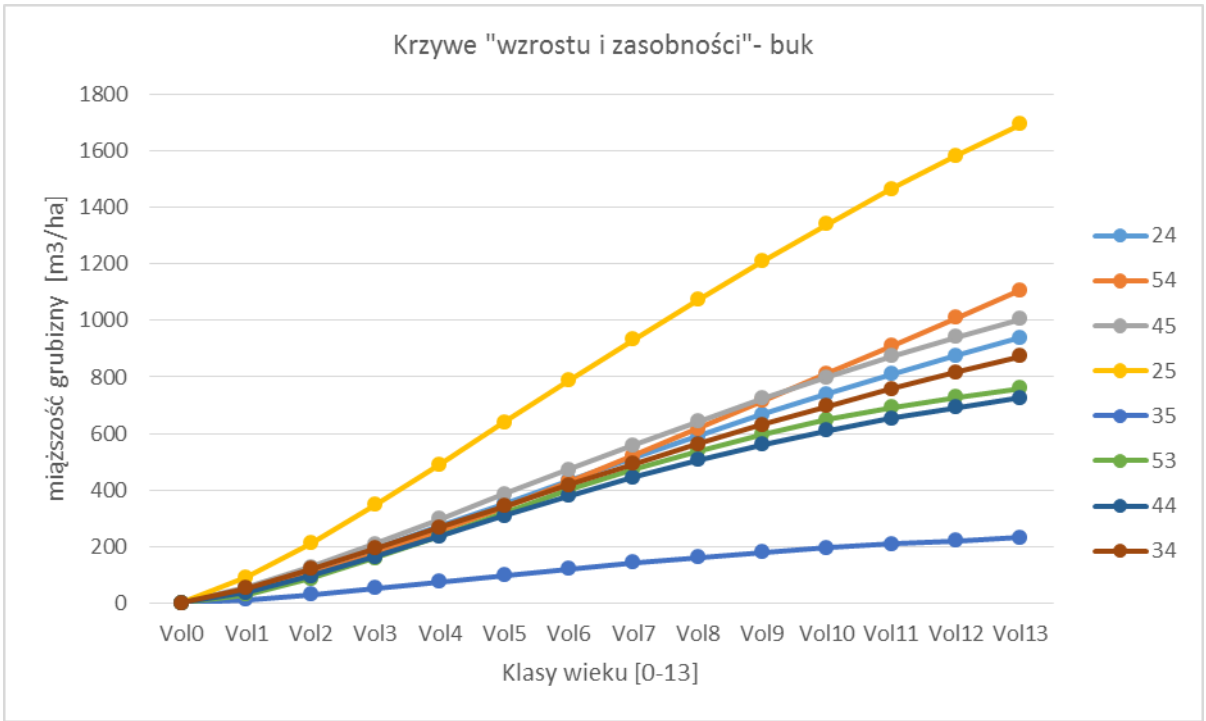
Krzywe „wzrostu i zasobności”	“Growth and yield” curves
Miąższość grubizny	Volume of round wood
Klasy wieku	Age classes
Olsza	Alder
Pozostałe iglaste	Other coniferous
Brzoza	Birch
Świerk	Spruce
Buk	Beech
Sosna	Pine
Pozostałe liściaste	Other broadleaved
Dąb	Oak



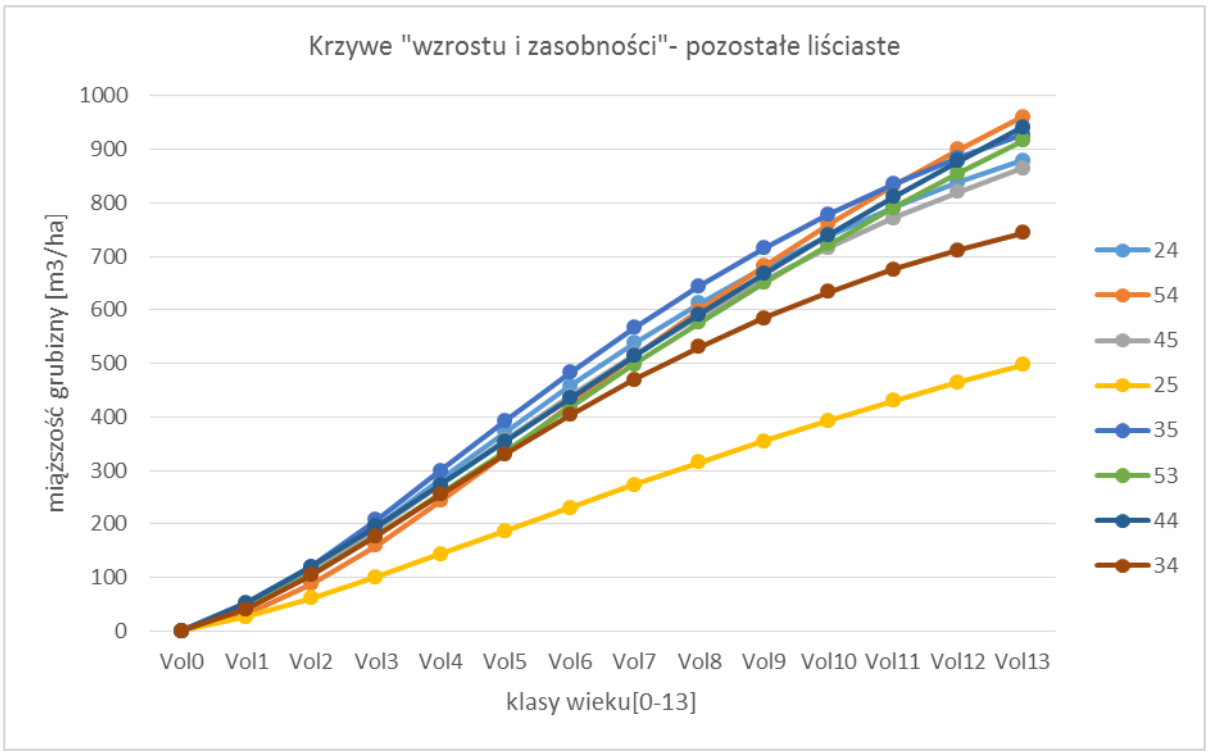

Krzywe "wzrostu i zasobności"- pozostałe iglaste
miąższość grubizny [m3/ha]
1600
1400
1200
1000
800
600
400
200
0
Vol0 Vol1 Vol2 Vol3 Vol4 Vol5 Vol6 Vol7 Vol8 Vol9 Vol10 Vol11 Vol12 Vol13
klasy wieku[0-13]
24
54
45
25
35
53
44
34


Krzywe "wzrostu i zasobności"- brzoza
miąższość grubizny [m3/ha]
900
800
700
600
500
400
300
200
100
0
Vol0 Vol1 Vol2 Vol3 Vol4 Vol5 Vol6 Vol7 Vol8 Vol9 Vol10 Vol11 Vol12 Vol13
Klasy wieku [0-13]
24
54
45
25
35
53
44
34


Krzywe "wzrostu i zasobności"- świerk
miąższość grubizny [m3/ha]
1200
1000
800
600
400
200
0
Vol0 Vol1 Vol2 Vol3 Vol4 Vol5 Vol6 Vol7 Vol8 Vol9 Vol10 Vol11 Vol12 Vol13
klasy wieku[0-13]
24
54
45
25
35
53
44
34


Krzywe "wzrostu i zasobności"- buk
miąższość grubizny [m3/ha]
1800
1600
1400
1200
1000
800
600
400
200
0
Vol0 Vol1 Vol2 Vol3 Vol4 Vol5 Vol6 Vol7 Vol8 Vol9 Vol10 Vol11 Vol12 Vol13
Klasy wieku [0-13]
24
54
45
25
35
53
44
34


Krzywe "wzrostu i zasobności"- sosna
miąższość grubizny [m3/ha]
1400
1200
1000
800
600
400
200
0
Vol0 Vol1 Vol2 Vol3 Vol4 Vol5 Vol6 Vol7 Vol8 Vol9 Vol10 Vol11 Vol12 Vol13
klasy wieku[0-13]
24
54
45
25
35
53
44
34


Krzywe "wzrostu i zasobności"- pozostałe liściaste
miąższość grubizny [m3/ha]
1000
900
800
700
600
500
400
300
200
100
0
Vol0 Vol1 Vol2 Vol3 Vol4 Vol5 Vol6 Vol7 Vol8 Vol9 Vol10 Vol11 Vol12 Vol13
klasy wieku[0-13]
24
54
45
25
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53
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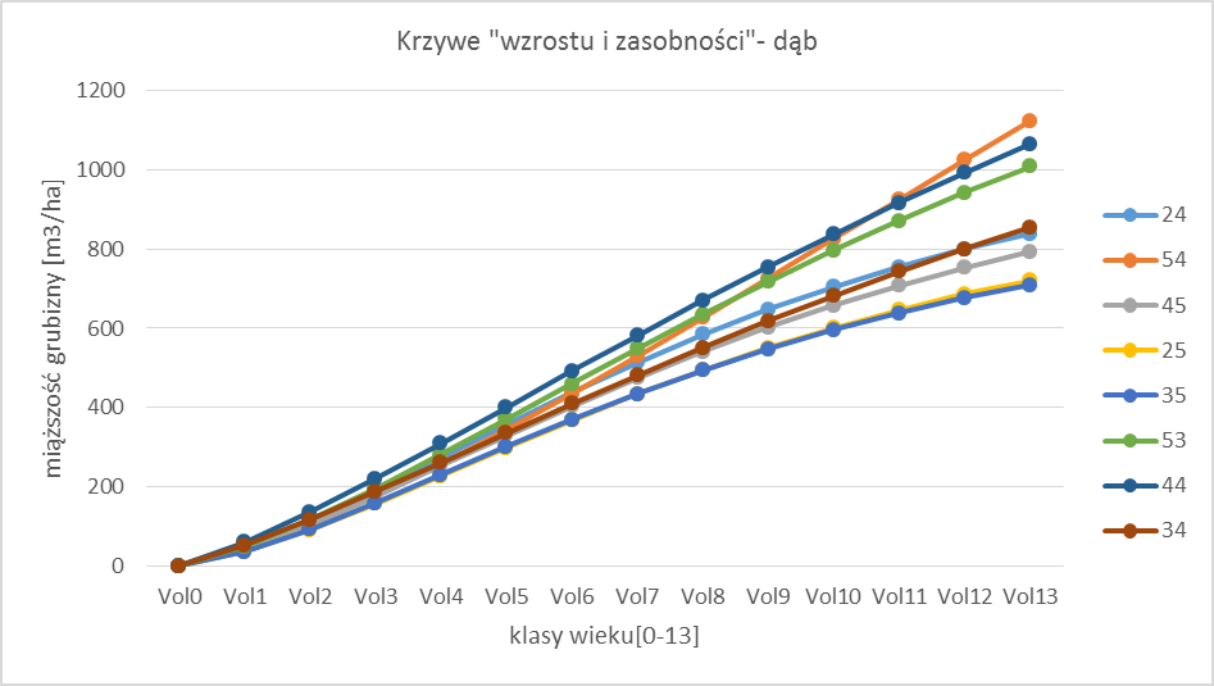
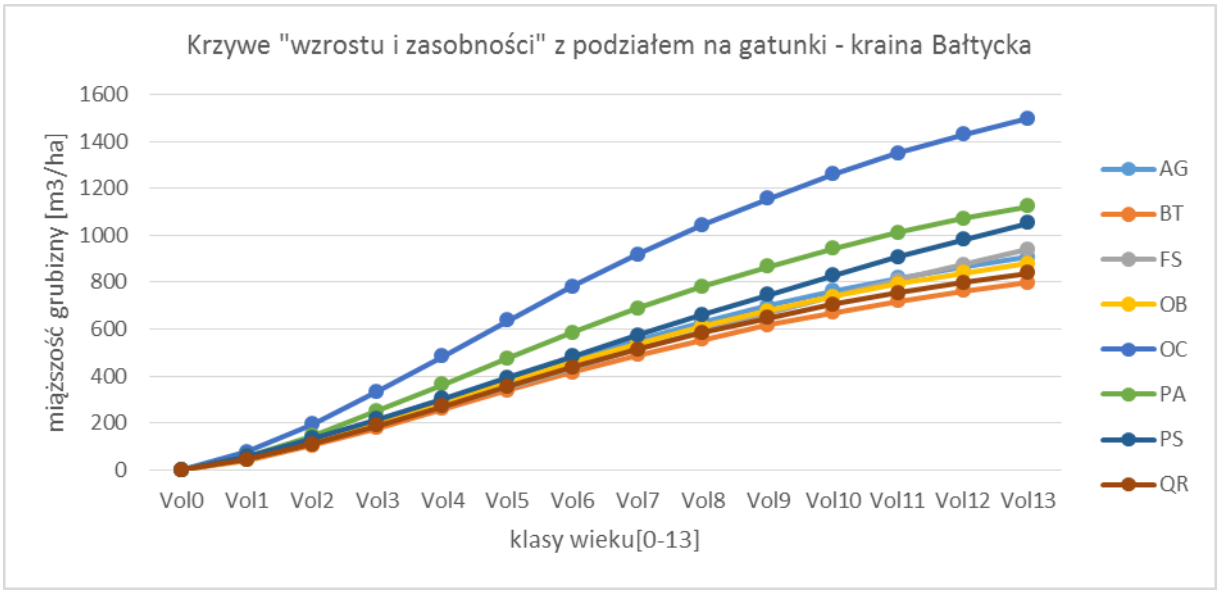
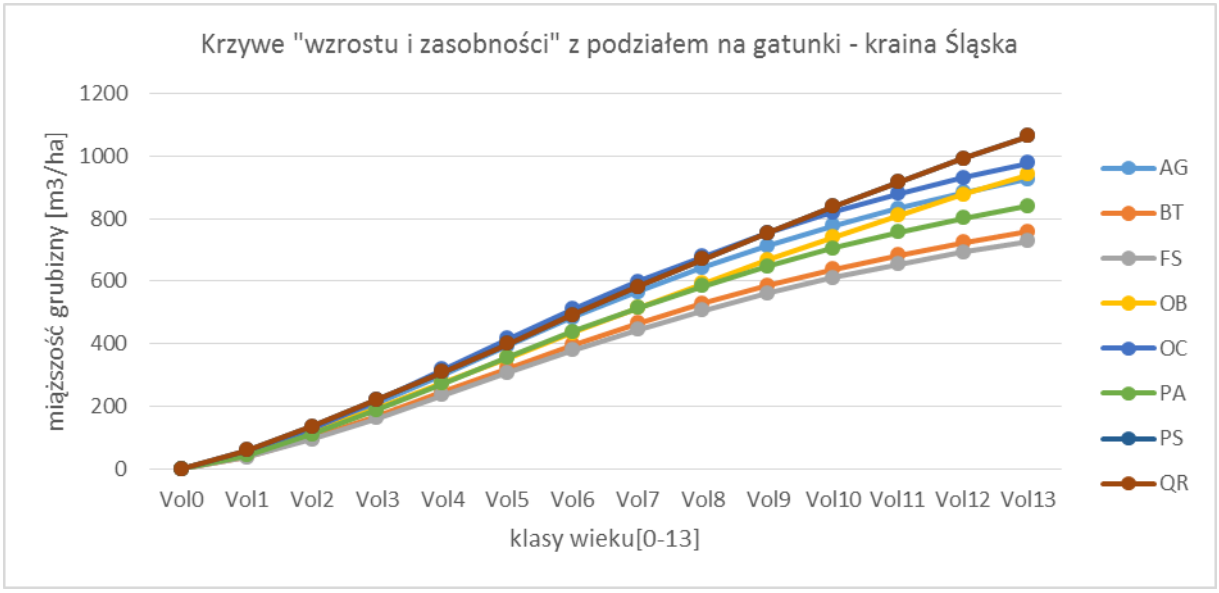


Division by nature regions

AG – alder, BT – birch, FS – ash, OB – other broadleaved, OC – other coniferous, PA – spruce, PS – pine, QR – oak

Miąższość grubizny	Volume of round wood
Klasy wieku	Age classes
Krzywe „wzrostu i zasobności” z podziałem na gatunki	“Growth and field” curves by species
Kraina Bałtycka	Baltic Nature Region
Kraina Śląska	Silesian Nature Region
Kraina Mazursko-Podlaska	Mazury and Podlasie Nature Region
Kraina Małopolska	Małopolska Nature Region
Kraina Wielkopolsko-Pomorska	Wielkopolska and Pomeranian Nature Region
Kraina Sudecka	Sudety Nature Region
Kraina Mazowiecko-Podlaska	Mazovia and Podlasie Nature Region
Kraina Karpacka	Carpathian Nature Region


Krzywe "wzrostu i zasobności" z podziałem na gatunki - kraina Bałtycka
miąższość grubizny [m3/ha]
1600
1400
1200
1000
800
600
400
200
0
Vol0 Vol1 Vol2 Vol3 Vol4 Vol5 Vol6 Vol7 Vol8 Vol9 Vol10 Vol11 Vol12 Vol13
klasy wieku[0-13]
AG
BT
FS
OB
OC
PA
PS
QR


Krzywe "wzrostu i zasobności" z podziałem na gatunki - kraina Śląska
miąższość grubizny [m3/ha]
1200
1000
800
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200
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Vol0 Vol1 Vol2 Vol3 Vol4 Vol5 Vol6 Vol7 Vol8 Vol9 Vol10 Vol11 Vol12 Vol13
klasy wieku[0-13]
AG
BT
FS
OB
OC
PA
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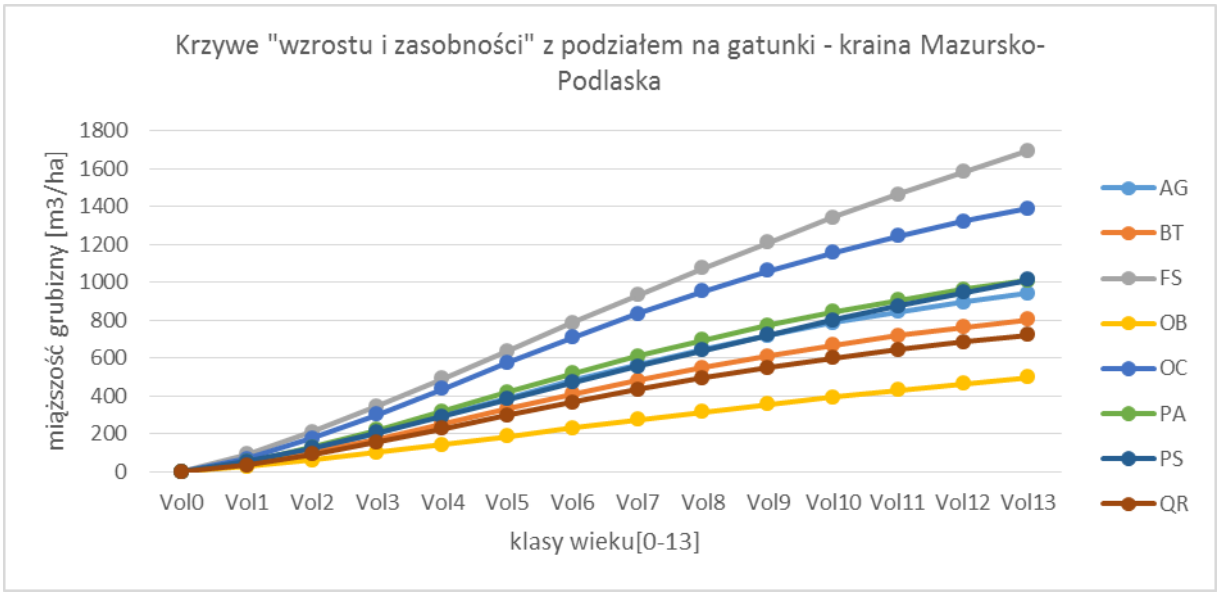
QR


Krzywe "wzrostu i zasobności" z podziałem na gatunki - kraina Mazursko-Podlaska
miąższość grubizny [m3/ha]
1800
1600
1400
1200
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600
400
200
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Vol0 Vol1 Vol2 Vol3 Vol4 Vol5 Vol6 Vol7 Vol8 Vol9 Vol10 Vol11 Vol12 Vol13
klasy wieku[0-13]
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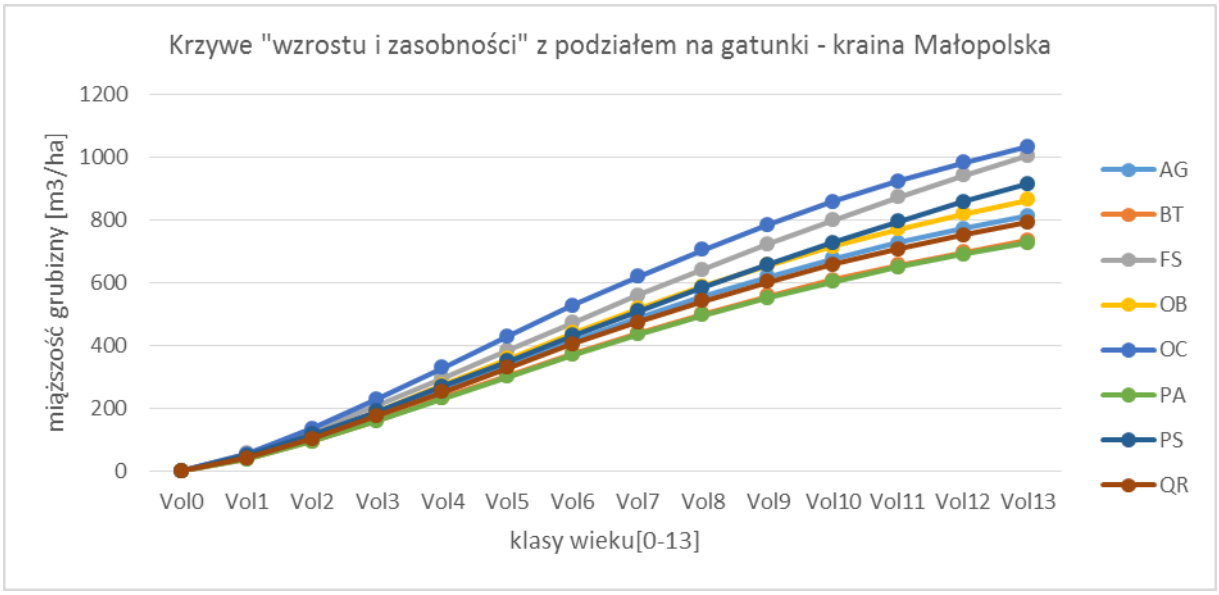
Krzywe "wzrostu i zasobności" z podziałem na gatunki - kraina Małopolska
miąższość grubizny [m3/ha]
1200
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Vol0 Vol1 Vol2 Vol3 Vol4 Vol5 Vol6 Vol7 Vol8 Vol9 Vol10 Vol11 Vol12 Vol13
klasy wieku[0-13]
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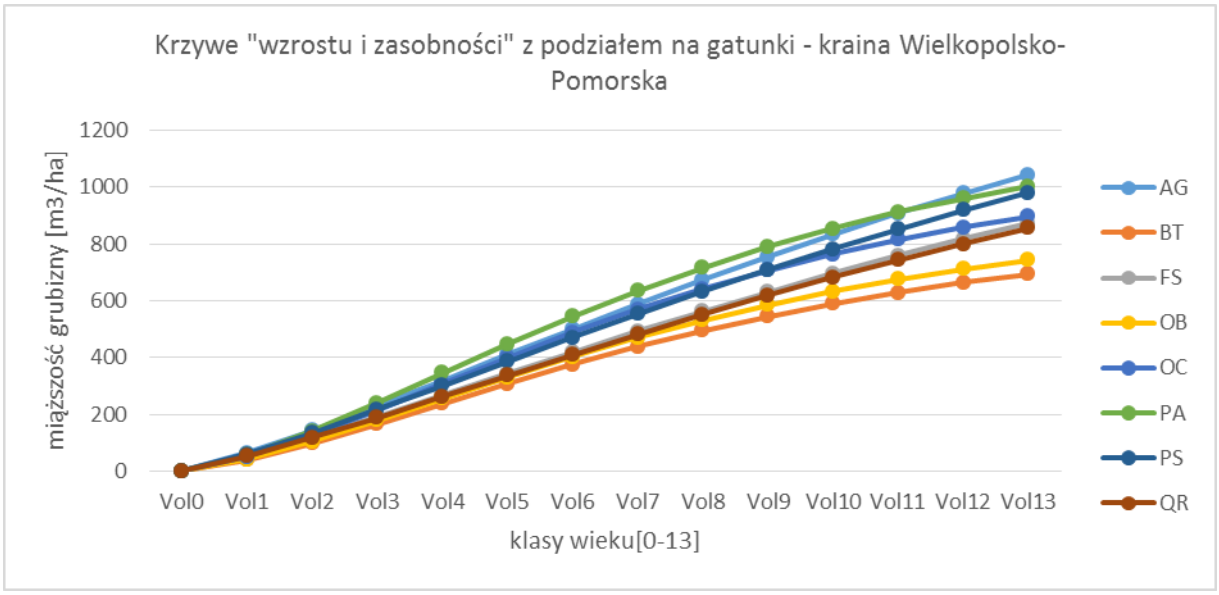
Krzywe "wzrostu i zasobności" z podziałem na gatunki - kraina Wielkopolsko-Pomorska
miąższość grubizny [m3/ha]
1200
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Vol0 Vol1 Vol2 Vol3 Vol4 Vol5 Vol6 Vol7 Vol8 Vol9 Vol10 Vol11 Vol12 Vol13
klasy wieku[0-13]
AG
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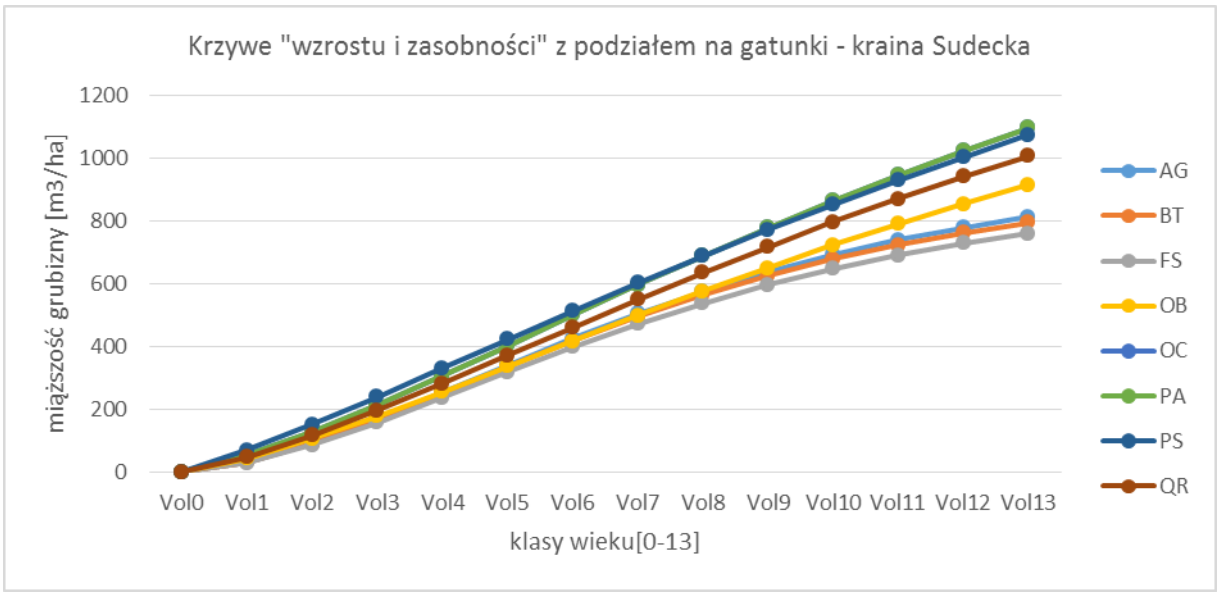
QR


Krzywe "wzrostu i zasobności" z podziałem na gatunki - kraina Sudecka
miąższość grubizny [m3/ha]
1200
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Vol0 Vol1 Vol2 Vol3 Vol4 Vol5 Vol6 Vol7 Vol8 Vol9 Vol10 Vol11 Vol12 Vol13
klasy wieku[0-13]
AG
BT
FS
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OC
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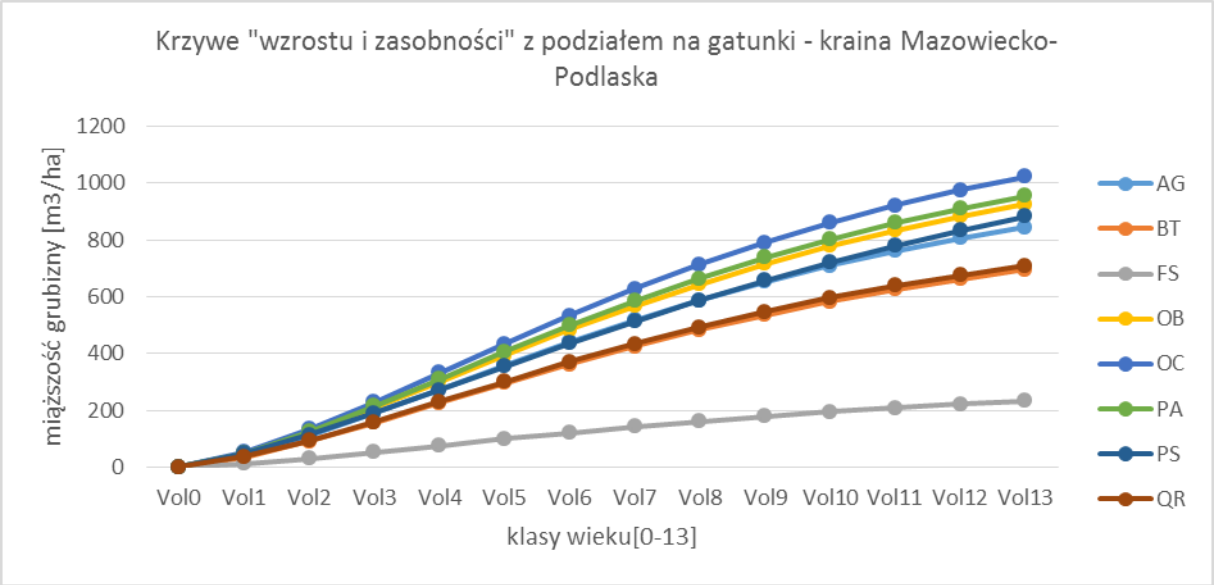

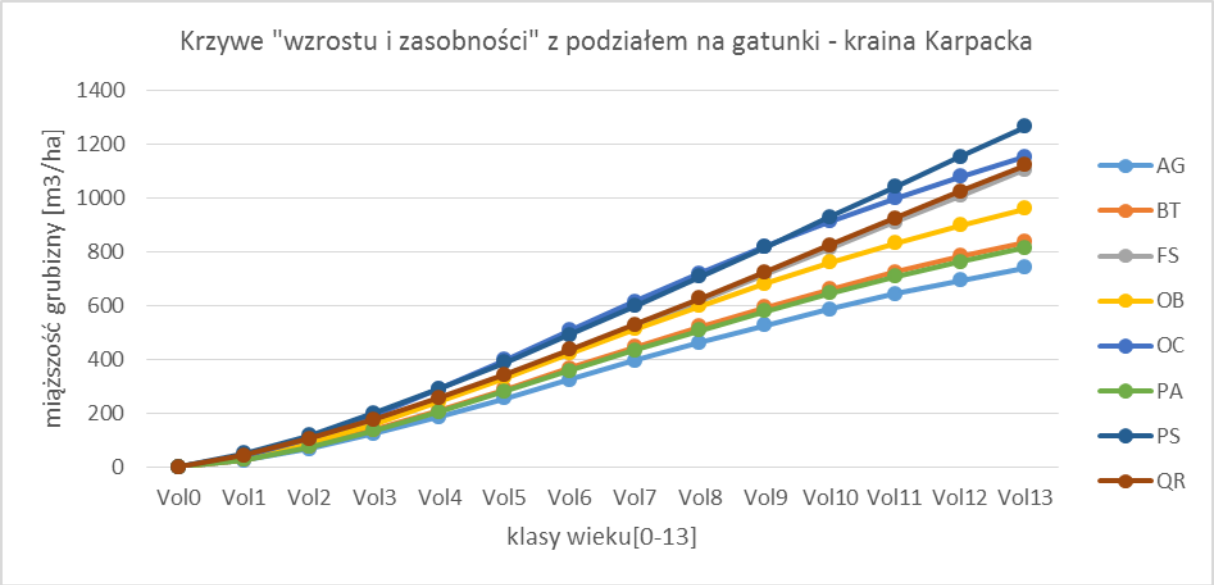

Annex II

The manner of meeting the criteria set in Section B of Annex IV to Regulation (EU) 2018/841

Item of Section B of Annex IV to Regulation (EU) 2018/841	Item of Section B of Annex IV 4 to the LULUCF Regulation	Section of the National Forestry Accounting Plan
(a)	General description of the determination of the forest reference level	1.2
(a)	Manner of applying the criteria set in Annex IV to the LULUCF Regulation	Annex II
(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 given carbon pool in the determination of the forest reference level	3.3.4

(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 to determine the forest reference level, consistent with the most recently submitted national inventory report	3.1
(c)	Description of the documentation on sustainable forest management practices and their intensity as well as the national policies adopted	3.1.3
(c)	Description of the 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 determining the forest reference level:	
(i)	the area under forest management;	2.3.3
(ii)	the emissions and removals from forests and harvested wood products as shown in greenhouse gas inventories and relevant historical data;	2.3.4
(iii)	the forest characteristics, including dynamic forest characteristics related to age, increments, rotation length and other information on forest management activities in the present management scenario;	2.3.5
(iv)	the historical and future harvest indicators, broken down into energy and non-energy uses.	2.3.6