LATVIA'S NATIONAL FORESTRY ACCOUNTING PLAN AND PROPOSED FOREST REFERENCE LEVEL 2021-2025

2019

ANNOTATION

Latvia’s National Forestry Accounting Plan (NFAP) is elaborated under the Regulation 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 (further in the text – LULUCF Regulation 2018/841) in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU. NFAP including a proposed Latvia’s Forest Reference Level (FRL) is developed for submission in 31 December 2018 for the period from 2021 to 2025.

The structure of Latvia’s NFAP is based on the Annex IV of the LULUCF Regulation 2018/841 Latvia’s NFAP takes account unbalanced age structure of forest with the aim of maintaining or strengthening long-term carbon sink. The projected future sink is based on an extrapolation of forest management practices and intensity from a reference period (2000-2009). Specific national circumstances and practices, such as lower harvest intensity or ageing of forests during the reference period are taken into account.

Latvia's FRL takes in account the future impact of dynamic age-related forest characteristics in order to avoid unduly constraining the forest management intensity as a core element of sustainable forest management practice, with the aim of maintaining or strengthening long-term carbon sinks.

The basic for calculations of GHG projections is AGM (Forest growth model) tool and EPIM (Emissions Projections and Inventory Model) which are elaborated by LSFRI Silava. Yasso model is used to calculate carbon stock changes in mineral soils. The description of the applied methodologies is provided in the NFAP to demonstrate consistency between the methods and data used to determine the proposed Latvia's FRL in the NFAP and those used in the reporting for managed forest land.

This Latvia’s NFAP for the period of 2021-2025 has been prepared in cooperation of Forest & Agriculture Departments of the Ministry of the Agriculture of Republic of Latvia and Latvian Forest Research Institute "Silava" (LSFRI Silava).

Latvia’s FRL calculations and explanations have been prepared by experts from LSFRI Silava – A. Lazdiņš, A. Lupiķis, A. Butlers, A. Bārdule, I. Kārkliņa, G. Šņepsts, J. Donis.

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1. GENERAL INTRODUCTION

1.1 General description of the construction of Latvia’s FRL

According to LULUCF Regulation 2018/841 removals from managed forest land are accounted against a forward-looking forest reference level (FRL) including harvested wood products (HWP). The projected future removals by sinks are based on an extrapolation of forest management practices and intensity from a reference period. A decrease in a sink relative to the reference level is accounted for as debits.

This chapter provides a general description of the construction of the reference level and a description on how the criteria according to LULUCF Regulation 2018/841 were taken into account.

The Latvia’s FRL has been estimated for period 2021-2025 to **-54 kt CO_2 eq yr**. The Latvia's FRL includes carbon stock changes and GHG emissions due to on-site incineration of biomass, forest fires, drainage, rewetting and forest fertilization that refers to managed forest lands (Table 1).

Latvia’s FRL is based on the National forest inventory (NFI) data (implemented since 2004 by LSFRI Silava, Latvian State Forest Research Institute ‘Silava’, 2018) and stand-wise forest inventory data maintained by the State forest service. To be able to characterize forest management practices since 2000 forest inventory data in the NFI plots are calculated backwards using equations utilized in the AGM model (Šņepsts, Kārkliņa, et al., 2018), and the stand-wise forest inventory data characterizing thinnings and forest regeneration.

Table 1: Average (2021-2025 and 2026-2030) of emissions and removals from managed forests in Latvia (in ktons CO_2 eq. yr^{-1})

Parameter		2021-2025	2026-2030
Living biomass	Total (3084 kha)	1147	1057
	Productive forest land managed for wood supply (2869 kha)	1113	1026
	Productive forests set-aside for nature conservation[1] (216 kha)	34	32
Drained organic soils	Dead wood	-361	21
	Litter, Soil	8204	8207
Other soils	Dead wood	-2224	130
	Litter, Soil	-	-
HWP	Total	-7723	-7241
	Sawn wood	-7735	-7241
	Wood panels	11	-
Biomass burning		747	699

[1] Areas where forest management including final felling and thinning is forbidden (more details in Figure 12).

Parameter	2021-2025	2026-2030
TOTAL WITHOUT HWP	**7513**	**10114**
TOTAL WITH HWP	**-210**	**2873**

In spite of increasing GHG emission projections during the accounting period the afforestation implemented over the previous decades will compensate most of the GHG emissions in forest land remaining forest land during the accounting period (Figure 1) and turn forest lands into net sink of CO_2 removals after 2030.

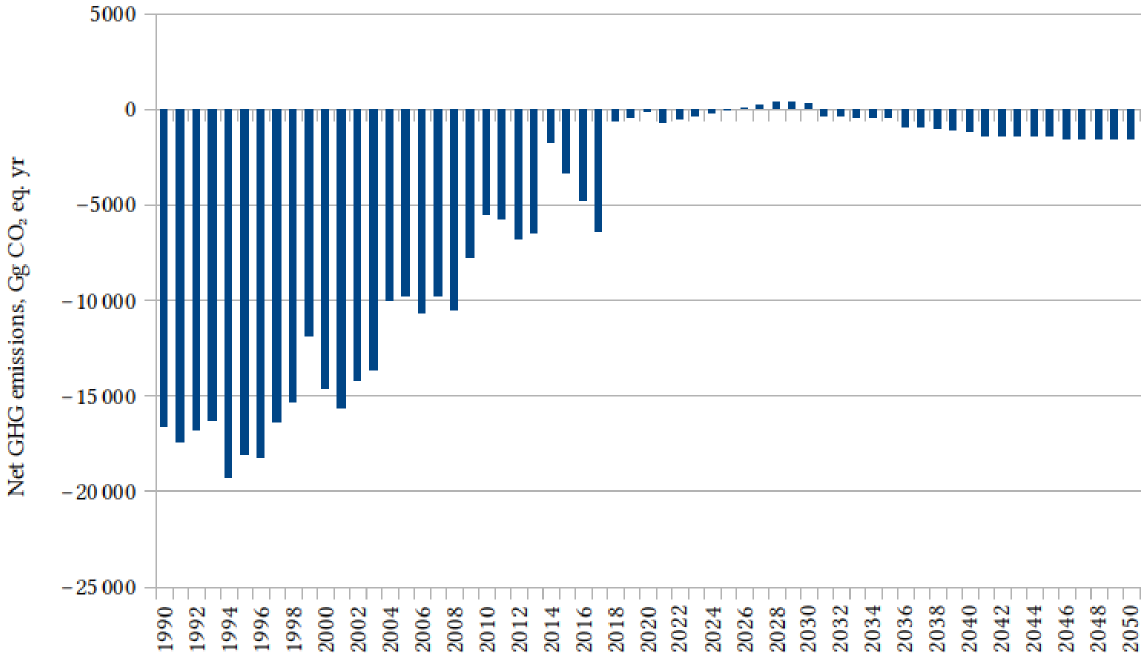

Figure 1: Net emissions in forest lands including afforestation.

The calculations of Latvia's FRL for managed forest land is based on simulations of the carbon stocks for period 2021-2025. The simulations of the forest management were implemented using AGM model (Šņepsts, Bārdule, & Lazdiņa, 2018; Šņepsts, Kārkliņa, et al., 2018), as well as documented forest management practices (stand-wise forest inventory data) in 2000-2009, including forestry and nature protection measures. The harvest level that has been used in model, corresponds to the harvest rate (proportion of volume extracted in final felling and available for final felling in 2000-2009), which is adopted to the forest age structure so that share of mature stands (available for final felling) at the end of 2030 is not bigger than at the end of 2009. Other emissions (due to forest fires) are based on activity data of the period 2000-2009 (applied as a proportion of forest area) and projected area of organic soils in 2021-2025 and 2026-2030.

In the calculations the same plots of the National Forest Inventory were used as in reporting for LULUCF sector to the EU and the UNFCCC. The Latvia's FRL includes all carbon pools except mineral soils, which are excluded from calculation as not a source of GHG emissions, and other GHG emissions (on-site incineration of biomass, forest fires, drainage, rewetting and forest fertilization) that have been reported to the EU and UNFCCC.

Forest definition is in Latvia’s NFAP and the National GHG inventory is harmonized. Transition period between land converted to forest land and forest land remaining forest land is set to 30 years (Table 2).

Table 2: Forest definition in Latvia’s NFAP

No	Parameter	Measurement unit	Value
1.	Minimal area of forest stand	ha	≥ 0.1
2.	Tree height at maturity age	m	≥ 5
3.	Basal area at maturity age	%	≥ 20
4.	Width of protective belts and other bands of trees	m	≥ 20
5.	Transition period between land converted to forest land and forest land remaining forest land (more details in chapter Projections of future climate conditions, page 58)	years	30

Instead of trends of implementation of management activities carried out during the period between 2000 to 2009 average values characteristic for this period are used in projections (the assumptions are provided in chapter Documentation of sustainable forest management practices as applied in the estimation of the forest reference level, page 36).

Characteristics of LULUCF sector in 2010-2016 is based of the 2018 Latvia’s National GHG inventory data, which are recalculated according to the proposed changes in the next inventory to harmonize projections and historical data with the upcoming GHG inventory report. Projections for 2017-2020 in the FRL scenario are estimated using AGM model and forest management assumptions used for FRL scenario (chapter Documentation of sustainable forest management practices as applied in the estimation of the forest reference level, page 36).

1.2 Consideration to the criteria as set in Annex IV of the LULUCF Regulation

1.2.1 Balance between anthropogenic emissions by sources and removals by sinks of GHG in the second half of this century

The FRL is consistent with the goal of achieving a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century, including enhancing the potential removals by ageing forest stocks that may otherwise show progressively declining sink.

The NFAP is contributing to the sustainable growth of managed forest lands to meet the growing need for harvested wood products. In regard to sustainable use of renewable resources, felling are not exceeding exceed the growth expressed as a gross annual increment. The elements of Annex IV of the LULUCF Regulation 2018/841 used in elaborating Latvia's FRL and corresponding chapters of this report are included in chapter Consideration to the criteria as set in Annex IV of the LULUCF Regulation (page 8) and Table 5.

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1.2.2 Mere presence of carbon stocks is excluded from accounting

Latvia’s FRL ensure that the mere presence of carbon stocks is excluded from accounting. This statement corresponds to Decision 16/CMP.1 under the Kyoto protocol. The principle requires to enlarge carbon stocks and the net carbon sinks, in addition to preservation of existing carbon stocks. Terrestrial vegetation of forest land does not contribute towards the reduction of atmospheric carbon. Therefore FRL supports accounting for net changes in forest carbon stocks. To gain sustainable growth, an additional growth must be obtained and emissions must be reduced in comparison to FRL.

1.2.3 Approaches applied to guarantee that emissions and removals resulting from biomass use are properly accounted

Latvia’s FRL ensures a robust and credible accounting, to guarantee that emissions and removals resulting from biomass use are properly accounted for. To ensure properly accounting, Latvia's FRL includes the following carbon pools: living biomass, dead wood, litter, soil and harvested wood products. By elaborating Latvia’s FRL, it is ensured that all carbon pools and GHG emissions are accounted. Off-site combustion of wood is accounted in energy sector, therefore harvest is assumed as a carbon emission from living biomass pool.

1.2.4 Inclusion of the carbon pool of harvested wood products

Latvia’s FRL includes the carbon pool of harvested wood products (HWP), providing a comparison between assuming instantaneous oxidation and applying the first-order decay function and half-life values.

In the accounts provided pursuant to Articles 6(1) and 8(1) relating to harvested wood products, emissions and removals resulting from changes in the pool of harvested wood products falling within the following categories (paper, wood panels, sawn wood) using the first order decay function, the methodologies and the default half-life values specified in Annex V of the regulation. The methodologies are described in details in the National GHG inventory report (Ministry of Environment protection and Regional Development, 2017).

The HWP is a key category of CO_2 removals in the national GHG inventory. Increase of removals in the harvested wood products during the last decade is associated with increase of harvesting rate and implementation of more advanced timber processing technologies. Approach B is used in calculation of the GHG emissions.

Net emissions due to production of the harvested wood products are calculated according to methodology in the 2013 IPCC Kyoto Protocol Supplement (T. Hiraishi et al., 2013). CO_2 emissions due to roundwood production in deforested land are accounted using instantaneous oxidation method and are not included in the FRL estimates.

The net emissions from the harvested wood products are calculated according to the methodology elaborated by Rüter, 2011 (refers to approach B in CRF Reporter). The methodology corresponds to Tier 2 for HWP in the 2013 IPCC Kyoto Protocol Supplement for HWP. Three main HWP groups are used in calculations – sawnwood, wood based panels and paper and paperboard (according to Table 2.8.1 of the 2013 IPCC Kyoto Protocol Supplement).

The calculation is based on harvesting statistics collected by the State forest service, production statistics by the Forest industry association, FAO and EUROSTAT. Linkage with land area used in the commercial felling is secured through the State forest service stand wise forest inventory system, where all commercial harvesting activities are recorded. Only domestically harvested wood is accounted in estimates.

If HWP is accounted using instant oxidation method, the FRL reduces to **1502 ktonnes CO_2 eq yr** for the period 2021-2025.

1.2.5 A constant ratio between solid and energy use of forest biomass as documented in the period from 2000 to 2009

When modelling FRL the ratio between raw materials of biomass from domestic forests and production of the product categories were constant in the Latvia's FRL scenario. Description of wood categories is provided in previous chapter (Inclusion of the carbon pool of harvested wood products, page 9). Average share of biofuel in the total use of woody biomass in the forest reference scenario is **52%**. Exported roundwood is taken into account in the calculation as non-energy use of timber.

In the ‘business as usual’ scenario the on-going bioenergy projects and industrial consumption, for instance, for pellet production is taken into account. Constant consumption of biofuel is considered after 2030.

Distribution of harvesting rate into energy and non-energy uses is calculated as proportion of total biomass product production and roundwood export and biofuel production from local sources. Proportion of biofuel and harvested wood product production from local sources is calculated using the same methodology described in chapter Inclusion of the carbon pool of harvested wood products and Demonstration of consistency between the pools included in the FRL (page 19). Summary of input data applied in the forest reference scenario is provided in Table 3 and summary of data applied in calculation of the ‘business as usual’ scenario are provided in Table 4. Average **share of biofuel** in the total use of woody biomass in the **FRL scenario is 52%** and in ‘business as usual’ scenario – 56%.

Table 3: Production of biofuel and harvested wood products in Latvia's FRL scenario

Parameter	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Biofuel production	6 868	7 411	7 902	8 826	8 631	8 119	8 314	7 634	7 098	9 724
Roundwood export	4 190	3 990	4 225	3 922	4 136	3 919	3 419	3 656	3 191	2 500
Harvested wood products from local wood	4 020	3 918	3 993	4 025	3 918	3 923	4 047	3 162	2 680	3 082

Parameter	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total wood consumption	**15 078**	**15 320**	**16 119**	**16 773**	**16 684**	**15 961**	**15 780**	**14 451**	**12 970**	**15 307**
Share of biofuel	46%	48%	49%	53%	52%	51%	53%	53%	55%	64%

Table 4: Production of biofuel and harvested wood products in 'business as usual' scenario

Parameter	2012	2013	2014	2015	2016
Biofuel production	9 705	8 434	9 924	9 385	9 468
Roundwood export	3 984	3 737	3 836	3 002	2 871
Harvested wood products from local wood	3 950	3 950	4 017	4 037	4 349
Total wood consumption	**17 639**	**16 120**	**17 777**	**16 424**	**16 688**
Share of biofuel	55%	52%	56%	57%	57%

1.2.6 Contribution to the conservation of biodiversity and the sustainable use of natural resources

Latvia as a member state of European Union contributes to implementation of European Union's policies in the field of biodiversity and sustainable use of natural resources. Particular targets and priorities both of EU biodiversity strategy to 2020 (European Commission, 2011) and EU Forest Strategy (European Commission, 2013) have been elaborated in national legislative acts and planning documents.

According to the highest national long-term development planning document Sustainable Development Strategy of Latvia until 2030 (Parliament of the Republic of Latvia, 2010a) targets related to EU biodiversity strategy and EU Forest Strategy are:

- to maintain and restore diversity of ecosystems and their natural structures;
- to maintain and enable diversity of local wildlife species;
- to facilitate conservation of traditional landscape;
- to ensure sustainable use of natural resources;
- the capitalization of nature resources (investment funds of green economy, knowledge transfer).

National Development Plan of Latvia 2014-2020 is the highest medium-term development planning document in Latvia. In regard to sustainable use of natural resources, as well as forests, the strategic objective "Sustainable Management of Natural and Cultural Capital" is determined (Cross-Sectoral Coordination Centre, 2012). The objective also includes target related to biodiversity or forestry, for instance, to support the natural capital as the basis for sustainable economic growth and promote its sustainable uses while minimizing natural and human risks, as well as individual measures related to biodiversity and sustainable forestry:

- to promote the sustainable use and biological diversity of land and other natural resources through the application of environmental conservation technologies;
- to increase the value of forest resources by minimising the environmental impact

and deploying conservation technologies.

Latvia's Forest Policy was adopted in 1998, which goal is to ensure a sustainable management of forests and forests lands. In Forest Policy likewise in EU Forest Strategy sustainable management is defined as administration of forests and forest lands in a way that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential ability to fulfill, now and in the future, relevant ecological, economic and social functions, at local, national and global levels, and that does not cause damage to other ecosystems (Cabinet of Ministers of Latvia, 1998a).

The economic aspects of Latvia's Forest Policy involve promoting various use of timber (EU Forest Strategy, priority 3.3.2) and social aspects – effort to balance the interests of society and forest owners regarding to forest values and labour relations (EU Forest Strategy, priority 3.3.1). Latvia's Forest Policy includes a range of ecological aspects, contributing to 2020 headline target of EU biodiversity strategy, for instance, estimation of forestry impact on environment, monitoring of forest stands, conservation of forest biotopes and species (EU biodiversity strategy, Target 2, Action 7, Cabinet of Ministers of Latvia, 1998).

Forest-based Sector Development Guidelines (2015-2020) is a medium-term policy planning document that consists of the forest-based sector development medium-term strategic goals, guidelines of policy development, directions of actions to achieve these goals and results in policies (Ministry of Agriculture of Latvia, 2015). The development goals of guidelines are:

- sustainable management of Latvia's forests (EU Forest Strategy, 2020 forest objective, priorities 3.3.1, 3.3.3; EU biodiversity strategy, 2020 headline target, Target 1, Action 1);
- forestry production of high added value (EU Forest Strategy, priority 3.3.2);
- potential of education and science corresponding to development of forest-based sector (EU biodiversity strategy, Target 1, Action 3).

In 2000 the National Programme on Biological Diversity was adopted by the Government of Latvia and by 2003 major part of activities listed in Action Plan of mentioned National Programme was implemented. Since the Government of Latvia adopted the Environmental Policy Concept 2014 - 2020 in 2014, the mentioned National Programme is considered out-of-date (Ministry of Environmental Protection and Regional Development of the Republic of Latvia, 2014). However, the Environmental Policy Concept 2014 - 2020 (EPC) also comprises biodiversity protection issues and is the actual environmental planning document in force (Ministry of Environmental Protection and Regional Development of the Republic of Latvia, 2014). ECP is general environmental planning document, which activities provide preconditions for incorporation of the biodiversity considerations into sectorial policies and land use plans (Ministry of Environmental Protection and Regional Development of the Republic of Latvia, 2014). The main goal is to provide ability of living in clean environment, by fulfilling actions towards sustainable development, maintaining the quality of environment and biological diversity (EU biodiversity strategy, 2020 headline target), ensuring sustainable use of natural resources, participation of society in making decisions and availability of information of environmental state (EU biodiversity strategy, Target 1, Action 3). In regard to sustainable use of natural resources a monitoring of forest resources and forest condition, as well as annual monitoring of GHG emission and GHG projections are defined as important measures in EPC (EU Forest Strategy, 2020 forest objective, priority 3.3.3).

Rural Development Programme 2014-2020 includes several targets that correspond to both EU biodiversity strategy to 2020 and EU Forest Strategy (Ministry of Agriculture of Latvia, 2018a). Goals of the Programme and measures that comply with the EU biodiversity strategy to 2020, are:

- to increase knowledge level of persons employed in agriculture, forestry and food industry (Target 1, Action 3);
- to restore, to protect and to improve ecosystems related to agriculture and forestry (2020 headline target and Target 3, Action 9);
- restoration of forest stands after natural disturbances (Target 1, Action 1).

Goals of the Programme and measures that comply with the EU Forest Strategy, are:

- to restore, to protect and to improve ecosystems related to agriculture and forestry (2020 forest objective, priority 3.3.4);
- to promote the development of innovative products for agriculture, food production and forestry (priority 3.3.2);
- to promote social incorporation, reduction of poverty and economical growth in rural areas (priority 3.3.1);
- to promote effective usage of resources and to support economics resistant to climate change with low emission level of carbon dioxide in agricultural, food and forestry sectors (priority 3.3.3);
- restoration of forest stands after natural disturbances (priorities 3.3.3 and 3.3.4);
- afforestation and improvement of stand quality in naturally afforested areas (priority 3.3.3);
- reconstruction and improvement of existing drainage systems in forest land (priority 3.3.3).

According to Target 3B of the EU Biodiversity Strategy by 2020 Member State's all publicly owned forests as well as forest holdings above a certain size that receive funding under the EU Rural Development Policy require Forest Management Plans or equivalent instruments. In Latvia the elaboration of forest management plans is regulated with Law on Forests (Parliament of the Republic of Latvia, 2000a) and The Regulation of the Cabinet of Ministers, No.67 "Rules for Forest Management Plan" (Cabinet of Ministers of Latvia, 2014).

Action 12 (Target 3B) of the EU Biodiversity Strategy determines to integrate biodiversity measures in forest management plans. The Law on Forests determines that owner of forest must take into account the following (Parliament of the Republic of Latvia, 2000a):

- maximum equable and sustainable utilisation of timber resources;
- general requirements of nature protection, in order to:
    - ensure the preservation of the biological diversity;
    - preserve the ability of the forest to protect the soil from erosion;
    - protect surface water and underground water from pollution;
    - preserve the essential elements of cultural heritage in the forest.

In accordance with The Regulation of the Cabinet of Ministers, No.67 “Rules for Forest Management Plan”, a forest management plan should contain information (number of) about registered specially protected nature territories, micro-reserves, specially protected biotopes and habitats of specially protected species, forest stands of genetic resources and cultural heritage. It is required that the forest management plan indicates impact of forest management practices on condition of forest resources and assessment rules of social and environmental spheres, as well as public participation in elaboration of state and municipal plans (Cabinet of Ministers of Latvia, 2014). The Regulation of the Cabinet of Ministers, No.936 “Rules for Forest Conservation in Forest Management” determines general nature protection requirements regarding to forest management and requirements in conservation of biologically significant forest elements (Cabinet of Ministers of Latvia, 2012a). The Regulation of the Cabinet of Ministers, No.935 “Rules for Tree Cutting in Forest” determines requirements for nature conservation referred to tree cutting and restrictions of clear cut (Cabinet of Ministers of Latvia, 2012b). All previously mentioned Regulations of the Cabinet of Ministers contribute to the objective of EU Forest Strategy – to ensure that all forests in the European Union are managed according to sustainable forest management principles, as well as priority 3.3.4 that refers to protecting forests and enhancing ecosystem services.

It should be noted that The Regulation of the Cabinet of Ministers, No.67 “Rules for Forest Management Plan” does not refer to specially protected nature territories (Cabinet of Ministers of Latvia, 2014). According to the Law On Specially Protected Nature Territories these areas are protected by general regulations on protection and use of protected territories, individual protection and use regulations and nature protection plans for the protected territories, including Natura 2000 territories (The Supreme Council of the Republic of Latvia, 1993). Action 1 (Target 1) of EU biodiversity strategy determines to establish of the Natura 2000 network and to ensure good management. In this context several legislative acts have been elaborated for specially protected nature territories – nature reserves, national parks and the North Vidzeme Biosphere Reserve, thereby contributing to conservation of biodiversity (Ministry of Environmental Protection and Regional Development of the Republic of Latvia, n.d.).

The purpose of Law on the Conservation of Species and Biotopes is to ensure biodiversity by protection of species and biotopes, thereby it contributes to targets of EU biodiversity strategy related to halting the loss of biodiversity, ensuring the good management of Natura 2000 territories, as well as priority of EU Forest Strategy related to protecting forests and ecosystem services. Moreover the law indicates relevance of education and information, thereby it is related to Action 3 (Target 1) of EU biodiversity strategy – to increase stakeholder awareness and involvement (Parliament of the Republic of Latvia, 2000b). The aspects of environmental education and information are mentioned also in Law on Forests, Law On Specially Protected Nature Territories and Environmental Protection Law (Parliament of the Republic of Latvia, 2000a; The Supreme Council of the Republic of Latvia, 1993). The purpose of Environmental Protection Law is to promote the preservation and recovery of the quality of the environment and the sustainable use of nature resources (Parliament of the Republic of Latvia, 2006).

Target 5 of EU biodiversity strategy determines that invasive alien species and their pathways are identified and prioritised by 2020. The measures for restricting the spread of the invasive alien plant species regulates The Regulation of the Cabinet of Ministers, No.559 “Regulation Regarding Restricting the Spread of the Invasive Alien Plant Species – Heracleum sosnowskyi Manden” (Cabinet of Ministers of Latvia, 2008).

Law on Pollution determines requirement to increase removal of carbon dioxide, including forestry activities and to reduce greenhouse gas emissions from activities, including land, land use change and forestry activities – harvested wood products (Parliament of the Republic of Latvia, 2001). Thereby the law contributes to priority of EU Forest Strategy related to changing climate. Protection Zone Law determines Baltic Sea and Gulf of Riga coastal protection zone that preserves the protective functions of the forest and eliminates the development of erosion processes, protection zones around marshes to stabilise the regime of humidity in the zone of contiguity transition of the forest and marsh, as well as forest protection zones around cities (Parliament of the Republic of Latvia, 1997). That corresponds to priority 3.3.4 of EU Forest Strategy regarding to protecting forests and enhancing ecosystem services.

It should be noted that FRL complies with concept of sustainable use of natural resources in such a way that harvest rates does not exceed availability of wood resources. By developing FRL, one of the tasks was to keep constant share of mature forests.

In 2017 in total 372 kha of the productive forests have different nature conservation related management restrictions, including 114 kha of forests not considered for roundwood supplies considering considerable management restrictions. Structure of the nature conservation restrictions is provided in Figure 12.

1.2.7 Integrity with the national projections of anthropogenic GHG emissions by sources and removals by sinks reported under Regulation (EU) No 525/2013

Latvia’s FRL is consistent with the national projections of anthropogenic greenhouse gas emissions by sources and removals by sinks reported under Regulation (EU) No 525/2013.

Latvia's reported projections includes the following carbon pools – living biomass, dead wood, litter, organic soil and harvested wood products, as well as the GHG emissions due to forest fires and incineration of harvesting residues and forest drainage. The FRL considers the same carbon pools. When reporting under Regulation (EU) No 525/2013 projection 'business as usual' scenario was used. However, in the FRL are used sustainable forest management practices 2000-2009. Therefore both projections may diverge.

The most recent data representing period between 1990 and 2016 are used in elaboration of NFAP. The most significant difference between both estimates is more optimistic harvesting projections in the already elaborated projections based on the assumption of continuing trend of harvest rate until 2020. In the 'business as usual' scenario elaborated for NFAP trend is replaced by average values of the harvest rate by species between 2011 and 2016, which is in line with the IPCC 2006 (Eggleston, Buendia, Miwa, Ngara, & Kiyoto, 2006), respectively, the last 5 years average value is used. Comparison of both estimates is provided in Figure 2. AGM model with 5 years calculation period and predefined harvest projections are used in both cases to project stock changes in forest.

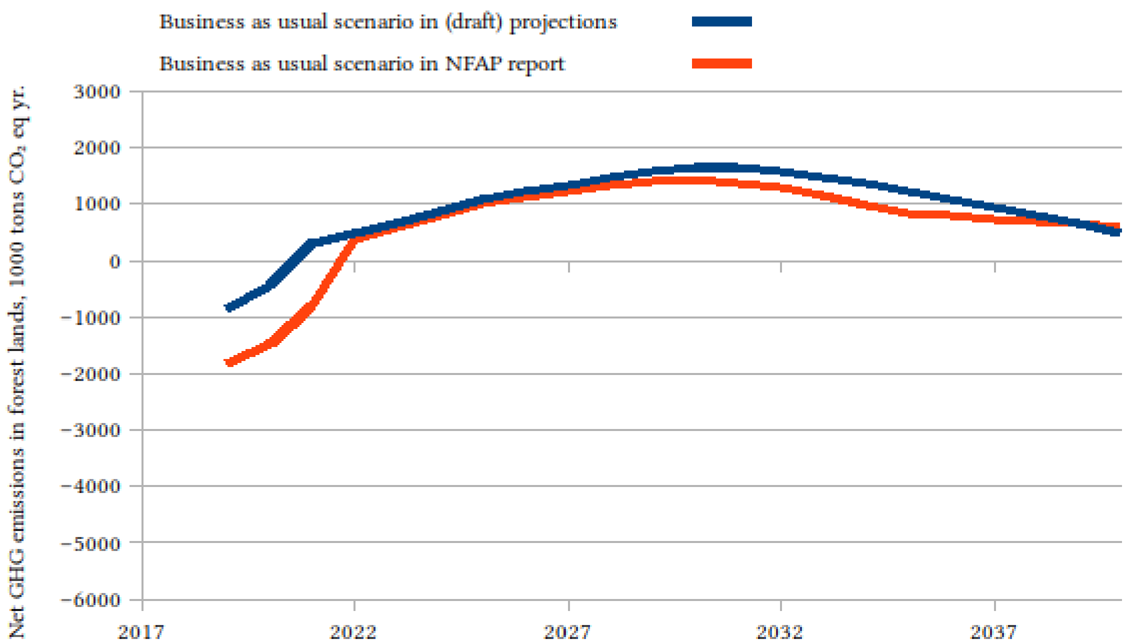

Figure 2: Net GHG emissions in forest lands according to 'business as usual' scenario in the projection report.

1.2.8 Integrity of applied models with the historical data from the national GHG inventory

Reference level is consistent with Latvia's GHG inventory (Ministry of Environment protection and Regional Development, 2018) and relevant historical data and is based on transparent, complete, consistent, comparable and accurate information. In particular, the model used to construct the reference level is able to reproduce historical data from the national greenhouse gas inventory. The national forest growth prediction model AGM is used in projections of forest growth and impact of forest management. Description of the model is available in the research report (Šņepsts, Kārkliņa, et al., 2018). The results of modelling – mortality, increment and harvesting in forest lands summarized in previously established strata are fed into OASIS (Organization for the Advancement of Structured Information Standards) Open Document Format for Office Applications compatible spreadsheet file based EPIM model, which is used to transfer activity data into GHG emissions in land use, land use change and forest sector and for reporting of activities listed in the Article 3.3 and 3.4 of the Kyoto protocol (Ministry of Environment protection and Regional Development, 2018).

To ensure consistent and complete reporting, the same definitions of carbon pools and the same sampling units used in FRL, as well as in reporting of greenhouse gas inventories under EU and UNFCCC.

Information according to Annex IV, section B of the Regulation 2018/841:

(a) a description of how each of the following elements were considered in the determination of the Latvia's FRL:

i. **the area under forest management** – the area of managed forest lands used in calculation of FRL increases between 2021 and 2025 due to reaching of 30 years age in afforested lands. Impact of deforestation between 2020 and 2025 is not considered in the Latvia's FRL following to the assumption that it is not sustainable forest management practice;

ii. **emissions and removals from forests and harvested wood products as shown in greenhouse gas inventories and relevant historical data –** emissions and removals from forests and harvested wood products as reported to the EU and the UNFCCC are similar to those reported in NFAP as it can be seen from Figure 2. The reported total net forest land removals are stable with an increase of total stock in spite the net removals temporarily decrease. The carbon stock changes reported to EU and to UNFCCC are updated with recent data before use in the FRL. The same NFI plots are used for estimating the FRL as for previous reporting;

iii. **forest characteristics, including dynamic age-related forest characteristics,** increments, rotation length and other information on forest management activities **under 'business as usual'** is interpreted as forest management practices during the time period 2011-2016. Projections in both scenarios are started with 2017. The projected age distribution is restricted by the projected harvest rate. The 'business as usual' practices sets distribution between forest regeneration, felling and thinning, distribution of harvested species (more information on the applied assumptions in FRL scenario is provided in chapter Detailed description of the modelling framework as applied in the estimation of the forest reference level (page 36) and on 'business as usual' scenario in chapter Forest management activities under ‘business as usual’, page 52);

iv. **historical and future harvesting rates** (Figure 5) disaggregated between energy and non-energy uses (chapter A constant ratio between solid and energy use of forest biomass as documented in the period from 2000 to 2009, page 10).

Detailed information according to the Annex IV, section B of the Regulation 2018/841 is provided in the following chapters. Summary of location of different elements is provided in Table 5.

Table 5: Consideration to Annex IV B. elements of the Regulation in the NFAP

Annex IV B paragraph item	Elements of the national forestry accounting plan according to Annex IV B.	Page number in the NFAP
(a)	A general description of the determination of the forest reference level	Page 6
(a)	Description of how the criteria in LULUCF Regulation were taken into account	Page 8
(b)	Identification of the carbon pools and greenhouse gases which have been included in the forest reference level	Page 19
(b)	Reasons for omitting a carbon pool from the forest reference level determination	Page 7
(b)	Demonstration of the consistency between the carbon pools included in the forest reference level	Page 19
(c)	A description of approaches, methods and models, including quantitative information, used in the determination of the forest reference level, consistent with the most recently submitted national inventory report	Page 33
(c)	A description of documentary information on sustainable forest management practices and intensity	Pages 36
(c)	A description of adopted national policies.	Pages 26
(d)	Information on how harvesting rates are expected to develop under different policy scenarios	Pages 27
(e)	A description of how the following element was considered in the determination of the forest reference level:	Pages 50 and 33
(i)	• The area under forest management	Pages 50
(ii)	• Emissions and removals from forests and harvested wood products as shown in greenhouse gas inventories and relevant historical data	Page 9
(iii)	• Forest characteristics, including: ◦ dynamic age-related forest characteristics ◦ increments ◦ rotation length ◦ other information on forest management activities under ‘business as usual’	Pages36, 19, 33, 29, 31
(iv)	• Historical and future harvesting rates disaggregated between energy and non-energy uses	Pages 10

2. PREAMBLE FOR THE REFERENCE LEVEL

The following chapters contains information on identification of the carbon pools and greenhouse gases, which have been included in the reference level, reasons for omitting a carbon pool from the reference level construction, and demonstration of the consistency between the pools included in the reference level.

2.1 Carbon pools and GHG included in the FRL

Latvia's FRL includes changes in the following carbon pools:

- living biomass;
- dead wood;
- litter;
- soil organic carbon;
- harvested wood products;
- emissions from drained organic soil;
- emissions from biomass burning.

Emissions from forest fertilization and mineralization of organic matter in mineral soils are not included in the calculation due to the fact that forest fertilization was not used in 2000-2009 and it is still happening only in limited area of research forests representing minor impact of GHG emissions. Additional CO_2 removals several times exceeding GHG emissions due to application of mineral fertilizers are not accounted either in the ‘business as usual’ scenario with existing climate change mitigation measures. Mineralization of organic matter is not accounted because soil carbon is not a source of GHG emissions according to modelling exercises done by Yasso model on the base of the results of AGM modelling data.

2.2 Demonstration of consistency between the pools included in the FRL

The methodology applied in elaboration of forest growth projections is described in the report on structure of the AGM model (Šņepsts, Kārkliņa, et al., 2018). Activity data and volume of trees is transformed into GHG emissions and CO_2 removals by EPIM model used in the 2018 National GHG inventory (Ministry of Environment protection and Regional Development, 2018) and summarized in the following paragraphs.

Forest land category includes emissions and removals resulting from carbon stock changes in living biomass, litter, dead wood, organic soils and emissions from drainage and rewetting of organic soils, and biomass burning.

The NFI and research data are used to estimate time series for areas and gross increment[2]. Mortality data are calculated on the base of the NFI data and mortality rate (stratified data in AGM model in projections). Distinction between forest land remaining forest land and areas converted to forest land is made according to the age of dominant species in forests on afforested land – if age of dominant species was less than zero in 1990, it is considered as land converted to forest, in other cases it is considered as forest land remaining forest land.

Carbon stock changes in above and below ground living and dead biomass are reported in the inventory. Decay factor for dead wood including harvesting residues not incinerated on-site is considered 20 years. In forest land remaining forest land, changes of organic carbon in litter and mineral soil organic matter in naturally dry and wet soils are assumed to be zero according to the national research data on carbon stock in forest soil in 2006 and 2012 (Lazdiņš et al., 2015).

Carbon stock changes are reported separately on naturally dry and wet mineral and organic soils and drained mineral and organic soils. Soils are considered organic as defined in the NFI: a soil is classified as organic if the organic layer (H horizon) is at least 20 cm deep. Conversion of forest stands on drained mineral or organic soil to naturally wet soil is accounted as rewetting; however, this measure is not transferred into forest reference scenario assuming that it is not sustainable forest management practice as any kind of deforestation.

The carbon stock change in living biomass is estimated with the Tier 2 method according to the 2006 IPCC Guidelines – carbon uptake and release of the living biomass correspond to the mean gross annual increment of forest growing stock, annual harvesting of trees and decay due to natural mortality.

The dynamics of carbon stock changes in living biomass is very much affected by commercial felling. The accessibility of forest resources was low at the beginning of the 1990s due to implementation of land reform; therefore, felling was also at a low level and the CO_2 sink of living biomass was high. The felling stock increased during 1990s with implementation of the land reform and reached top average in early 2000s.

Calculations of carbon stock changes and GHG emissions in forest lands are based on activity data provided by the NFI (area, living biomass and dead wood) and Level I forest monitoring data (soil organic carbon). Data from State forest service are used to estimate commercial felling related emissions and removals. The calculation of GHG emissions and CO_2 removals in historical forest lands is based mainly on research report "Elaboration of the model for calculation of the CO_2 removals and GHG emissions due to forest management" (Lazdiņš, Donis, & Strūve, 2012b, 2012a) and factors and coefficients elaborated within the scope of the research program on impact of forest management on GHG emissions and CO_2 removals (Lazdiņš et al., 2015).

Methodologies for estimation of carbon stock changes and GHG emissions are considerably improved during recent submissions; they are merged together into the "Emissions projection & inventory model (EPIM)" spreadsheet tool. New version with

[2] Summary of National Forest Inventory, source:http://www.silava.lv/userfiles/file/2010%20nov%20MRM_visi%20mezi_04-08g.xls

harmonized input data are elaborated for the UNFCCC and the Kyoto protocol reporting within the scope of the National GHG inventory and projections of GHG emissions. The tool is still under development.

Land use and land use change data in EPIM are elaborated separately to simplify tool structure, the connection is organized as linked tables;

- main input data – area under different growth and management conditions, species composition, gross annual increment, mortality per area, harvesting rate and species composition and others;
- calculations are done on annual basis using periodic (5 years period) and annual input data;
- historical data (1990-2004) – backward calculation on the base of the NFI data; for 1970-1989 research data and expert judgements are utilized;
- all modules in the spreadsheet are merged together following to the forest management cycle (from growth to decay);
- the tool combines all land use and land use change categories.

Content of the tool (separate calculation sheets):

- living biomass (annual increment of living biomass, summary of growing stock and characteristics of biomass);
- mortality (natural reduction of number of living trees, estimation of decay of harvesting residues, calculation of dynamics of carbon stock in dead biomass);
- commercial harvesting (input to the harvested wood products, losses in above-ground and below-ground biomass);
- harvested wood products (carbon stock change in domestcially originated and consumed harvested wood products);
- emissions from soils (CO_2, CH_4 and N_2O from drained organic soils and CH_4, DOC, CO_2 emissions from rewetted soils in forest land and wetlands);
- fire (emissions of CO_2, CH_4 and N_2O due to incineration of harvesting residues and wildfires);
- conversion from forests (as a land use change to estimate area of managed forests);
- afforestation (carbon stock change in living biomass, dead wood and litter);
- cropland (emissions from soil, carbon stock change in living and dead biomass);
- grassland (emissions from soil, carbon stock change in living and dead biomass, wildfires);
- conversion of cropland and grassland (emissions or removals in soil);
- settlements (carbon stock change in soil, living and dead biomass);

- managed wetlands (emissions from soil, carbon stock change in living and dead biomass).

Commercial felling in the GHG inventory is evaluated using following approaches:

- dominant species specific harvesting data since 1970 (1990-2013 Central statistical bureau data updated by NFI data, since 2014 NFI, 1970-1989 research papers, Saliņš, 2002);
- decomposition of crown and underground biomass – 20 years; species specific wood densities and different biomass expansion factors (BEFs) for coniferous and deciduous trees.

The methodology for harvested wood products is based on Rüter, 2011. More detailed description is provided in chapter Inclusion of the carbon pool of harvested wood products in page 9.

Emissions from drained soils are accounted – 0.52 tonnes C ha^{-1} (Lazdiņš, Butlers, & Lupiķis, 2014; Lazdiņš & Lupiķis, 2014; Lazdiņš, Lupiķis, & Okmanis, 2014; Lupiķis & Lazdins, 2017) and 2.8 kg N_2O-N ha^{-1} (Takahiro Hiraishi et al., 2013) annually from organic soils.

Area of organic soils in the forest lands is reported according to structure of distribution of the forest stand types. Total area of organic soils as well as total area of forests was updated according to research data on land use structure according to the NFI (Lazdiņš & Zariņš, 2010).

Drained organic soil in forest land is source of CH_4 emissions. CH_4 emissions are calculated by equation 2.6 in the IPCC Wetlands Supplement. The CH_4 emission factor for organic soils of drained forest land (Table 2.3 and Table 2.4 in the IPCC Wetlands Supplement) is 2.5 kg CH_4 ha^{-1} yr^{-1} and emission factor for drainage ditches is 217 kg CH_4 ha^{-1} yr^{-1}. Fraction of the total area of drained organic soil which is occupied by ditches is 0.025 (Table 2.4 in the IPCC Wetlands Supplement).

GHG emissions from rewetted organic soils are estimated according to the Tier 1 methods. Emission factor for CO_2-C (0.5 tonnes CO_2-C ha^{-1} yr^{-1}) is taken from Table 3.1 of the IPCC Wetlands Supplement. N_2O emissions from rewetted organic soils according to the Tier 1 method are assumed to be negligible and are not estimated, CH_4 emissions are calculated applying Tier 1 method using equation 3.7 of the IPCC Wetlands Supplement. Default emission factor (216 kg CH_4-C ha^{-1} yr^{-1}) from Table 3.3 was used.

Rewetting is reported under forest land – conversion of forests on drained organic soils to forest on naturally wet soil. The conversion is usually approved by changes in ground vegetation and groundwater table during the site visits. Rewetting takes place due to wearing of drainage systems. In 2016, total rewetted area according to comparison of the NFI data is 16.05 kha. It is assumed that the increase of rewetted area increases linearly and 2 kha of forests were rewetted every year from 2009 to 2016 according to an average figures for 2009-2013 provided by the NFI and linear extrapolation of 5 years average in 2014, 2015 and 2016.

Biomass burning includes GHG emissions (CO_2, CH_4, N_2O) from biomass burning on forest land comprising wildfires and controlled burning, as well as wildfires in grassland. Total aggregated emissions from biomass burning in 2016 were 85.93 kt of CO_2 eq.

Taking into account that wetlands (bogs and fens) belong to forest land according to national land use definitions, emissions associated with wildfires in wetlands cannot be separated and are reported under forest lands remaining forests. No evidences of forest fires or grassland wildfires are found in land converted to forest in the NFI plots having special forest land category – burnt forest; therefore it is considered that no forest fires takes place in afforested area. The approach used in the Latvia's GHG inventory ensures that emissions from biomass burning are not overlapping.

The area statistics on forest wildfires are compiled by the State forest service and they are based on information given by the local units.

Emissions from biomass burning are represented by incineration of harvesting residues during forest logging operations. The activity data for this calculation was based on an outdated study until 2010 (Lazdiņš & Zariņš, 2013). Now a questionnaire for private forest owners on utilization of harvesting residues is used (Lazdiņš & Lazdiņa, 2013). This switch leads to reduction of emissions in 2005. In case of on-site incineration of harvesting residues during commercial harvesting, all emissions also are applied to the forest land remaining forest land category, because no commercial felling takes place in young stands (younger than 20 years) on land converted to forest land.

Tier 1 and 2 methods of calculation provided in the 2006 IPCC Guidelines were utilized. Emissions from any type of fires were calculated using default method from IPCC 2006 Guidelines and country specific activity data. Tier 1 method and default emission factors of calculation provided in the 2006 IPCC Guidelines was utilized to estimate emissions due to wildfires. Amount of burned biomass is considered according to average growing stock of living biomass, dead wood and litter in a particular year. Combustion efficiency or fraction of biomass combusted (dimension-less) is considered 0.45 according to Table 2.6 of the 2006 IPCC Guidelines3. Tier 2 method and default emission factors of calculation provided in the 2006 IPCC Guidelines was utilized to estimate emissions due to controlled incineration of harvesting residues. Emissions from controlled fires were calculated considering average sto7ck of harvesting residues (BEF for conversion of stem biomass to above-ground biomass), which considerably increased due to increase of estimates of harvesting stock. The following assumptions have been made for burned harvesting residues calculation:

- 1990 to 2000 – 50 % of harvesting residues are left for incineration and 67 % of the left residues are incinerated, the rest are left to decay;
- 2001 to 2004 – 30 % of harvesting residues are left for incineration and 67 % of the left residues are incinerated, the rest are left to decay;
- 2005 to 2009 – 7 % of harvesting residues are left for incineration and 100 % of

[3] Combustion factor values (proportion of prefire biomass consumed) for fires in a range of vegetation types.

the left residues are incinerated; the rest of the residues are left for decay or extracted for bioenergy production.

- starting from 2010 – 4 % of harvesting residues are left for incineration and 100 % of the left residues are incinerated; the rest of the residues are left for decay or extracted for bioenergy production.

CO_2 emissions are calculated only from wildfires taking into account that carbon located in harvesting residues is already accounted as losses in living biomass. Incinerated residues are extracted from removals in dead wood. CO_2 emissions are reported using instant oxidation method and do not appear in the inventory as removals in dead wood.

Activity data consist of areas of land remaining in a land-use category and land converted to other land-use category on drained organic soils. Default N_2O emission factors for drained organic soils are shown in Table 6 according to Table 2.5 of the IPCC Wetlands Supplement.

Table 6: Tier 1 N_2O emission/removal factors for drained organic soils

Land-use category	Climate / vegetation zones	Emission factor (kg N_2O-N ha^{-1} yr^{-1})	95% Confidence interval	
Forest land, drained	Temperate	2.8	-0.57	6.1

2.3 Description of the long-term forest strategy

Long-term forest strategy in Latvia is determined by adopted national policies in forestry and related sectors like agriculture, energy and nature conservation. One of the most important and direct forest strategy documents is Latvian forest sector development is Forest and associated sectors development guidelines for 2015-2020 (Ministry of Agriculture of Latvia, 2015). These guidelines are regularly updated and harmonized with related policies and new challenges of forest sector, particularly, the increase of the role of forest lands in climate change mitigation is highlighted in the current edition of the guidelines. In addition to Latvian forest sector development is Forest and associated sectors development guidelines for 2015-2020 there are other sectoral policies, like energy, nature conservation and agriculture, that play an important role in establishment of long-term forest development vision.

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

According to Latvian Forest Law forest and forest land are separated. Forest is an ecosystem that consists of forest land that is covered by woody vegetation fulfilling certain criteria (listed in Table 2, page 8). Forest definition in national land register, GHG inventory report and calculation of Latvia's NFAP are harmonized. Forest land without woody vegetation meeting threshold values listed in Table 2 are forest infrastructure (roads, ditches, protective belts) or wetlands except water bodies outside forests.

According to the NFI in 2017 there were 3191.38 kha of forest stands, including areas afforested since 1990. The total area of forests lands, including wetlands and forest infrastructure, is 3575.14 ha. In total forest land equals to 55 % of the area of Latvia. 48% of forest land belongs to state and 52% are privately owned.

Area of forests with different management restrictions is 495 kha, including 237 kha of forests where management activities are completely or significantly (final felling forbidden) prohibited (Figure 12, page 51). These areas are considered in the Latvia's FRL accounting as areas, where forest management will not occur.

Forest ageing is one of the issue identified during elaboration of the Latvia's FRL. 28% of forests (holding more than 50% of growing stock) are available for final felling, including 19% of forest area being 1-20 years older than the threshold value for the final felling age and 9% of over-mature forests, which are more than 20 years older than the threshold age criteria for final felling (Figure 3). The share of middle age stands, which will become available for final felling during the following 10-20 years 75% of forests will become available for final felling. The most of these forests are birch and pine stands, which have high commercial value and might be utilized to considerably higher extend.

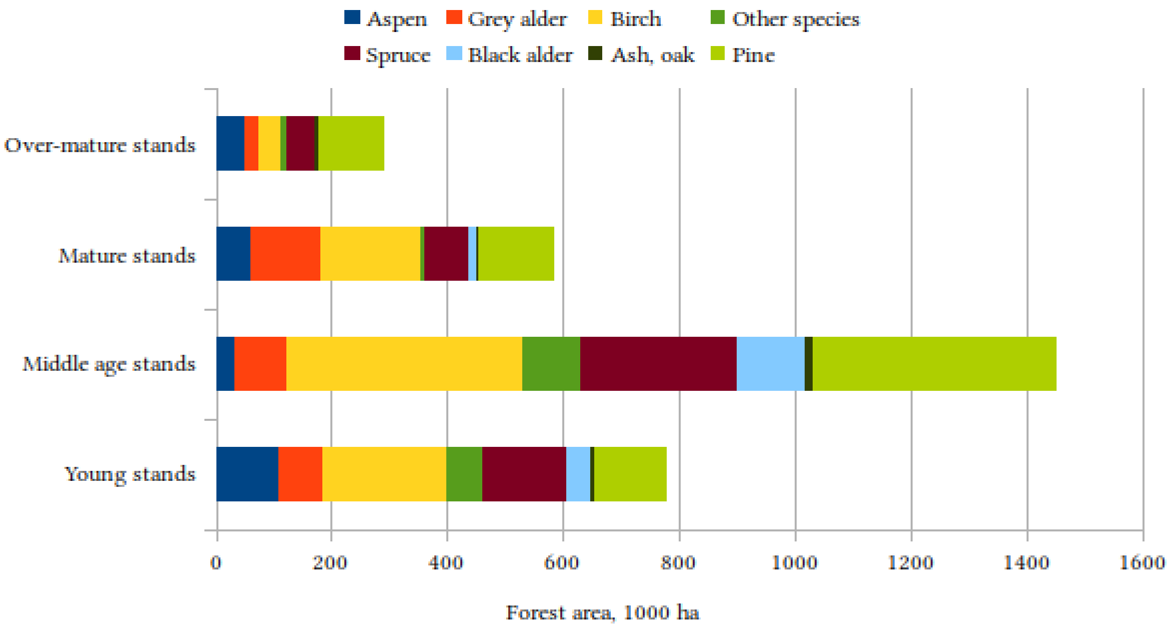

Figure 3: Forest age structure in Latvia in 2017 (NFI data).

Growing stock in forests at the end of 2016 was about 669 mill. m^3 (extrapolated value on the basis of NFI data). It increased by 11% in comparison to 2000.

2.3.2 Information on adopted national policies

2.3.2.1 Forest sector

Latvia's Forest Policy has been elaborated to gain a compromise among all stakeholders of forestry. Latvia's Forest Policies targets are (Cabinet of Ministers of Latvia, 1998b):

- to ensure a sustainable management of forests and forests lands;
- to generate favourable environment for development of economic;
- to conserve ecological functions of forest;
- to ensure social functions of forest.

Forest-based Sector Development Guidelines goals and directions promote to achieve targets of Latvia’s Forest Policy, for instance, sustainable management of Latvia’s forests, forestry production of high added value, potential of education and science corresponding to development of forest-based sectors (Cabinet of Ministers of Latvia, 1998b).

Law on Forests is the main law of the forestry of Latvia. The purpose of the law is to regulate sustainable management of all the forests, by guaranteeing equal rights and independence of economic activities, and determining equal obligations to all forest owners. The Law on Forests defines sustainable forest management as management and utilisation of forest and forest land in such a manner and at such a level as to maintain the biological diversity, productivity and vitality thereof, as well as regeneration ability and the ability to fulfil significant ecological, economic and social functions at the present time and in the future, on a local and global scale. The Law on Forests determines, when felling is permitted and prohibited, for instance, final felling is permitted, when forest stand has reached a certain final felling age that depends on dominant tree species, site index, and the final felling diameter (Parliament of the Republic of Latvia, 2000a).

The Saeima of Republic of Latvia adopted Law on Forests in 2000, since then there have been several amendments in the law (Parliament of the Republic of Latvia, 2000a). Particular environmental laws – Law On Specially Protected Nature Territories and Protection Zone Law have been adopted in 1993 and 1997, respectively (Parliament of the Republic of Latvia, 1997; The Supreme Council of the Republic of Latvia, 1993). While in the period 2000 – 2009 was adopted the following laws: Law on Pollution (2001), Environmental Protection Law (2006), as well as several laws on particular nature reserves and national parks (Parliament of the Republic of Latvia, 2001, 2006; The Supreme Council of the Republic of Latvia, 1993). There have been amendments in mentioned legacy acts, however, the laws with planning documents have formed a basis for sustainable forestry and conservation of biodiversity.

2.3.2.2 Energy sector

By 2050 European Union is moving to a competitive low-carbon economy. Currently Latvia elaborates low-carbon development strategy for 2050 (Ministry of the

Environmental Protection and Regional Development, 2017). According to the The Sustainable Development Strategy of Latvia until 2030, a target of 45% greenhouse gas emissions reduction compared to 1990 level is set (Parliament of the Republic of Latvia, 2010b). In 2016 Latvia approved the Guidelines for Energy Sector Development 2016-2020 that is a sectoral planning document. The long-term targets of Latvia's energy policy are (Cabinet of Ministers of Latvia, 2016):

- to improve sustainability in energy sector that promotes sustainability in economical, social and environmental dimension. To fulfill the target it is planned to increase energy efficiency and to promote use of high-efficiency technologies and the usage of renewable energy sources;
- to increase security of energy distribution by minimising geopolitical threats, developing infrastructure and ensuring various energy sources.

The target of at least a 40 % domestic reduction in economy-wide greenhouse gas emissions by 2030 compared to 1990 is set (European Parliament, Council of the European Union, 2018). According to the Directive (2009/28/EC) – to increase the use of renewable energy sources from 32,6% of gross final energy consumption in 2005 up to 40% in 2020 (European Parliament, Council of the European Union, 2009).

2.3.2.3 Agriculture

Rural Development Plan 2014-2020 is sectoral planning document. There main measures and priorities are (Ministry of Agriculture of Latvia, 2018b):

- increase education level of persons that are employed in agriculture and forestry – a measure contributes to precise usage of fertilizers, protection of water quality and reduces soil erosion threats;
- reduction of GHG emissions in agriculture;
- restoration of drainage systems in agricultural lands and forest lands – the measure promotes CO_2 removals in soil;
- increasing CO_2 removals in forest lands;
- effective management of abandoned agricultural lands;
- conservation of biodiversity in agricultural lands and forest lands.

2.3.2.4 Nature conservation

By implementing EU biodiversity strategy, Latvia contributes to 2050 vision – biodiversity and the ecosystem services it provides, its natural capital, are protected, valued and appropriately restored, as well as 2020 headline target – Halting the loss of biodiversity and the degradation of ecosystem services in the EU by 2020. Nature conservation aspects are also discussed in chapter Contribution to the conservation of biodiversity and the sustainable use of natural resources, page 11.

2.3.3 Description of future harvesting rates under different policy

scenarios

Development of harvesting rates are evaluated for 2 scenarios – ‘business as usual’ and Latvia's FRL scenario. In the ‘business as usual’ scenario roundwood and biofuel demand projections are compared with the recent harvest rates (2011-2016 average values). In the Latvia's FRL scenario average harvest rate in 2000-2009. In both scenarios harvest rate in final felling is calculated as comparison of volume of extracted trees and growing trees available for final felling. Volume of trees extracted in thinning and selective felling is calculated using probability functions developed from harvesting statistics in 2000-2009 (Latvia's FRL scenario) and 2011-2016 (‘business as usual’ scenario).

2.3.3.1 Harvest projections under Latvia’s FRL scenario

Primary assumptions applied to estimate harvesting intensity, like share of wood actually extracted in final felling in comparison to resources available for final felling and proportion of roundwood extracted in thinning is provided in Table 7 and Table 8. The values provided in the tables represent average conditions in 2000-2009. Share of resources extracted in final felling is updated so that the share of mature forests at the end of 2030 equals or is smaller than the average share of mature forests in 2000-2009.

Table 7: Assumptions for the final felling rate from available wood

No	Species	Share of forests at final felling age in the reference period (2000-2009)	Share of available volume extracted in final felling
1.	Aspen	40.1% (20% under normal distribution)	2.7%
2.	Grey alder	67.1% (33% under normal distribution)	2.3%
3.	Birch	24.1% (14% under normal distribution)	7.0%
4.	Other species	7.4% (no specific value)	8.2%
5.	Spruce	22.1% (13% under normal distribution)	4.9%
6.	Black alder	4.6% (12% under normal distribution)	24.9%
7.	Ash, oak	33.0% (11% under normal distribution)	3.8%
8.	Pine	27.3% (10% under normal distribution)	3.7%

Table 8: Proportion of harvests outside final felling

No	Species	Share of harvests
1.	Aspen	6.3%
2.	Grey alder	11.3%
3.	Birch	22.9%
4.	Other species	26.6%

5.	Spruce	27.8%
6.	Black alder	18.1%
7.	Ash, oak	36.4%
8.	Pine	33.0%

Projections of harvest rates in comparison to growing stock are provided in Figure 4. According to the reference scenario carbon stock in living biomass will continue to increase till 2050 (Figure 18, page 61) and beyond.

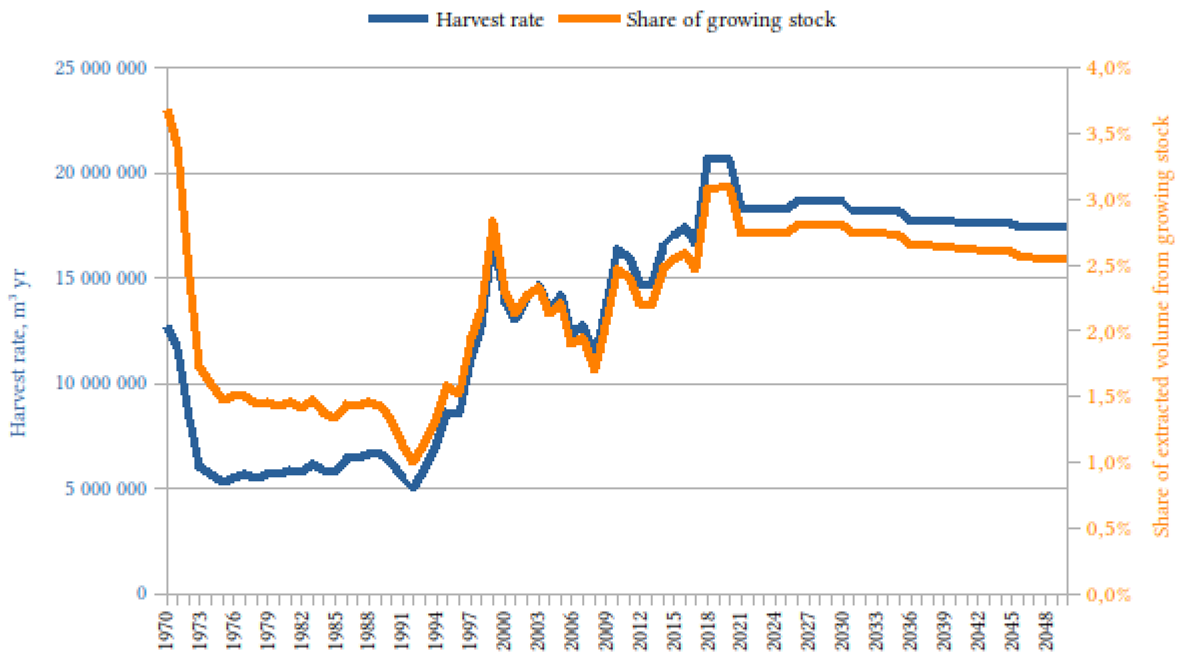

Figure 4: Projections of harvest rate in the Latvia's FRL scenario.

2.3.3.2 Harvest projections under 'Business as usual' scenario

Assumptions applied to estimate harvesting intensity in 'business as usual' scenario, specifically, share of wood actually extracted in final felling in comparison to resources available for final felling and proportion of roundwood extracted in thinning is provided in Table 9 and Table 10. The values provided in the tables represents average conditions in 2011-2016. Share of final felling considerably increases in the 'business as usual' scenario in comparison to the FRL scenario, because of significant impact of windblows in 2005, which led to considerable increase of share of different kinds of selective fellings. Age structure is not considered in the 'business as usual' scenario.

Table 9: Assumptions for the final felling rate from available wood

No	Species	Share of forests at final felling age in the reference period (2011-2016)	Share of available volume extracted in final felling
1.	Aspen	35.9%	3.0%
2.	Grey alder	48.1%	5.1%
3.	Birch	30.3%	4.0%

No	Species	Share of forests at final felling age in the reference period (2011-2016)	Share of available volume extracted in final felling
4.	Other species	6.5%	9.5%
5.	Spruce	21.8%	4.4%
6.	Black alder	15.8%	9.1%
7.	Ash, oak	41.2%	1.2%
8.	Pine	30.0%	4.5%

Table 10: Proportion of harvests outside final felling

No	Species	Share of harvests
1.	Aspen	5.2%
2.	Grey alder	8.1%
3.	Birch	10.8%
4.	Other species	23.4%
5.	Spruce	29.7%
6.	Black alder	12.4%
7.	Ash, oak	15.5%
8.	Pine	19.3%

Harvesting projections in the ‘business as usual’ scenario is based on the recent (2011-2016) forest management statistics provided by the NFI and State forest service. It is assumed that the harvesting intensity will remain at a level reached during 2011-2016. Average species specific values instead of trend, which was applied in the recent projections’ report, is used in the calculation.

Summary of harvest projections and historical data including comparison with the growing stock is shown in Figure 5. According to the figure the proportion of extracted wood is continuously decreasing in spite of slightly increasing harvest rate, which means that the growing stock in forests is continuously increasing in the ‘business as usual’ scenario.

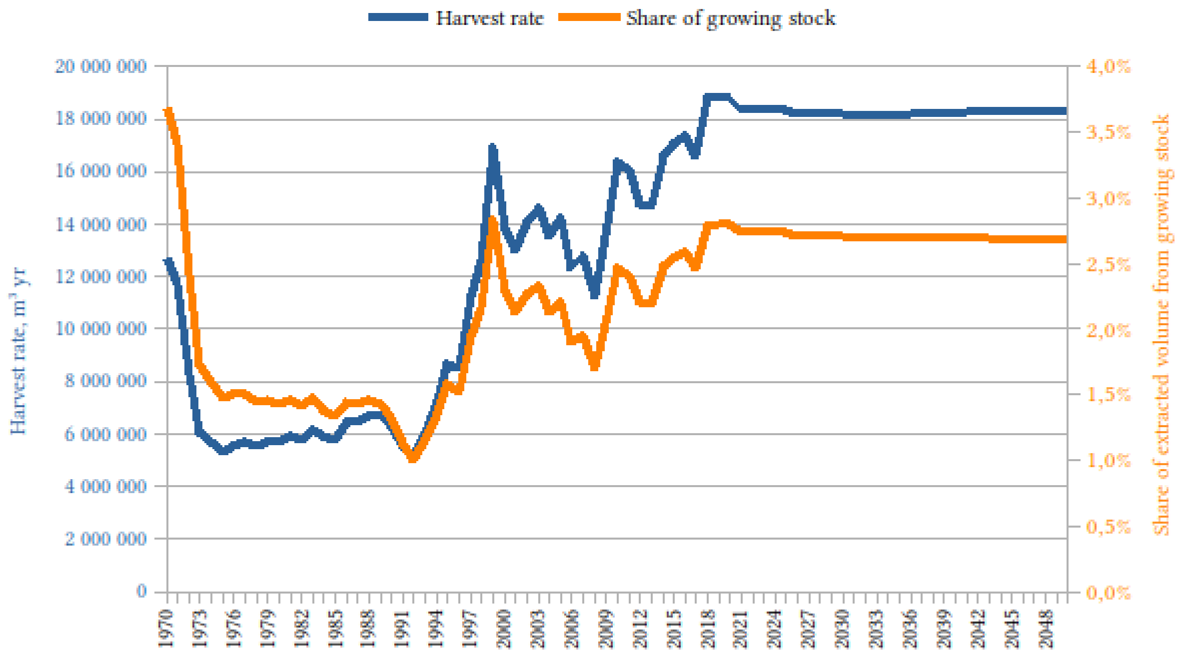

Figure 5: Projections of harvest rate in the 'business as usual' scenario.

Harvesting projections are compared with projections of roundwood demand for local and export markets approving that no significant increase in demand is forecasted, respectively, use of average harvest rates may represent projections of future harvests as a market driven event. More detailed information is provided in report on projections of roundwood and biofuel demand (Krasavcevs, 2018).

2.3.3.3 Harvest projections under 'even age structure' scenario

Harvesting projections in the 'even age structure' scenario is based on the assumption that forests by species reach normal age distribution in 2 generations, respectively, in 80 years for aspen and 200 years for pine. Current (at the end of 2016) species composition is used in the calculation as a starting point and no changes in species composition by area are projected in calculation of the necessary area of final felling. Thinning intensity is assumed to be the same as in 'business as usual' scenario. Average proportion of roundwood extracted in final felling in comparison to roundwood available for final felling is provided in Table 11.

Table 11: Assumptions for the final felling rate

No	Species	Share of available volume extracted in final felling
1.	Aspen	6.2%
2.	Grey alder	8.4%
3.	Birch	8.7%
4.	Other species	15.0%
5.	Spruce	11.8%
6.	Black alder	10.0%

No	Species	Share of available volume extracted in final felling
7.	Ash, oak	8.9%
8.	Pine	5.3%

Summary of harvest projections and historical data including comparison with the growing stock is shown in Figure 5. In spite this scenario in long term would lead to stabilization of age structure of forests in Latvia it also leads to considerable reduction of growing stock because of reduction of proportion of mature stands with wigh growing stock. The harvest stock should be increased to 35 mill. m^3 (4.3% of the growing stock).

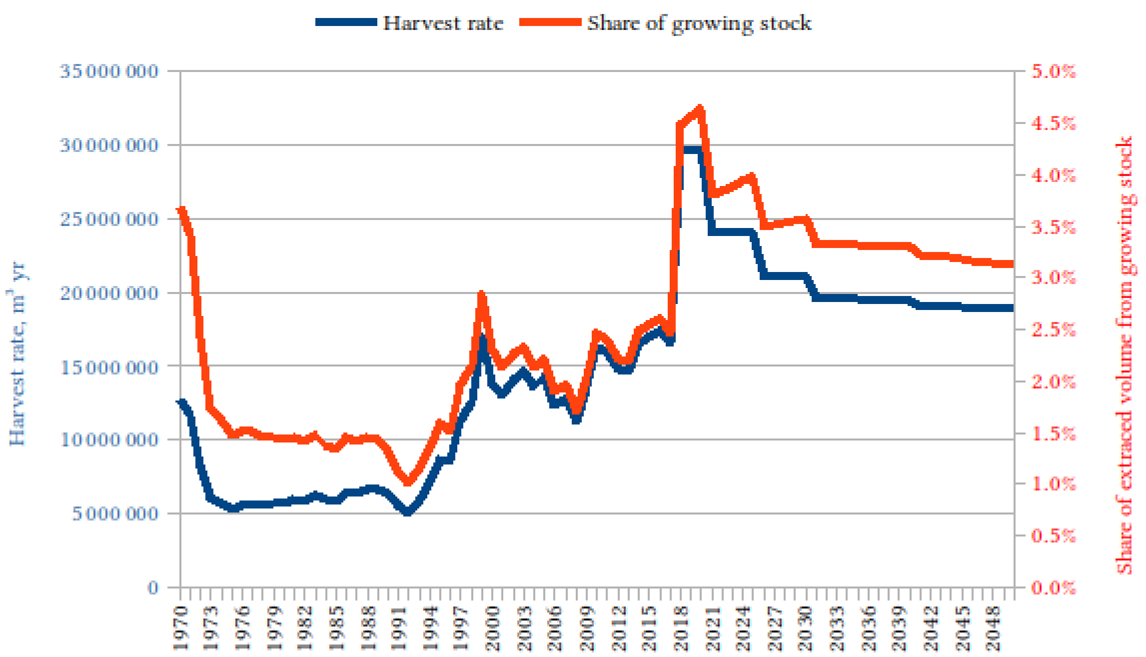

Figure 6: Projections of harvest rate in the 'even age structure' scenario.

If compared to the market projections harvest rate under this scenario considerably exceeds the demand therefore this scenario is not considered further. However study results points to necessity to consider forest ageing in forestry and related policies and development of industries, which can consume the exceeding forest resources to secure sustainable growth in future.

3. DESCRIPTION OF MODELLING APPROACH

The following chapters contains description of approaches, methods and models, including quantitative information, used in the construction of the Latvia's FRL, consistent with the most recently submitted national inventory report and documentary information on sustainable forest management practices and intensity and adopted national policies.

The methods applied to calculate carbon stock changes and GHG emissions in forest lands are available in the 2018 National GHG inventory report (Ministry of Environment protection and Regional Development, 2018).

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

The Latvia's FRL is the expected average annual net removals of greenhouse gases in 2021-2025, based on simulations of the carbon stocks and GHG emissions on managed forest land starting from 2017 assuming the continuation of forest management practices as observed 2000-2009.

In the calculations, the same sample plots from the NFI as in the reporting of the LULUCF sector to the EU and the UNFCCC have been used.

The Latvia's FRL comprise all carbon pools currently reported to the EU and the UNFCCC (above-ground and below-ground living biomass, dead wood, litter and soil organic carbon), as well as other emissions associated to forest land included in these reports (emissions from drained organic soils and biomass burning).

Development of carbon stocks are simulated on plot level using AGM model developed by LSFRI Silava and verified by stratified data by EFDM and spreadsheet model developed as a prototype of the AGM model. Organic soils are simulated using tier 2 emission factors and country specific activity data assuming that the area of organic soils is not reducing due to mineralization during the reporting period. Carbon pools in mineral soils are simulated using Yasso model. Other emissions are based on average emissions 2000-2009 and the state of forests and areas 2016.

The development of carbon stocks have been simulated using the documented forest management practice 2000-2009, including measures in forestry and environmental protection measures aimed at preserving biological diversity. The harvest level in the simulation is set to the intensities of final felling by species in 2000-2009, which are adopted so to avoid ageing of forests and increase of share of over-aged stands. On forest land formally set-aside for nature conservation no harvest is forecasted.

Forest land amount according to GHG projections for 2021-2025 in Latvia is 3084 kha (at the end of period); all of the forest areas are assumed as productive forests. 216 kha of productive forests are protected in a way which prohibits regular supply of wood resources. About 50% of productive forests are managed by Joint Stock Company

“Latvia's State Forests”, the rest are managed by private companies, municipalities and individuals.

3.2 Documentation of data sources as applied for estimating the forest reference level

The assumptions in Latvia's FRL are based on the forest management variables provided by the National forest inventory (NFI) and Stand-wise forest inventory. Considering that the NFI is started in 2004, the situation in Latvian forests is extrapolated to 2000 using the Stand-wise inventory, particularly, area of clear-felling, share of selective felling in final felling and area of commercial and pre-commercial thinning, as well as area of sanitary felling is taken from the Stand-wise inventory and extrapolated to growing stock in mature stands and intensities of thinning identified during the 1st (2004-2008), the 2nd (2009-2013) cycle of the NFI and the 1st year of the 3rd NFI cycle.

During the 1st cycle of the NFI all fresh (up to 5 years old) stumps were measured in all NFI plots in forest land providing opportunity to estimate intensity of commercial thinning and volumes extracted in different types of harvests. Country specific conversion factors were elaborated to recalculate stump diameter to diameter of trees at 1.3 m height (Liepins & Liepins, 2015). After calculation of diameter the standard NFI methodology was applied to estimate extracted volume. An important factor, which had to be determined in recalculation of historical data, was dominant species and stand age in previous generation of trees, if the final felling was done between 2000 and the 1st visit to the NFI plot in 2004-2008. In the most cases it was possible using stump measurement data; however, in some cases dominant species or age of stand or both parameters could not be identified. In such cases probability of distribution of dominant species in forest regeneration described in further chapters was used and the most common final felling age of the selected species was assumed. Harvested stock were extrapolated using the average values of growing stock at certain age decade depending from site type, site index and dominant species.

Different approach was used to estimate harvested stock in the period between 2004 and 2009. NFI data from the 2nd and 3rd cycle (mortality and harvesting in NFI plots) were used to estimate volume of recently died and extracted trees. It was assumed that the half of the harvesting events observed in the NFI plots measured 1st time in 2004 and 2nd time – in 2009 took place before middle of 2006 and the rest – in the second half of 2006, 2007 and 2008. Similarly harvesting events were distributed for all years of the NFI cycle.

After application of the harvesting estimates growing stock and other parameters of the stand in all NFI plots in forest lands were recalculated to 2000. The mortality rates were developed according to data obtained in comparison of the 1st and 2nd NFI plots. The mortality equations are dominant species, age, site index and basal area specific, respectively, changes in any of these parameters will affect mortality rate.

The model assumptions are built for 3 scenarios, from which only the ‘business as usual’ and Latvia's FRL scenario are further evaluated:

- **basic forest management scenario (‘business as usual’)**, assuming continuation of forest management practice in 2011-2016, respectively harvest rates depends only from availability of wood resources for certain type of felling in forest stands with different dominant species assuming that the specific share of the forest area (average values in 2011-2016) available for specific felling are extracted in 2021-2030. Area and type of sanitary felling are estimated according to forest age, species and stand type composition;
- **sustainable forest management scenario (Latvia's FRL scenario)**, assuming, in contrast to the basic scenario, that the harvesting rate in final felling is adopted to species specific age structure of forests and increases in case if the share of over-mature stands is growing if the basic scenario, respectively the sustainable forest management scenario avoids ageing of forests. Assumptions characterizing forest management in 2000-2009 are applied in calculations);
- **sustainable forest management scenario aiming at harmonized age structure**, in contrast to previous scenario, adopts harvest rate to the age structure of forest stands so that even, species specific age structure can be reached in 2 rotations. This scenario conforms to the principles applied in projections of sustainable harvesting stock in state forests by the State forest service. This scenario, as well as the sustainable forest management scenario, do not considers changes of dominant species after forest regeneration, respectively, application of the probabilities described in further chapters will affect the species composition.

All forests are divided into 46 primary groups (strata) in the projections according to ownership and stand type characterized by soil material (peat or mineral soil), fertility and water regime (naturally dry, drained or naturally wet). Primary groups then are divided into 5 sub-groups depending from management regime – production forests with no nature conservation related management restrictions and protected forests with 3 levels of the management limitations (Figure 7).

Calculations with AGM model are done at a single NFI plot level (about 8000 plots in total) and summarized in strata before calculations with spreadsheet model and EFDM model. Single plot calculations are summarized into strata after calculation, if AGM model is used.

3.2.1 Documentation of stratification of the managed forest land

No stratification is used in the Latvia’s National GHG inventory for LULUCF sector for primary calculations. After calculation of stock changes in living and dead biomass, sample plots are stratified according to soil parent material and water regime to calculate soil carbon stock changes using Yasso model or fixed emission factors (in organic soils).

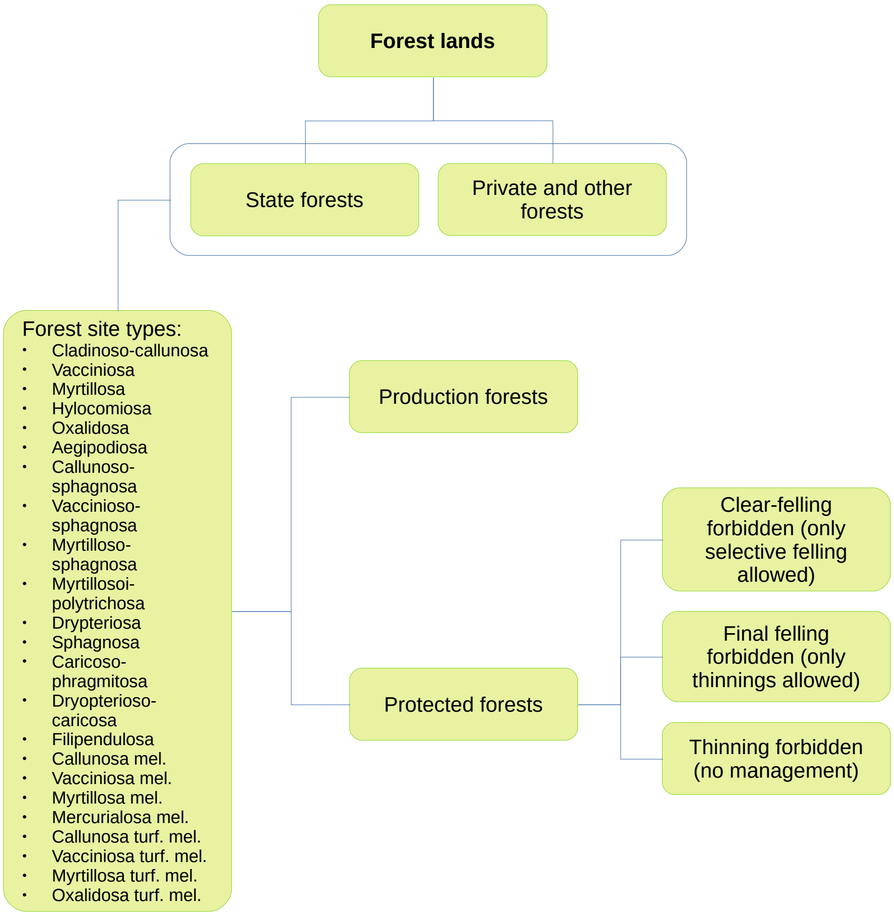

Figure 7: Identified categories (strata) of forests.

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

In modelling of Latvia's FRL the harvest level is set to species specific average of annual available stock on managed forest lands for wood supply (Table 7). In productive forests that are left for nature conservation no harvesting is allowed therefore in modelling their development is projected as continuous cover forestry without management activities. The harvests outside final felling are calculated as a proportion of those harvests by volume in comparison to final felling in 2000-2009 according to the State forest service data (Table 8). More detailed information of forest practices is provided in the following chapter.

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

The Latvia’s FRL is elaborated using AGM model providing projections of growing stock, mortality, increment and harvests in forest land. The basic assumptions in AGM model are probabilities of forest regeneration method and dominant species depending from stand type and ownership, probability of early tending and pre-commercial thinning and target species depending from stand type, forest regeneration method, dominant species during the regeneration stage and ownership, probability and intensity of commercial thinning depending from stand type, dominant species and ownership, probability final felling depending from above-mentioned parameters and probability and type of sanitary felling (determined by above-mentioned parameters and age of forest stand). AGM is applied at a level of NFI plot or a sector (sector is part of a plot, if plot is split into pieces representing different land uses). Harvest rate in final felling is pre-determined in calculation of the Latvia's FRL so that area of mature forest stands of different tree species is not increasing in 2030 in comparison to average value in 2000-2009. Data on increments, mortality and harvests (5 years totals) obtained by AGM model are interpolated to annual values and feed into EPIM model, which transforms these data into carbon stock changes and GHG emissions.

3.3.1 Forest regeneration

Species suitable for the forest regeneration and corresponding minimal permitted number of trees in regenerated stands according to legal documents being in force in 2000 are shown in Table 12.

Table 12: Tree species used in forest regeneration and corresponding minimal number of trees permitted in forest stands approved as regenerated

Species	Species ID	Minimal number of trees in regenerated stands
Pine	1	3000
Spruce	3	2000
Birch	4	2000
Alder	6	2000
Aspen	8	2000
Grey alder	9	2000
Oak	10	1500
Ash	11	1500
Linden	12	2000
Larch	13	2000
Elm	16	1500
Beech	17	1500
Hornbeam	18	1500
Poplar	19	2000
Willow	20	2000
Goat willow	21	2000
Fir	23	2000
Maple	24	1500
Rowan	32	2000
Cherry	56	2000

The probability of artificial forest regeneration is modelled separately for state and other forests according to data provided by the State forest service for the period between 2000 and 2009[4] (Table 13). The AGM model assumes that artificial regeneration takes place after final felling of pine, spruce, birch and aspen. Probability of regeneration with each species is modelled separately for different forest owners' groups (state and other forests) according to data provided by the State forest service for the period between 2000 and 2009[4] (Table 14).

Table 13: Probability of artificial forest regeneration depending from dominant tree species[4]

Forest type	Other forests	State forests
Cladinoso-callunosa	0.6686	0.7942
Cladinosa-callunosa	0.4945	0.7603
Vaccinosa	0.4679	0.8374
Myrtillosa	0.2750	0.8867
Hylocomiosa	0.1189	0.6437
Oxalidosa	0.0596	0.2126
Aegipodiosa	0.6860	0.5188
Callunoso-sphagnosa	0.3580	0.7325
Vaccinioso-sphagnosa	0.1434	0.6169
Myrtilloso-sphagnosa	0.0609	0.3016
Myrtillosoi-polytrichosa	0.0316	0.1173
Drypteriosa	0.0500	0.0981
Sphagnosa	0.0565	0.1002
Caricoso-phragmitosa	0.0410	0.0628
Dryopterioso-caricosa	0.0500	0.0474
Filipendulosa	0.7823	0.9153
Callunosa mel.	0.5945	0.8797
Vacciniosa mel.	0.2427	0.8074
Myrtillosa mel.	0.0959	0.4188
Mercurialosa mel.	0.1510	0.4686
Callunosa turf. mel.	0.2520	0.7044
Vacciniosa turf. mel.	0.1422	0.5580
Cladinosa-callunosa	0.0878	0.3542

Table 14: Probability of dominant trees species in case of artificial forest regeneration by sowing or planting by forest type[4]

Forest type	State forests			Other forests			
	pine	spruce	birch	pine	spruce	birch	aspen
Cladinosa-callunosa	1			1			

4 http://www.vmd.gov.lv/valsts-meza-dienests/statiskas-lapas/publikacijas-un-statistika/meza-statistikas-cd?nid=1809#jump

Forest type	State forests			Other forests			
	pine	spruce	birch	pine	spruce	birch	aspen
Vaccinosa	1			1			
Myrtillosa	1			1			
Hylocomiosa	0.5026	0.4769	0.0205	0.2799	0.6752	0.0449	
Oxalidosa		0.9548	0.0452		0.9141	0.0571	0.0288
Aegipodiosa		0.8538	0.1462		0.8124	0.1155	0.0721
Callunoso-sphagnosa	1			1			
Vaccinioso-sphagnosa	1			1			
Myrtilloso-sphagnosa	0.5142	0.4502	0.0356	0.2438	0.6831	0.0731	
Myrtillosoi-polytrichosa	0.0142	0.8548	0.1310	0.0263	0.8956	0.0726	0.0055
Drypteriosa		0.9349	0.0651		1.0000		
Sphagnosa	1			1			
Caricoso-phragmitosa	0.5457	0.2530	0.2013	0.1860	0.5823	0.2317	
Dryopterioso-caricosa	0.0580	0.7191	0.2229	0.0239	0.7122	0.2639	
Filipendulosa		0.8113	0.1887	0.1139	0.8481	0.0380	
Callunosa mel.	1			1			
Vacciniosa mel.	1			1			
Myrtillosa mel.	0.4409	0.5162	0.0429	0.2845	0.6381	0.0774	
Mercurialosa mel.		0.9021	0.0979		0.7825	0.1792	0.0383
Callunosa turf. mel.	1			1			
Vacciniosa turf. mel.	1			1			
Myrtillosa turf. mel.	0.4521	0.4437	0.1042	0.1980	0.6322	0.1698	
Oxalidosa turf. mel.		0.7629	0.2371		0.7745	0.2060	0.0195

3.3.2 Forest thinning

The age and dominant tree height suitable for different types of thinning (tending, pre-commercial thinning and commercial thinning) are defined in the program for different species (Table 15). Ownership is not considered in this assumption. The interval and intensity of thinning is also defined in the program using the NFI data.

Table 15: Threshold values limiting height of trees and age of stand limiting probability of different thinnings

Dominating tree species	Early tending				Pre-commercial thinning				Commercial thinning			
	Hmin	Hmax	Amin	Amax	Hmin	Hmax	Amin	Amax	Hmin	Hmax	Amin	Amax
Pine	0.1	1.9	1	5	2.0	11.9	6	40	12.0	—	—	80
Spruce	0.1	1.9	1	5	2.0	11.9	6	40	12.0	—	—	60
Birch	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Alder	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Aspen	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	30

Dominating tree species	Early tending				Pre-commercial thinning				Commercial thinning			
	Hmin	Hmax	Amin	Amax	Hmin	Hmax	Amin	Amax	Hmin	Hmax	Amin	Amax
Grey alder	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	30
Oak	0.1	1.9	1	5	2.0	11.9	6	40	12.0	—	—	80
Ash	0.1	1.9	1	5	2.0	11.9	6	40	12.0	—	—	60
Linden	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Larch	0.1	1.9	1	5	2.0	11.9	6	40	12.0	—	—	80
Elm	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Beech	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Hornbeam	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Poplar	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	30
Willow	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	30
Goat willow	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	30
Fir	0.1	1.9	1	5	2.0	11.9	6	40	12.0	—	—	60
Maple	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Rowan	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Cherry	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60

It is possible to define in more detail how often, by what tree stand criteria and with what intensity the thinning is performed.

3.3.2.1 Early tending

In addition to age and height restrictions (Table 15) it is possible to define how often the early tending is modelled sorting by property type (state and other forests), regeneration method (artificially or naturally) and forest type (Table 16).

Table 16: Number of early tending by origin of the forest stand, ownership and forest type

Forest type	Naturally regenerated tree stands		Anthropogenically regenerated tree stands	
	State forests	Other forests	State forests	Other forests
Cladinoso-callunosa	2	0	3	2
Vacciniosa	2	0	3	2
Myrtillosa	2	0	3	2
Hylocomiosa	2	0	3	2
Oxalidosa	2	0	3	2
Aegipodiosa	2	0	3	2
Callunoso-sphagnosa	2	0	3	2
Vaccinioso-sphagnosa	2	0	3	2
Myrtilloso-sphagnosa	2	0	3	2
Myrtillosoi-polytrichosa	2	0	3	2
Drypteriosa	2	0	3	2
Sphagnosa	2	0	3	2

Forest type	Naturally regenerated tree stands		Anthropogenically regenerated tree stands	
	State forests	Other forests	State forests	Other forests
Caricoso-phragmitosa	2	0	3	2
Dryopterioso-caricosa	2	0	3	2
Filipendulosa	2	0	3	2
Callunosa mel.	2	0	3	2
Vacciniosa mel.	2	0	3	2
Myrtillosa mel.	2	0	3	2
Mercurialosa mel.	2	0	3	2
Callunosa turf. mel.	2	0	3	2
Vacciniosa turf. mel.	2	0	3	2
Myrtillosa turf. mel.	2	0	3	2
Oxalidosa turf. mel.	2	0	3	2

3.3.2.2 Pre-commercial thinning

It is possible to define what ranges of height and age of the dominating tree species of the 1st storey of the tree stand thinning is planned for (Table 15, Cabinet of Ministers of Republic of Latvia, 2012).

It is possible to define what stand density the thinning is modelled for and proportionally how many stands are to be thinned in the current five year period in accordance with the criteria (Table 17). The stand density at which pre-commercial thinning is planned is determined according to the Joint Stock Company "Latvia state forests" guidelines for the forest thinning.

Table 17: Indicators for planning pre-commercial thinning

Type of property	Density[5] at which pre-commercial thinning is planned	Proportion of stands to be thinned in the five year period	Maximum number of pre-commercial thinning
State forest	0.90	0.60	2
Other forests	0.90	0.40	1

The program assumes that after thinning there will be 100-125% of trees in comparison to optimal number of trees (AS 'Latvijas valsts meži', 2008).

The program allows for defining tree species suitable for the forest type as well as order them in preferable order of priority, therefore pre-commercial thinning will be modelled so as to achieve pure stands of high priority tree species. All tree and bush species can be separated into 3 groups (Table 18):

- tree species which can form a forest stand and can be target tree species:
    - tree species (priority code 1-8) which are defined in the priority tree species list,

[5] Number of trees in the First story in comparison to normal number of trees.

    - tree species (11) which are not defined in the priority tree species list, but can be target, tree species where they already are the dominating tree species, however, if they are not the dominating tree species they are left in quantities that do not interfere with the growth of target tree species trees,
    - tree species (9) which can be target tree species in cases where species of the two former groups cannot form a forest stand (N<Nmin),
- tree species (33) which cannot form a forest stand and cannot be target tree species, but are left in the forest stand in quantities that do not interfere with the growth of the target tree species,
- bush and tree species (22) which are removed completely in pre-commercial thinning.

Table 18: Target tree species priority groups[6] by forest type

Tree species	Forest stand type																						
	Cladinoso-callunosa	Vacciniosa	Myrtillosa	Hylocomiosa	Oxalidosa	Aegipodiosa	Callunoso-sphagnosa	Vaccinioso-sphagnosa	Myrtilloso-sphagnosa (9)	Myrtillosoi-polytrichosa (10)	Drypteriosa (11)	Sphagnosa	Caricoso-phragmitosa	Dryopterioso-caricosa	Filipendulosa	Callunosa mel.	Vacciniosa mel.	Myrtillosa mel.	Mercurialosa mel.	Callunosa turf. mel.	Vacciniosa turf. mel.	Myrtillosa turf. mel.	Oxalidosa turf. mel.
Pine	1	1	1	1	9	9	1	1	1	9	9	1	1	9	9	1	1	1	9	1	1	1	9
Spruce	9	9	9	2	1	1	9	9	2	1	1	9	3	9	9	9	9	2	1	9	9	2	1
Birch	9	9	9	3	3	3	9	9	3	3	3	2	2	1	2	9	9	3	2	9	9	3	2
Alder	9	9	9	9	4	4	9	9	9	4	4	9	9	2	1	9	9	4	4	9	9	4	4
Aspen	9	9	9	9	6	6	9	9	9	6	6	9	9	9	9	9	9	9	6	9	9	9	6
Grey alder	9	9	9	9	8	8	9	9	9	7	7	9	9	9	9	9	9	9	9	9	9	9	9
Oak	11	11	11	4	2	2	11	11	4	2	2	11	11	11	11	11	11	11	3	11	11	11	3
Ash	9	9	9	9	5	5	9	9	9	5	5	9	9	9	3	9	9	9	5	9	9	9	5
Linden	9	9	9	9	7	7	9	9	9	9	9	9	9	9	4	9	9	9	7	9	9	9	7
Elm	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Beech	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Hornbeam	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Poplar	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11

6 1-9 – Order of target tree species (1 – highest priority, 9 – lowest priority); 11 – if the species is the dominating one, then it is the target species, if it is not, then it is left in quantities that do not interfere with the growth of the target species; 22 – tree and bush species which are removed completely in pre-commercial thinning; 33 – tree species which are left in quantities that do not interfere with the growth of the target species.

Tree species	Forest stand type																						
	Cladinoso-callunosa	Vacciniosa	Myrtillosa	Hylocomiosa	Oxalidosa	Aegipodiosa	Callunoso-sphagnosa	Vaccinioso-sphagnosa	Myrtilloso-sphagnosa (9)	Myrtillosoi-polytrichosa (10)	Dryypteriosa (11)	Sphagnosa	Caricoso-phragmitosa	Dryopterioso-caricosa	Filipendulosa	Callunosa mel.	Vacciniosa mel.	Myrtillosa mel.	Mercurialosa mel.	Callunosa turf. mel.	Vacciniosa turf. mel.	Myrtillosa turf. mel.	Oxalidosa turf. mel.
Willow	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Goat willow	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
Cherry	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Maple	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Juniper	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
Rowan	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Crab apple	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
Hawthorn	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
Other conifers	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Other broad leaved trees	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22

3.3.2.3 Commercial thinning

It is defined in the program at which stand density thinnings are modelled and what is proportion of stands conforming to criteria of stands suitable for thinning, which will be thinned during current 5 years period (Table 19).

Table 19: Indicators of commercial thinning planning

Type of property	Density[7] at which thinning is planned	Proportion of stand thinned in current five year period	Maximum number of commercial thinning
State forests	0.85	0.60	3
Other forests	0.85	0.40	3

It is possible to define a range of basal area after thinning, in the default setting it is 100-125% of the minimum basal area listed in regulations (Cabinet of Ministers of Latvia, 2012b). The program allows to define various types of commercial thinning (NG; if neutral selection, then NG=1.0; if thinning from below, then NG>1.0; if thinning from top, then NG<1.0) and their proportion (Table 20). It is also possible to define the proportion of every type of thinning i.e. the area where every type of thinning is carried out on is proportional to the total area thinning is carried on. These indicators

7 The proportion of basal area to a normal basal area in the 1st storey.

are sorted by type of property.

Table 20: Type and proportion of commercial thinning

Type of property	Type of Commercial thinning	NG	Proportion
State forests	Top down	0.85	0.00
	Neutral	1.00	0.00
	Bottom up	1.15	1.00
Other forests	Top down	0.85	0.00
	Neutral	1.00	0.00
	Bottom up	1.15	1.00

It is possible to change the suitability of tree species to the forest type (Table 21), which directly impacts the proportion of species in the tree stand after commercial thinning.

Table 21: Priority group (suitability) of tree species according to forest type[8]

Forest type	Pine	Spruce	Birch	Alder	Aspen	Grey alder	Oak	Ash	Linden	Larch	Elm	Beech	Hornbeam	Poplar	Willow	Goat willow	Fir	Maple	Cherry	Other
Cladinoso-callunosa	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vacciniosa	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myrtillosa	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hylocomiosa	1	1	1	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	0	0
Oxalidosa	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0
Aegipodiosa	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	0
Callunoso-sphagnosa	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vaccinioso-sphagnosa	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myrtilloso-sphagnosa	1	1	1	0	0	0	1	1	0	1	0	0	0	0	0	0	1	0	0	0
Myrtillosoi-polytrichosa	0	1	1	1	1	1	1	1	0	1	0	0	0	1	0	0	1	0	0	0
Drypteriosa	0	1	1	1	1	1	1	1	0	1	0	0	0	1	0	0	1	0	0	0
Sphagnosa	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Caricoso-phragmitosa	1	1	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Dryopterioso-caricosa	0	1	1	1	0	0	1	1	0	1	0	0	0	0	0	0	1	0	0	0
Filipendulosa	0	1	1	1	0	0	1	1	0	1	0	0	0	0	0	0	1	0	0	0

8 1 – tree species suitable for forest type, 0 – tree species unsuitable for forest type.

Forest type	Pine	Spruce	Birch	Alder	Aspen	Grey alder	Oak	Ash	Linden	Larch	Elm	Beech	Hornbeam	Poplar	Willow	Goat willow	Fir	Maple	Cherry	Other
Callunosa mel.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vacciniosa mel.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myrtillosa mel.	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Mercurialosa mel.	0	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	1	1	1	0
Callunosa turf. mel.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vacciniosa turf. mel.	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Myrtillosa turf. mel.	1	1	1	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0
Oxalidosa turf. mel.	0	1	1	1	1	0	1	1	1	1	1	1	1	1	0	0	1	1	1	0

3.3.3 Final felling

The program allows to define the final felling age and diameter. In the default setting the age and diameter at which final felling is carried out is set at values listed in current regulation (Table 22, Cabinet of Ministers of Latvia, 2012b; Parliament of the Republic of Latvia, 2000).

Table 22: Age and diameter of final felling

Tree species	Species ID	Final felling age (years) depending on site index			Final felling diameter (cm) depending on site index			
		0 and 1	2 and 3	4; 5 and 6	0	1	2	3
Pine	1	101	101	121	39	35	31	27
Spruce	3	81	81	81	31	29	29	27
Birch	4	71	71	51	31	27	25	22
Alder	6	71	71	71	999	999	999	999
Aspen	8	41	41	41	999	999	999	999
Grey alder	9	31	31	31	999	999	999	999
Oak	10	101	121	121	999	999	999	999
Ash	11	81	81	81	999	999	999	999
Linden	12	81	81	81	999	999	999	999
Larch	13	101	101	121	999	999	999	999
Other pines	14	101	101	121	999	999	999	999
Other spruces	15	81	81	81	999	999	999	999
Elm	16	81	81	81	999	999	999	999
Beech	17	81	81	81	999	999	999	999

Tree species	Species ID	Final felling age (years) depending on site index			Final felling diameter (cm) depending on site index			
		0 and 1	2 and 3	4; 5 and 6	0	1	2	3
Hornbeam	18	81	81	81	999	999	999	999
Poplar	19	41	41	41	999	999	999	999
Willow	20	31	31	31	999	999	999	999
Goat willow	21	31	31	31	999	999	999	999
Fir	23	81	81	81	999	999	999	999
Maple	24	81	81	81	999	999	999	999
Rowan	32	31	31	31	999	999	999	999
Cherry	56	81	81	81	999	999	999	999

It is possible to define the final felling area sorted by dominant species and type of property. In the default setting the final felling is modelled for the same volume felled between 2001 and 2009[9] (Table 23).

Table 23: Area of stands harvested in final felling (1000 ha in 5 years period)

Species	State forests	Other forests
Pine	25.347	23.205
Spruce	8.815	28.579
Birch	19.911	33.066
Alder	1.457	2.206
Aspen	6.094	13.999
Grey alder	0.665	22.403
Oak	0.011	0.162
Ash	0.150	0.304
Other species	0.000	0.000
Total	62.446	123.924

It is possible to define the proportion of the area sorted by type of final felling (clear felling, selective felling) and type of property (state and other forests). In the default setting the proportion of final felling area is in accordance with the average values in 2001-2009[10] (Table 24).

Table 24: Proportion of final felling area sorted by type of property and type of final felling

Type of felling	Other forests	State forest
Selective felling	0.1719	0.0647
Clear felling	0.8281	0.9353

9 State forest service statistics CD 2002-2010.
10 State forest service statistics CD 2001-2009.

3.3.4 Sanitary felling

Due to windblown in 2005 the share of sanitary fellings in the first half of the reference period is considerably bigger in comparison to the period 2006-2009. To avoid overestimation of harvesting due to natural disturbances 2005 is excluded from calculation of projections of sanitary fellings.

Depending on the trees species and its decimal age group, it is possible to define a probability of sanitary felling in the tree stand (Table 25). The program allows to define a proportion of selective and sanitary clear felling depending on the dominating tree species in the tree stand which in the default setting is in accordance with the last three years[11] (Table 26).

Harvests due to natural disturbances are not excluded from the projected harvest rate; however, changes in age structure of forests might lead to increase of sanitary felling and, in turn, total harvests in future.

Table 25: Probability of sanitary felling depending on the dominating tree species in the tree stand and its decimal age group

Decimal age group	Pine	Spruce	Birch	Alder	Aspen	Ash	Other species
1	0	0	0	0	0	0	0
2	0.0002	0.0008	0.0004	0.0003	0.0004	0	0
3	0.0010	0.0067	0.0022	0.0010	0.0011	0	0
4	0.0033	0.0200	0.0053	0.0020	0.0020	0	0
5	0.0068	0.0347	0.0083	0.0028	0.0026	0	0
6	0.0108	0.0424	0.0098	0.0032	0.0028	0.0008	0
7	0.0143	0.0407	0.0095	0.0031	0.0026	0.0117	0
8	0.0165	0.0328	0.0079	0.0026	0.0022	0.0478	0
9	0.0173	0.0231	0.0059	0.0020	0.0017	0.0744	0
10	0.0167	0.0147	0.0041	0.0015	0.0013	0.0554	0
11	0.0151	0.0085	0.0026	0.0010	0.0009	0.0231	0
12	0.0129	0.0046	0.0016	0.0007	0.0006	0.0060	0
13	0.0105	0.0024	0.0009	0.0004	0.0004	0.0011	0
14	0.0083	0.0011	0.0005	0.0003	0.0003	0.0001	0
15	0.0063	0.0005	0.0003	0.0002	0.0002	0	0
16	0.0047	0.0002	0.0001	0.0001	-	0	0
17	0.0034	0.0001	0.0001	0.0001	-	0	0
18	0.0024	0	0	0	-	0	0
19	0.0016	0	0	0	-	0	0
20	0.0011	0	0	0	-	0	0

11 State forest service statistics CD 2001-2009, excluding 2006.

Decimal age group	Pine	Spruce	Birch	Alder	Aspen	Ash	Other species
21	0.0007	0	0	0	-	0	0
22	0.0005	0	0	0	-	0	0
23	0.0003	0	0	0	-	0	0
24	0.0002	0	0	0	-	0	0
25	0.0001	0	0	0	-	0	0
26	0.0001	0	0	0	-	0	0
27	0.0001	0	0	0	-	0	0
28	0	0	0	0	-	0	0
29	0	0	0	0	-	0	0
30	0	0	0	0	-	0	0

Table 26: Proportion of selective and clear sanitary felling depending on the dominating tree species in the tree stand

Dominating tree species	Clear sanitary felling	Selective sanitary felling
Pine	0.0290	0.9710
Spruce	0.0545	0.9455
Birch	0.0590	0.9410
Alder	0.0718	0.9282
Aspen	0.0785	0.9215
Ash	0.3193	0.6807

4. FOREST REFERENCE LEVEL

Latvia's FRL is based on assumption of continuation of sustainable forest management practice according to situation in 2000-2009 as described in chapter Balance between anthropogenic emissions by sources and removals by sinks of GHG in the second half of this century (Table 7 and 8, page 28) and chapter Description of the general approach as applied for estimating the forest reference level, page 33.

Latvia's FRL is -54 ktons CO_2 eq yr^{-1} with HWP and 1495 ktons CO_2 eq yr^{-1} if instant oxidation of HWP method is applied to calculation (Figure 8 and 9).

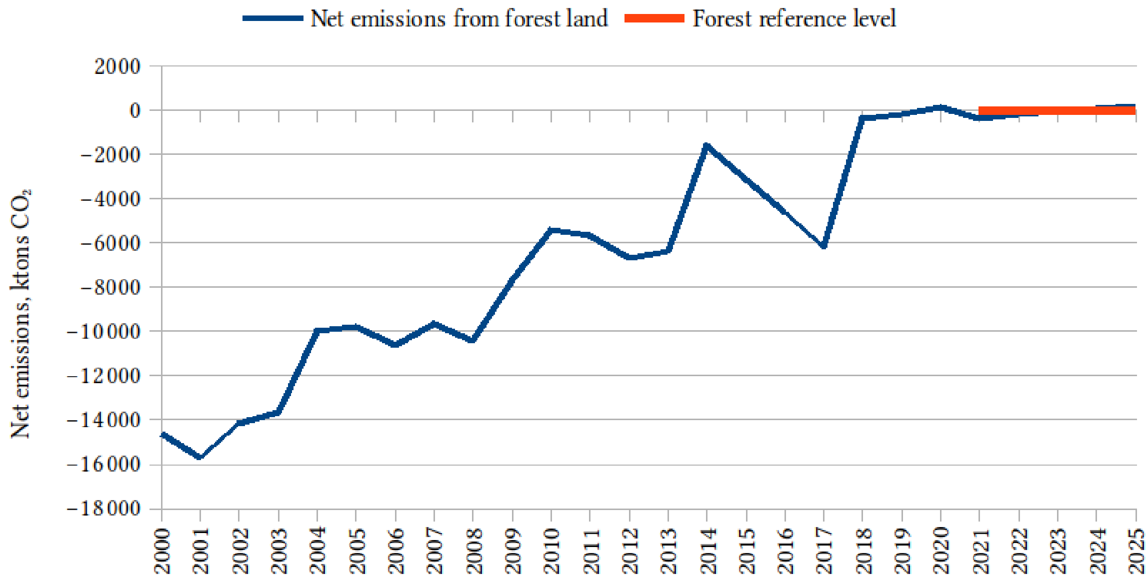

Figure 8: Forest reference level and historical GHG emissions in forest land.

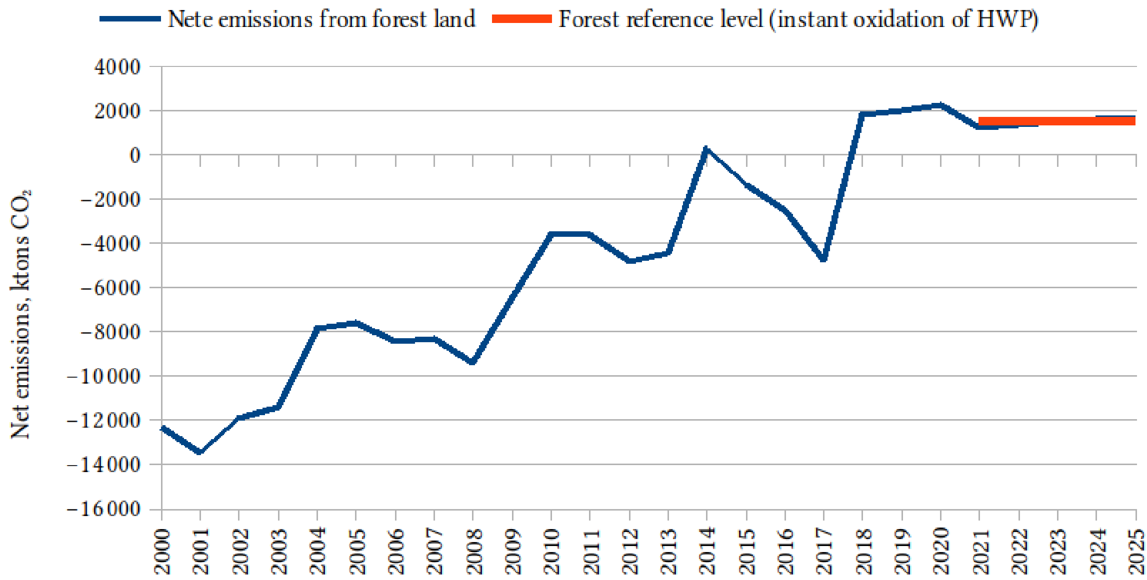

Figure 9: Forest reference level and historical GHG emissions in forest land in case of instantaneous oxidation of HWP.

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

Forest land remaining forest land reported in the 2018 National GHG inventory in 2016, including drained organic soils is considered in calculation of the FRL (Figure 10). The only difference with the GHG inventory report is application of 30 years transition period for afforested lands. Therefore the total area of forest land remaining forest land in the FRL calculation is smaller in comparison to the area reported in the GHG inventory report (Figure 11).

After 2020 area of forest land remaining forest land in FRL calculation increases from 3137 kha to 3178 kha in 2030. No land use changes like afforestation or deforestation are considered between 2021 and 2030 in the FRL scenario. It is assumed in the projections that area of organic soils will not reduce due to mineralization of organic matter.

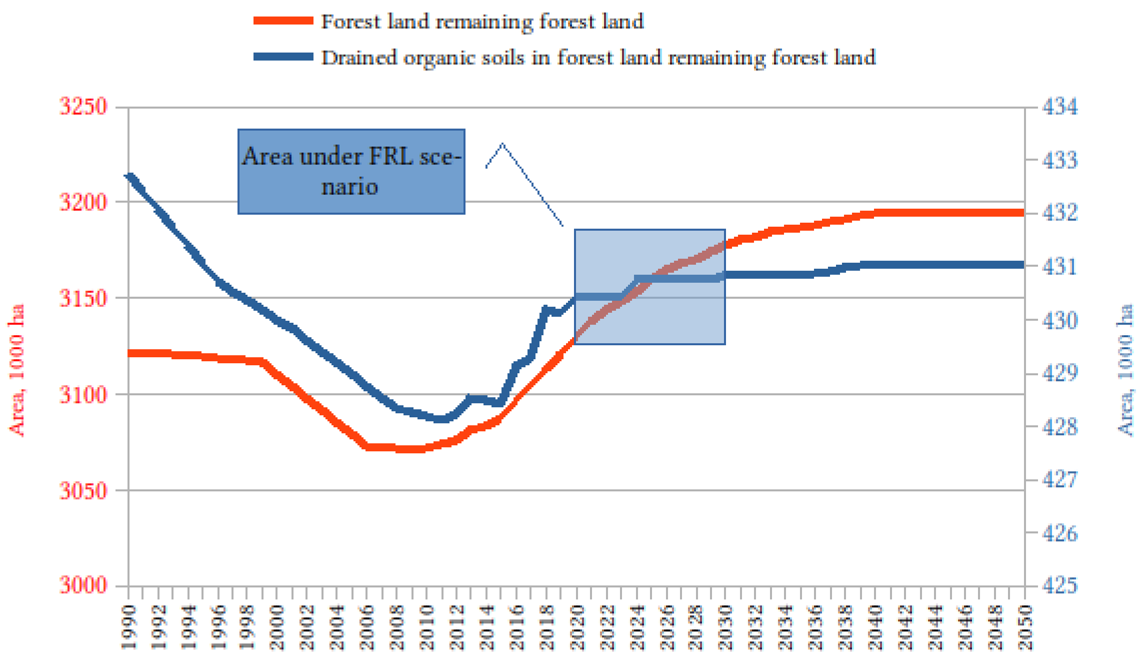

Figure 10: Area of forests considered in FRL calculation.

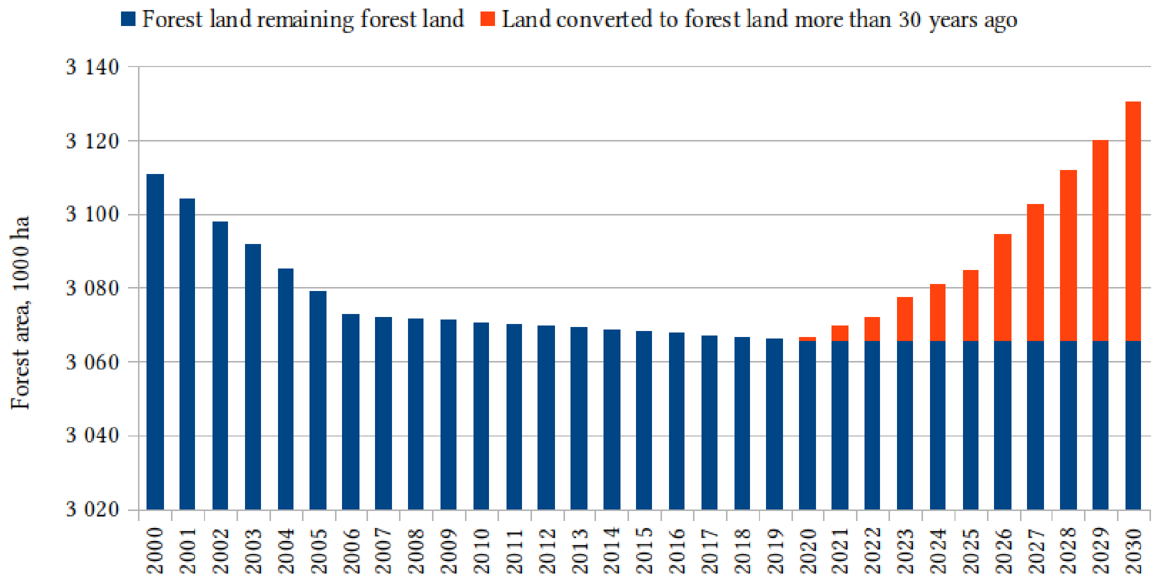

Figure 11: Impact of land converted to forest land on forest area during the reporting period.

Nature conservation areas in forest land remaining forest land are considered in the FRL scenario by intersection of geospatial information of the NFI plots and nature conservation areas provided by the State forest service. Situation at the end of 2016 was used to compare with the NFI plots. Summary of distribution of the forest management restrictions is shown in Figure 12.

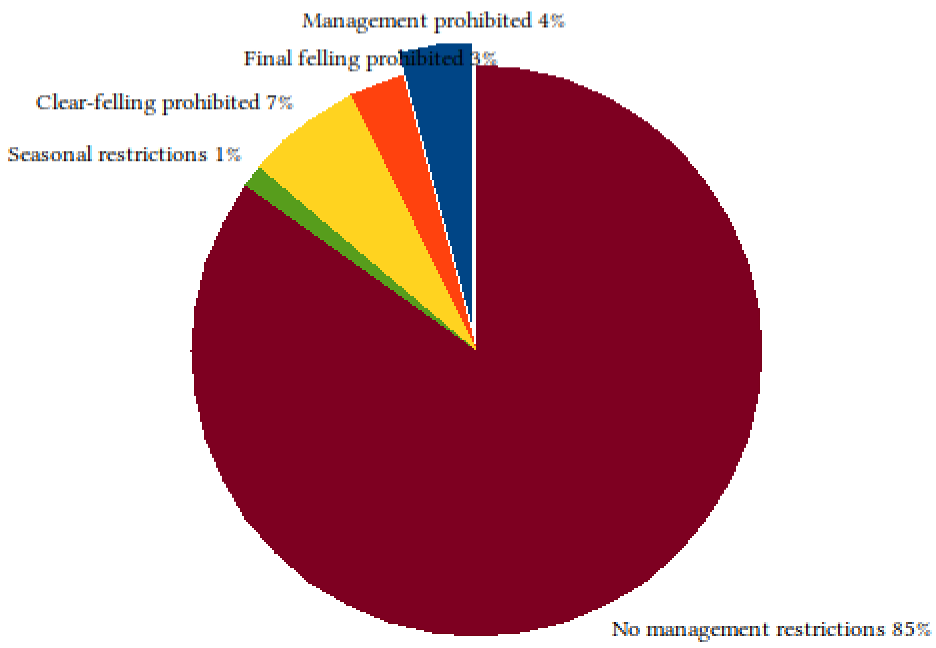

Figure 12: Summary of distribution of forest management restrictions.

Forest characteristics are stratified according to stand type, dominant species, ownership and age class, which are affected by management assumptions. For instance, increment potential is considerably higher in artificially regenerated forests, where thinnings are done according to the good practice guidance. This means that modelled stocks, increments and mortalities may vary within the age class depending from the applied management assumptions. More detailed description of stand parameters is provided in description of AGM model (Šņepsts, Kārkliņa, et al., 2018) and chapter Detailed description of the modelling framework as applied in the estimation of the forest reference level (page 36).

4.1.1 Forest management activities under 'business as usual'

Business as usual scenario is elaborated to estimate harvesting stock under different policies, particularly, continuation of the management practices as they were implemented in 2011-2016.

4.1.1.1 Forest regeneration

It is possible to define tree species suitable for forest regeneration and growing so that the forest stand is considered regenerated. In the default setting these criteria are defined accordingly with current regulations (Cabinet of Ministers of Republic of Latvia, 2012, Table 12).

It is possible to define artificially regenerated area content by forest type and property groups (state and other forests). The default setting models the probability of regenerated clearings sorting by property groups (state and other forests) accordingly with the arithmetic average proportion of artificially regenerated forest stands in 2013-2016[12] (Table 27).

It is possible to define which tree species and how much will be regenerated artificially sorted by forest type and property groups (state and other forests). The default setting allows for pine, spruce, birch, alder and oak to be planted after felling, but it is possible to define other tree species. Every tree species option is modelled sorting by property group (state and other) and forest type accordingly with the arithmetic average proportion of artificially regenerated forest stands in 2013 – 2016 (Table 28).

Table 27: Probability of artificially regenerated forests by forest type[13]

Forest type	Other forests	State forests
Cladinoso-callunosa	0.4789	0.6626
Cladinosa-callunosa	0.6801	0.6877
Vaccinosa	0.5767	0.8321
Myrtillosa	0.2108	0.7869
Hylocomiosa	0.1197	0.3943
Oxalidosa	0.0750	0.1385
Aegipodiosa	0.0000	1.0000
Callunoso-sphagnosa	0.4297	0.7622
Vaccinioso-sphagnosa	0.1599	0.4593

[12] SFS statistikas CD 2013-2016.
[13] Arithmetic average proportion of artificially regenerated forests from in 2013-2016 in the data published by SFS.

Forest type	Other forests	State forests
Myrtilloso-sphagnosa	0.0783	0.1477
Myrtillosoi-polytrichosa	0.0851	0.0435
Drypteriosa	0.0230	0.0675
Sphagnosa	0.0347	0.0928
Caricoso-phragmitosa	0.0827	0.0452
Dryopterioso-caricosa	0.0232	0.0508
Filipendulosa	1.0000	0.9642
Callunosa mel.	0.6729	0.9349
Vacciniosa mel.	0.2643	0.7151
Myrtillosa mel.	0.0884	0.2016
Mercurialosa mel.	0.1770	0.7633
Callunosa turf. mel.	0.3582	0.7783
Vacciniosa turf. mel.	0.1925	0.4976
Cladinosa-callunosa	0.1396	0.2380

Table 28: Probability of regenerated trees species when sowing or planting by forest type[14]

Forest type	State forests					Other forests			
	pine	spruce	birch	black alder	oak	pine	spruce	birch	black alder
Cladinosa-callunosa	1.000					1.0000			
Vaccinosa	1.000					1.0000			
Myrtillosa	1.000					1.0000			
Hylocomiosa	0.552	0.3998	0.0470		0.0004	0.2549	0.7110	0.0340	
Oxalidosa	0.0266	0.8003	0.1578	0.0062	0.0090	0.0169	0.9163	0.0595	0.0073
Aegipodiosa		0.4069	0.5289	0.0271	0.0371		0.8751	0.0742	0.0507
Callunoso-sphagnosa	1.0000					1.0000			
Vaccinioso-sphagnosa	1.0000					1.0000			
Myrtilloso-sphagnosa	0.6268	0.2832	0.0873	0.0027		0.2498	0.7061	0.0354	0.0087
Myrtillosoi-polytrichosa	0.0695	0.6534	0.2570	0.0201		0.0264	0.7613	0.1480	0.0644
Drypteriosa		0.5504	0.4496				0.7820	0.1833	0.0346
Sphagnosa	1.0000					0.4821	0.5179		
Caricoso-phragmitosa	0.6641	0.1808	0.1478	0.0073		0.1963	0.4782	0.2351	0.0905
Dryopterioso-caricosa	0.1906	0.4647	0.2267	0.1179		0.0333	0.5109	0.1738	0.2820
Filipendulosa		0.6093	0.3907				0.4423		0.5577

14 Arithmetic average share of artificially regenerated areas in 2013-2016 in SFS data.

Forest type	State forests					Other forests			
	pine	spruce	birch	black alder	oak	pine	spruce	birch	black alder
Callunosa mel.	1.0000					1.0000			
Vacciniosa mel.	1.0000					1.0000			
Myrtillosa mel.	0.4990	0.3786	0.1200	0.0024		0.3709	0.5561	0.0558	0.0172
Mercurialosa mel.		0.6759	0.2856	0.0280	0.0106		0.7882	0.1378	0.0740
Callunosa turf. mel.	1.0000					1.0000			
Vacciniosa turf. mel.	1.0000					1.0000			
Myrtillosa turf. mel.	0.5062	0.2610	0.2113	0.0215		0.3791	0.4000	0.1859	0.0349
Oxalidosa turf. mel.		0.4101	0.5490	0.0374	0.0035		0.6103	0.2691	0.1206

4.1.1.2 Thinning of forest stand

It is possible define the height and age at which early tending, pre-commercial and commercial thinning is performed (Table 29).

Table 29: Various height and age regulations for thinning

Dominating tree species	Early tending				Pre-commercial thinning				Commercial thinning			
	Hmin	Hmax	Amin	Amax	Hmin	Hmax	Amin	Amax	Hmin	Hmax	Amin	Amax
Pine	0.1	1.9	1	5	2.0	11.9	6	40	12.0	—	—	80
Spruce	0.1	1.9	1	5	2.0	11.9	6	40	12.0	—	—	60
Birch	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Alder	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Aspen	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	30
Grey alder	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	30
Oak	0.1	1.9	1	5	2.0	11.9	6	40	12.0	—	—	80
Ash	0.1	1.9	1	5	2.0	11.9	6	40	12.0	—	—	60
Linden	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Larch	0.1	1.9	1	5	2.0	11.9	6	40	12.0	—	—	80
Elm	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Beech	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Hornbeam	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Poplar	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	30
Willow	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	30
Goat willow	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	30
Fir	0.1	1.9	1	5	2.0	11.9	6	40	12.0	—	—	60
Maple	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Rowan	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60
Cherry	0.1	1.9	1	5	2.0	11.9	6	20	12.0	—	—	60

It is possible to define in more detail how often, by what tree stand criteria and with what intensity the thinning is performed.

Early tending

In addition to age and height restrictions (Table 29) it is possible to define how often the early tending is modelled sorting by property type (state and other forests), regeneration method (artificially or naturally) and forest type (Table 16).

Pre-commercial or young tree stand thinning

It is possible to define what ranges of height and age of the dominating tree species of the 1st storey of the tree stand thinning is planned for (Table 29).

It is possible to define what stand density the thinning is modelled for and proportionally how many stands are to be thinned in the current five year period in accordance with the criteria (Table 17).

Density is calculated with the number of trees in the 1st storey in proportion to the normal number of trees listed in regulations (Cabinet of Ministers of Republic of Latvia, 2007) which is calculated by the AGM in accordance with the dominating species in the 1st storey.

No more than 2 instances of thinning are modelled in state forests, but in other forests no more than one pre-commercial thinning, however, it is possible to change this value.

It is possible to define what number of trees will be left after the pre-commercial thinning. In the default setting 100-125% of the optimal number of trees is modelled to remain (AS ‘Latvijas valsts meži’, 2008), which can be calculated by the AGM program. It is possible to set the minimal number of trees listed in regulations as a reference point as well (Cabinet of Ministers of Latvia, 2012b) which can be calculated by AGM program. The distribution range of remaining number of trees can be changed as well.

The program allows for defining tree species suitable for the forest type as well as order them in preferable order of priority, therefore pre-commercial thinning will be modelled so as to achieve pure stands of high priority tree species. All tree and bush species can be separated into 3 groups (Table 18):

- ✓ tree species which can form a forest stand and can be target tree species:
    - tree species (priority code 1-8) which are defined in the priority tree species list,
    - tree species (11) which are not defined in the priority tree species list, but can be target, tree species where they already are the dominating tree species, however, if they are not the dominating tree species they are left in quantities that do not interfere with the growth of target tree species trees,
    - tree species (9) which can be target tree species in cases where species of the two former groups cannot form a forest stand (N<Nmin),
- ✓ tree species (33) which cannot form a forest stand and cannot be target tree species, but are left in the forest stand in quantities that do not interfere with the growth of the target tree species,

- ✓ bush and tree species (22) which are removed completely in pre-commercial thinning.

Commercial thinning

It is possible to define the minimal height and maximum age at which commercial thinning is planned in the 1st storey of the tree stand (Table 29).

It is possible to define what stand density commercial thinning will be modelled for and how many stands will be thinned in the current five year period according to the criteria (Table 19).

It is possible to define a range of basal area after thinning, in the default setting it is 100-125% of the minimum basal area listed in regulations (Cabinet of Ministers of Latvia, 2012b) which in the program is calculated by the AGM model. When modelling changes in forest resources it is possible to change this reference point (minimal basal area) by modifying this formula or replacing it with another formula in the program.

The program allows to define various types of commercial thinning (NG; if neutral selection, then NG=1.0; if thinning from the bottom up, then NG>1.0; if thinning from the top down, then NG<1.0) and their proportion (Table 20). It is also possible to define the proportion of every type of thinning i.e. the area where every type of thinning is carried out on is proportional to the total area where thinning is carried out. These indicators are sorted by type of property.

It is possible to change the suitability of tree species to the forest type (Table 21) which directly impacts the proportion of species in the tree stand after commercial thinning.

4.1.1.3 Final felling

The program allows to define the final felling age and diameter. In the default setting the age and diameter at which final felling is carried out is set at values listed in current regulation (Cabinet of Ministers of Latvia, 2012b; Parliament of the Republic of Latvia, 2000a, Table 22).

It is possible to define the final felling wood stack and area sorted by type of property. In the default setting the final felling is modelled for the same volume felled in the last five years (Table 30).

Table 30: Volume of final felling

Species	State forests				Other forests	
	proposed area of felling		final felling in the last 5 years		final felling in the last 5 years	
	area, 10^3 ha	wood stock, 10^6 m^3	area, 10^3 ha	wood stock, 10^6 m^3	area, 10^3 ha	wood stock, 10^6 m^3
Pine	33.982	8.7133	34.563	9.3605	27.669	5.7461
Spruce	10.919	3.0493	9.395	2.5685	18.693	3.8388
Birch	37.475	8.8073	25.675	6.8589	44.284	8.2789
Alder	3.208	0.7591	1.126	0.3189	2.993	0.5740
Aspen	6.170	1.7973	6.479	2.0330	12.626	2.4510

Species	State forests				Other forests	
	proposed area of felling		final felling in the last 5 years		final felling in the last 5 years	
	area, 10^3 ha	wood stock, 10^6 m^3	area, 10^3 ha	wood stock, 10^6 m^3	area, 10^3 ha	wood stock, 10^6 m^3
Grey alder			0.734	0.1407	32.221	4.6901
Oak	0.054	0.0109	0.001	0.0004	0.227	0.0321
Ash	0.255	0.0564	0.164	0.0218	0.607	0.0966
Other species			0.014	0.0033	0.249	0.0301
Total	92.063	23.1937	78.151	21.3060	139.570	25.7377

It is possible to define the proportion of the area sorted by type of final felling (clear felling, selective felling) and type of property (state and other forests). In the default setting the proportion of final felling area is in accordance with the last 5 years[15] (Table 31).

Table 31: Proportion of final felling area sorted by type of property and type of final felling

Type of felling	Other forests	State forest
Selective felling	0.1715	0.0560
Clear felling	0.8285	0.9440

4.1.1.4 Sanitary felling

It is possible, depending on the trees species and its decimal age group, to define a probability of sanitary felling in the tree stand (Table 25). The program allows to define a proportion of selective and sanitary clear felling depending on the dominating tree species in the tree stand which in the default setting is in accordance with the last three years[16] (Table 26).

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

Emissions and removals from forests and HWP as shown in GHG inventories and relevant historical data are estimated using methods applied in the National GHG inventory including use of the same activity data and models. The EPIM model was used in both cases to transfer the activity data into GHG emissions and CO_2 removals.

However, there is difference in application of the NFI data in calculations. In the 2018 National GHG inventory 5 years summaries are used till 2013 and moving cycle of NFI is used since 2014, respectively every next year data from the 5 recent NFI measurement years are applied. In the calculation of the FRL stand data obtained in the 1st cycle of the NFI are calculated backwards to 2000 and then all plots are modelled from the same starting point with 5 years step and then interpolated to estimate annual changes.

15 SFS statistics CD 2013-2016.
16 SFS statistics CD 2015-2017.

The results of the model verification using selected number of the NFI sample plots are not affected by wind-blows in 2005 and 2010 are published in a research report available from the internet (Šņepsts, Bārdule, et al., 2018). Further information on forest management practices is provided in chapters Detailed description of the modelling framework as applied in the estimation of the forest reference level (page 36) and Inclusion of the carbon pool of harvested wood products (page 9).

4.3 Projections of future climate conditions

Climate changes (increase of average temperature) are considered in calculations of soil carbon stock changes in mineral soils using Yasso07 model. The applied climate parameters (Figure 13) are published in earlier studies on evaluation of carbon stock changes in soil (Bārdulis, Lupiķis, & Stola, 2017).

Modelling results are used to demonstrate that mineral soils in forest lands are not a net source of GHG emissions (Figure 14), therefore the soil carbon pool, except drained organic soils, is not used in estimation of the Latvia's FRL. Forest growth assumptions (Chapter Description of the general approach as applied for estimating the forest reference level, page 33) and forest growth modelling results under Latvia's FRL scenario are used to determine soil carbon stack changes.

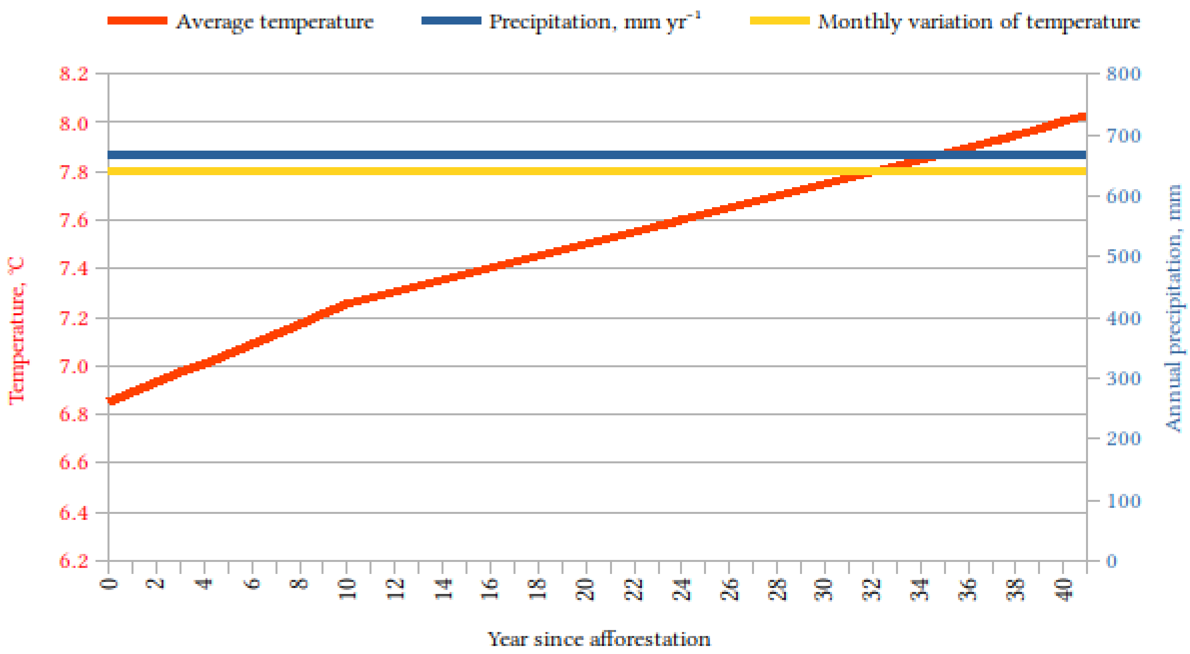

Figure 13: Climate changes considered in soil carbon stock change modelling.

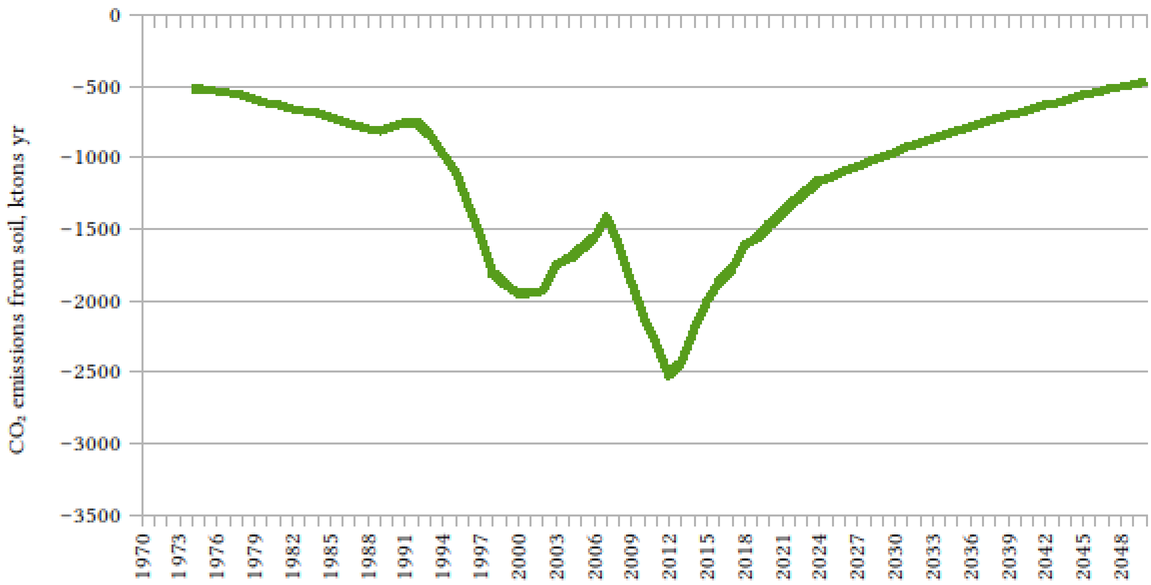

Figure 14: Projections of soil carbon stock changes in mineral soils under Latvia's FRL scenario.

The 30 years transition period is used for land use changes in afforested lands in calculation of the reference level, respectively, all areas afforested since 1990 are transferred from the category land converted to forest land to category forest land remaining forest land after reaching 30 years age. According to Yasso07 modelling results accumulation of carbon continuous for more than 30 years (Figure 15 and 16) in birch, spruce and pine stands, which are the most common tree species in afforested areas. Initial carbon stock is assumed according to average conditions in grassland in Latvia (Bardule, Lupikis, Butlers, & Lazdins, 2017) and assumptions of structure of organic material from earlier studies in Finland (Palosuo, Heikkinen, & Regina, 2015). A 100 years calibration period is applied before afforestation assuming that initial land use is mature forest with average soil carbon stock characteristic for fertile soils (Bārdulis et al., 2017; Lazdiņš, Bārdule, Stola, & Krišāns, 2013).

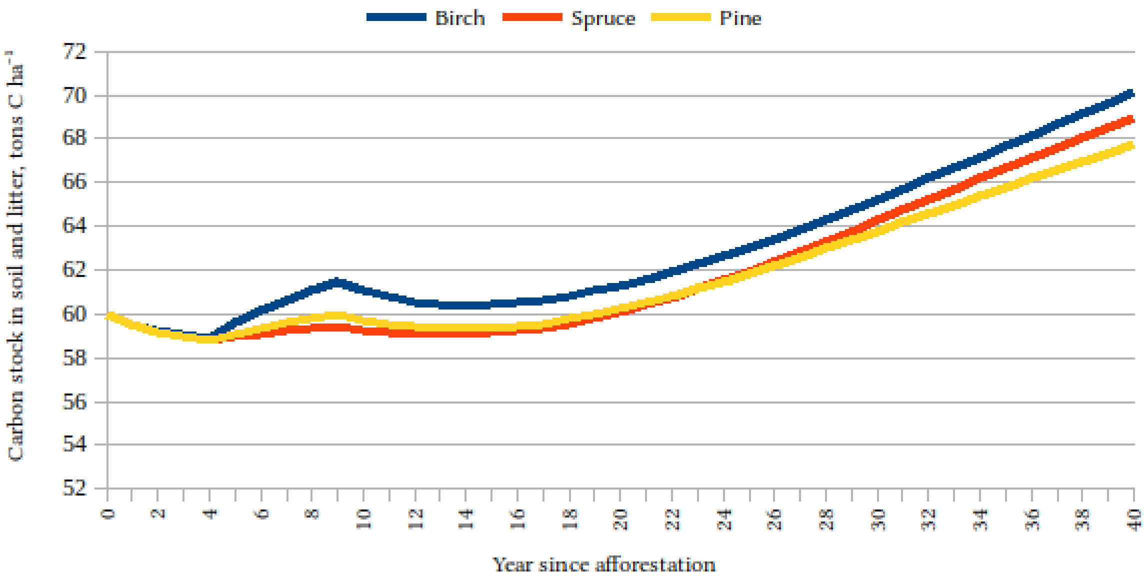

Figure 15: Projections of soil carbon stock in afforested lands.

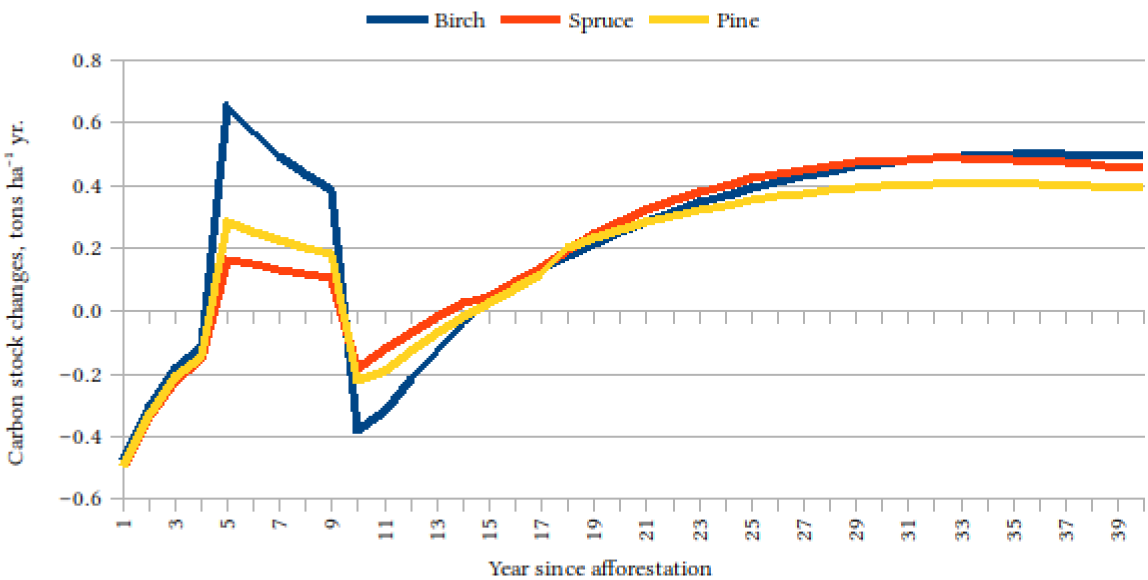

Figure 16: Projections of soil carbon stock changes in afforested lands.

4.4 Calculated carbon pools and greenhouse gases for the forest reference level

Latvia has proposed the 2021-2025 FRL of -54 ktons CO_2 eq yr^{-1} applying the first-order decay function for harvested wood products (HWP) and 1495 ktons CO_2 eq yr^{-1} assuming instantaneous oxidation of HWP. The proposed value consists of net GHG emissions per year from organic soils and forest fires and accumulations of CO2 eq. in dead wood, HWP and living biomass (Figure 17).

According to the Figure 18 implementation of the FRL scenario will lead to continuous increase of carbon stock in forest carbon pools, especially in dead wood and living biomass carbon pool.

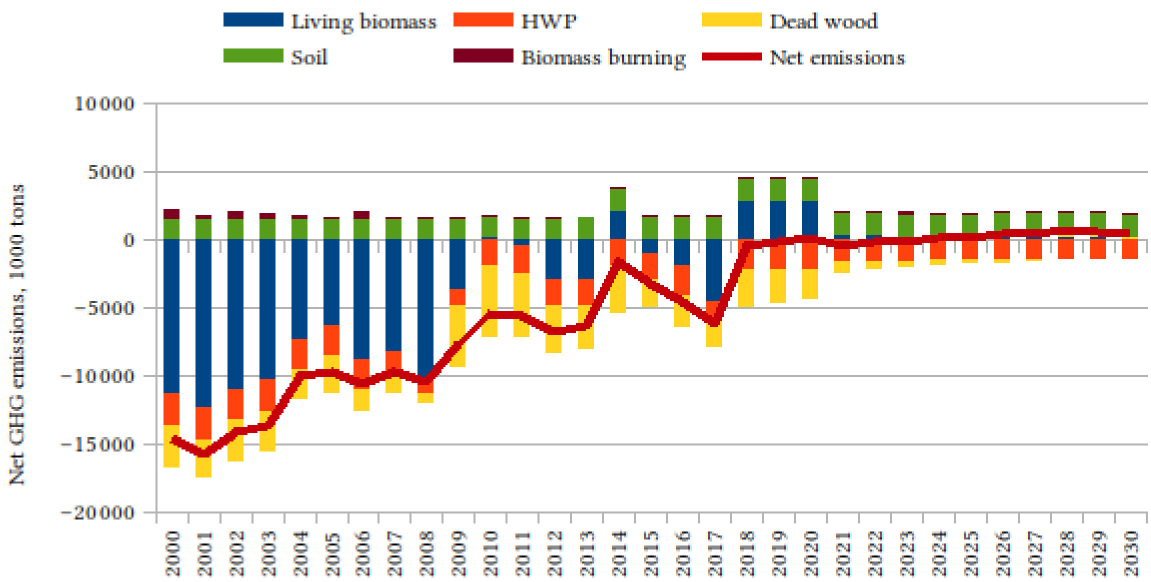

Figure 17: Projection of net GHG emissions in forest lands.

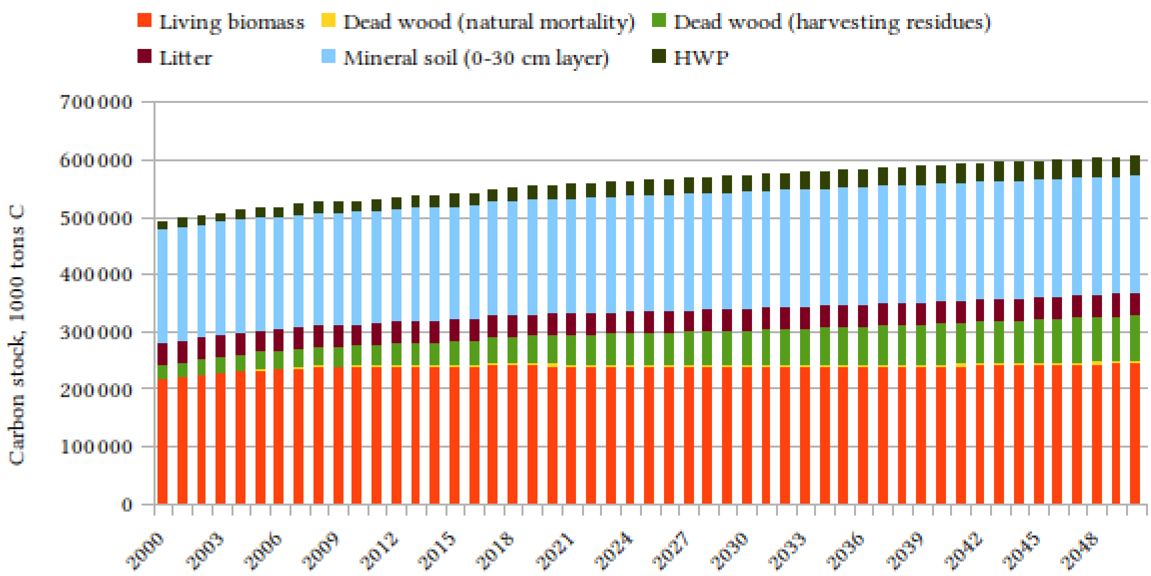

Figure 18: Projection of carbon stock in forest lands.

Projections of annual gross increment, mortality, harvest rate and growing stock values for the period between 2000 and 2050 in Figure 19 demonstrates continues increase of growing stock in forests in spite of increase of harvest rate between 2010 and 2020.

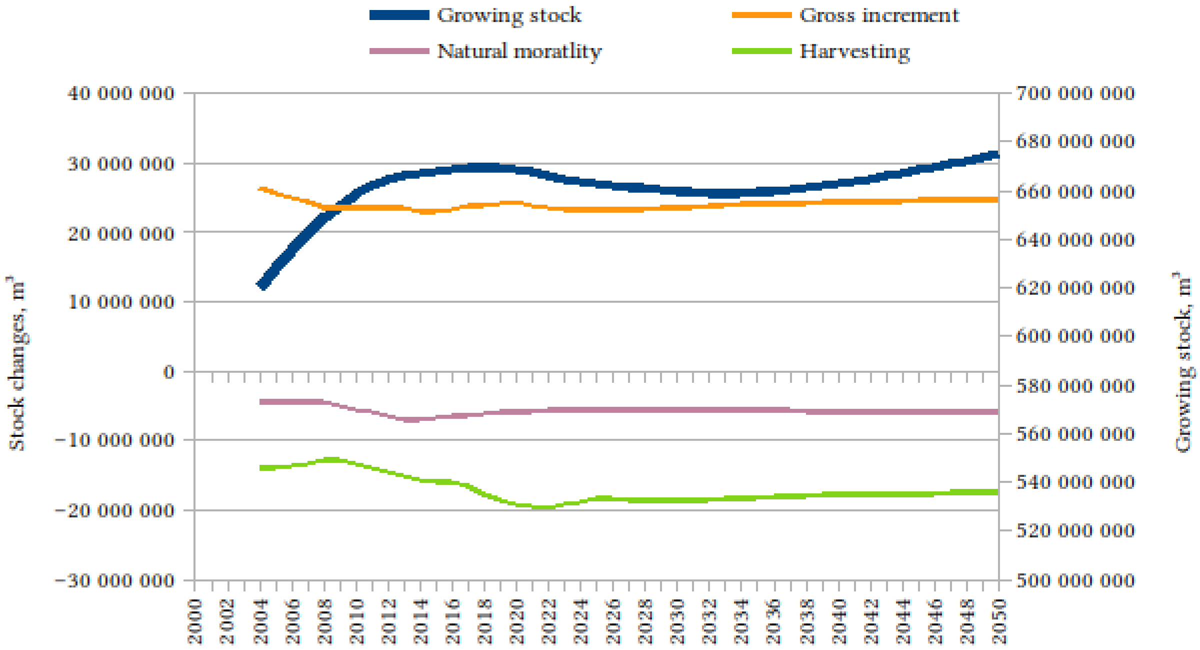

Figure 19: Projection of growing stock changes in forest lands.

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