National Forestry Accounting Plan for Germany

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Content

Chapter 1: General Introduction

1.1 General description of the forest reference level for Germany

This National Forestry Accounting Plan has been prepared pursuant to Article 8 of REGULATION (EU) 2018/841 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework (hereafter referred to as: the Regulation), and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU and especially in accordance with the requirements set out in Annex IV B of the Regulation.

About 30% of Germany's area is forested and all forest lands are considered managed. The actual management and the management applied in the Reference Period are sustainable and in line with EU- and national forest and natural resource use related policies.

The German Forest Reference Level (FRL) has been estimated in accordance with the requirements and framing conditions set out in the Regulation. It contains all gases and pools given in Annex I of the Regulation.

The FRL was estimated to be net emissions of -39.217 million tons CO_2-equivalent per year in the first Compliance Period 2021 – 2025.

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

The German FRL is based on forest management practices conducted between 2000 and 2009. These were sustainable by the standards and criteria of the MCPFE (Forest Europe 2015). They resulted in net removals in this period, as shown in the 3rd NFI (2012). Thus, the forest management applied and the resulting FRL are oriented towards "achieving a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century" as requested in Annex IV A (a) of the Regulation. They also contribute "to the conservation of biodiversity and the sustainable use of natural resources, as set out in the EU forest strategy, Member States' national forest policies, and the EU biodiversity strategy" as requested in Annex IV A (f). Forest management in the reference period (RP) covered all age classes and, as shown in Annex I, table 2, yielded considerable removals by ageing forest stocks as called for in Annex IV (A) a of the Regulation. The calculation of the FRL is based on changes or rates of change for all pools considered, so the mere presence of carbon stocks is excluded from accounting as requested by Annex IV A (b) of the Regulation.

The FRL is also embedded in the existing and proven reporting framework used under the Convention, including the provisions on HWP, and is derived from and replicates historical data already included in the GHG Inventory and Reporting, so the requirements of Annex IV A (c), (d), (g) and (h) of the Regulation are also fulfilled.

Chapter 2: Preamble for the forest reference level

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

The German Forest Reference Level includes the following pools:

- above-ground (living) biomass
- below-ground (living) biomass
- litter
- dead wood
- soil organic carbon
- harvested wood products

and gases:

- CO_2
- CH_4
- N_2O

as requested by Annex I of the Regulation and as already reported under the Convention and currently accounted under the Protocol of Kyoto.

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

See Chapter 3.

2.3 Description of the long-term forest strategy

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

The state of Germany's forests is documented in the National Forest Inventory, openly accessible at https://www.bundeswaldinventur.de. The latest full inventory is of 2012 (BMEL 2015). As reported for the greenhouse gas emissions assessment in 2016, Germany's stocked forest land covers appr. 10.8 million hectares and is completely reported under the Convention in the respective land use category "Forest Land remaining Forest Land". All forests in Germany are considered to be under management and are thus covered by the approach chosen to estimate the FRL.

The legal frame for forest management in Germany is set by the Federal Forest Act and the Forest Acts of the Federal States. National forest-related policies include the National Forest Strategy 2020 (Waldstrategie 2020, BMELV 2011), the Charter for Wood (Charta für Holz 2.0, BMEL 2018), the Climate Action Plan 2050 (Klimaschutzplan 2050, BMUB 2016), and the National Strategy on Biological Diversity (Nationale Strategie zur biologischen Vielfalt, BMUB 2007).

2.3.2 Description of future harvesting rates under different policy scenarios

Projections of future forest management are available from the WEHAM 2012 base scenario (Schmitz et al. 2016) and a research project ("WEHAM-Szenarien", Oehmichen et al. (2018)).

The base scenario describes forest and timber resource development for 2012 – 2052 based on the state of the forest as shown in the NFI 2012. The scenario is deducted from measurements (e.g., increments) and expert judgement on future harvest intentions of forest owners and managers. An earlier version of the Base Scenario's management data are currently used for the FMRL under the Protocol of Kyoto. While the Base Scenario reflects the intentions and possibilities currently known and foreseeable, the scenarios applied in the „WEHAM-Szenarien" project are also based on the state of the forest in 2012, but describe alternative policies ("wood preference" and "nature conservation") and also a "business as usual"-scenario that keeps up trends etc. as in force in 2012. The scenarios have been developed with regard to stakeholder perspectives, but are research-oriented and do not reflect any officially adopted policies.

The wood-preference scenario aimed to reduce the volume of standing stock to the level of the NFI in 1987 (i.e., by appr. 14%) by reducing production times and target diameters in relation to the base scenario. To satisfy an (assumed) higher demand for timber in the future, the share of area of Douglas fir is significantly increased in rejuvenated stands, at the expense of spruce and pine.

The nature conservation-oriented scenario is aimed at increasing the share in area of actual potential natural vegetation by converting stands of mainly spruce and pine, where they are not on their natural sites. Thus, the share of coniferous stands is decreased and that of broadleaved species increased. For trees growing on their natural sites, production times are also increased and, by this, standing timber volumes are raised.

The harvesting potentials of the three scenarios for the CPs are given in Table 1. Please note that these scenarios and the FRL originate from different methodological frameworks and have different underlying assumptions about harvest intensities and strategies. Therefore, the FRL does not equal any of the three scenarios and comparisons should take the methodological differences into account.

Table 1: Harvest (raw wood potential as useable timber, [Mio. m^3 a^{-1} (over bark)]) of three scenarios (Base: Base Scenario, WPS: wood preference scenario, NCS: nature conservation oriented scenario)

CP	**Base**	**WPS**	**NCS**
2021-2025	76.95	115.94	83.62
2026-2030	74.61	116.76	79.88

Chapter 3: Description of the modelling approach

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

Germany applies a stock-difference method in GHG reporting and applies comparable approaches in constructing the FRL. Changes in the different pools during the RP have been determined individually per pool and are also modelled (for the CP) per pool. The development of the living biomass and the amount of wood harvested is modelled using the approach described in Annex I and the calculation framework of the NFI already used in the German GHG Inventory and Reporting. The use of the stock difference method assures that all forest characteristics mentioned in Annex IV B (e) III of the Regulation are implicitly regarded without having to be addressed individually. The amount of harvested wood is used to estimate the changes in the HWP pool with the model Wood Carbon Monitor (Rüter 2016). Emissions from changes in the dead wood pool and from forest fires were assumed to be equal to the mean from the RP, respectively. The development of the litter pool is modelled with soil carbon in Yasso15 (for details, see Ziche et al. 2019). Details on the different models and simulators are given in the most recent NIR and Annexes I and II.

Assumptions concerning climate change

In preparing the FRL it was assumed that climate change between the RP and the CP does not influence net emissions or removals from any pool significantly. Climate trends present in the data from the RP are indirectly included in the parametrization and modelling of the FRL, e.g. influences of changes in climate on tree increment. This is considered to be in line with the “business as usual” requirement. Soil carbon in mineral soils and litter and dead wood were modelled in a project where climate scenario data were employed (Ziche et al. 2019). For the other pools, no models are available that incorporate climate data, and, because these pools are far less sensitive to climatic drivers than e.g. litter decomposition, there is no need to include climate data when projections span only comparatively short time frames.

Assumptions concerning area of MFL

For the FRL, the following changes in the area of managed forest land are considered: for deforestation (which is subject to legal permission in Germany), the projected value is set to zero. This way, all deforestation is assured to be accounted for. With regard to afforestation, the transition of afforested land after 20 year transition period is included in the forest area of the respective years of the CP.

Starting year of projection

In order to properly consider the dynamic age-related characteristics of the managed forest lands as requested by Art. 8 (5) of the Regulation in the stock-difference approach chosen for the German GHGI framework, the most recent data on area and age-class distributions available are used in the projection of living biomass and HWP. To date, the most recent information result from the NFI 2012 and the values given in this paper are based on this data. The results of the Carbon Inventory 2017 will be available in 2019 and Germany plans a technical correction for the FRL projections accordingly.

Assumptions concerning HWP

The projection of emissions and removals arising from the HWP pool is implemented with the computer model WoodCarbonMonitor already used for the German GHG inventory reporting. It is documented in the NIR 2018 and in Rüter (2016). In order to derive the contribution of the HWP pool to emissions and removals in the FRL, the time series of wood-removals projected by the forest management model are used as input parameter for the calculation. In a first step, annual rates of change of the projected wood-removals as compared to the historic average within the RP (2000 to 2009) are derived. In a second step, these annual rates of change are applied to the average historic carbon inflow during the RP to the HWP pool within the three relevant HWP commodity classes, which represent the material use of wood (i.e. sawnwood, wood-based panels and paper and paperboard). The subsequent calculations of future emissions and removals arising from the HWP pool are conducted in exactly the same way as for the GHG inventory reporting, thus full methodological consistency between FRL and GHGI is ensured.

The projected harvest amounts are given with the description of the forest management modelling in Annex I.

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

The FRL is based on data gathered by the National Forest Inventories (1987, 2002, 2012), the Inventory Study 2008, the Carbon Inventory 2017, the National Forest Soil Inventories I (1987 – 1994) and II (2004 - 2008) and the Forest fire statistics (2001-2017).

3.2.1 Documentation of stratification of the managed forest land

For the purpose of estimating the FRL the managed forest land was stratified by volume class (of growing stock) and age class (20 yrs.) as described in detail in Annex I.

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

The objective of sustainable Forest Management in Germany is defined as "permanently and optimally secure the diverse economic, ecological and social benefits of the forest for the use of the present and future generations." (BMEL 2015). The basic principles are laid down in the Federal Forest Act and the respective Forest Acts and Laws of the Länder and other laws concerning the use of natural resources. The enforcement of the respective rules and regulations is in the hands of the responsible authorities in the Federal States (Länder). In addition, between 70 % and 80 % of Germany's managed forest lands were subject to certification by either FSC, PEFC (or both), or NATURLAND (BMEL 2017). The forest management practices applied in Germany in the RP were sustainable with regard to the criteria set out by the MCPFE (Forest Europe 2015) and as assessed by the UNECE / FAO Forestry and Timber Section (UNECE 2017). As far as Forest Management Practices have been differentiated for modelling purposes, these are documented and explained in the respective Annex to this document.

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

The modelling is conducted in several steps: First, the annual change of above- and belowground biomass is modelled in volume class – age class strata, using the stock-difference approach and the same algorithms and functions as in the existing GHGI (see Annex I for details). In the same step, the amount of harvested wood is projected (see Annex I) and used as input in the modelling of the HWP pool with the model Wood Carbon Monitor. The litter pool was simulated, together with the soil carbon pool of mineral soils, with YASSO15, and projections for net emissions from organic soils and dead wood were added (see Annex II for details).

Natural disturbances

To date, Germany does not intend to apply the Natural Disturbance provision laid down in Article 10 of the Regulation.

Chapter 4: Forest reference level

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

The aggregated FRL for Germany is estimated to be net emissions of -39.217 million tons CO_2-equivalent per year in the first Compliance Period 2021 – 2025. The contribution of the individual pools considered here are given in Table 2. Net emissions from the respective pools from the RP are given for comparison.

Table 2: Annual net emissions from different pools (Mio. t CO_2-eq. a^{-1})

Pool	2021 - 2025
Living biomass	-36.183
Soil (including litter)	5.063
dead wood	-2.202
Forest fires	0.036
HWP	-5.931
Sum	-39.217

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

Consistency between the FRL and the latest national inventory report is assured by using the same methodological framework and the same data sources (see above and Annex I – III for details).

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

See 4.1 and Annex I and II.

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Annexes to National Forest Accounting Plan for Germany – Annex I

Modelling framework for projecting the Forest Reference Level

Part I: above- and belowground biomass – “Alternative Approach”

I.I Background

The European Parliament and the Council of the European Union have adopted a regulation on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU (REGULATION (EU) 2018/841 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 30 May 2018).

The regulation inter alia requests member states to account for the impact of forest management (or human induced emissions from forestland and its management) for the time after 2020 until 2030, subdivided into the compliance periods (CP) (2021-2025 and 2026-2030). For managed forest lands the common approach proposed by the regulation is based on the construction of a forward-looking baseline, so called forest reference level (FRL).

This should be based on an extrapolation of forest management practices and intensity from a reference period (RP, 2000 - 2009). In other words the expected impact of the prolonged application of (sustainable) forest management as documented for the RP should form the basis for the FRL, which should take into account differences in forest structures and conditions between RP and CP such as unbalanced (forest) age structures.

The regulation especially notes that country-specific characteristics should be reflected and that the best available data should be used in the construction of the FRL. Consistency between the methods and data used to determine the proposed forest reference level and those used in the GHG reporting for managed forest land needs to be ensured.

The FRL should take into account relevant historical data and shall be based on transparent, complete, consistent, comparable and accurate information. In particular, the model used to construct the reference level shall be able to reproduce historical data from the National Greenhouse Gas Inventory.

I.II Stratification of managed forest land

The GHG reporting on land generally follows a simple approach: activity data (AD, here: areas of forests) are multiplied by emission factors (EF, here: net emissions from particular carbon pools per unit of activity data) to calculate resulting emissions. In the German GHGI, the EF for (living) biomass for Forest Land remaining Forest Land is calculated following the stock-difference method from two consecutive forest inventories. As there is no stratification in the GHGI that could be used in constructing the FRL, data from the NFI 2002 are used for stratification purposes instead, i.e. the combination of standing volume classes and age classes (Table I-1). Germany's forest has more than 150 tree species. Although only about 10 dominate the forest and generate most of the goods and services, including tree species in the stratification results in large variation. In the German NFI, age classes of 20 years are also standard for age-related classifications. Since management is more correlated to standing stocks and stock density than age, the forest was classed in 15 volume classes (0-<50, 50 – <100, …, >=700 m^3 ha^{-1}).

This kind of classification is used to provide in depth information on the situation of forests and it also represents the distribution of dynamic age-related characteristics at the time of the inventory. The differences between two consecutive inventories yield the differences in carbon stocks, which can be expressed as an EF per hectare of forest that was in a specific stratum at the start of the period (Table I-2). It reflects the impact of the forest management (and, eventually, natural disturbances) on this class regarding net emissions or removals per unit of activity data in the class (area).

The EF per area unit (ha) for a single class is calculated from repeatedly measured NFI data. The reference period (2000 – 2009) contains two inventories (2002 and 2008). To exclude influences from outside the RP, the EF for the RP is thus calculated as the change in carbon stocks per hectare in the respective stratum (area of the volume and age classes) from 2002 to 2008 (NFI 2002 to Inventory Study 2008). In every case, only inventory plots that are located in the 8km by 8km grid used for GHG reporting were used to assure consistency with the GHGI. Combined with the distribution of the strata's areas, the overall emission can be calculated as well as an average EF which takes into account the strata's distribution at a given time. The removals due to harvest or other losses can be derived in these strata, too (see Table I-3). The total net emissions during the Compliance Period are then estimated by multiplying the average EF by the total area of forest land remaining forest land plus the land area moving from "land converted to forest land" (afforestation) after a 20 year transition period in each year of the CP, taken from the most recent GHGI (see NIR 2018[1], table 361). This is in line with the GHG inventory and reporting under the Convention. For comparison, the net emissions in the respective age class / volume class strata are given in Table I-4.

[1] NIR 2018: National Inventory Report for the German Greenhouse Gas Inventory 1990 – 2016, https://unfccc.int/documents/65712

Table I-1: Area [kha] distribution of volume classes at the beginning of the RP (NFI 2002), rounded

	volume class [m³ ha^{-1}]															
age class [y]	**0 - <50**	**<= 50 - <100**	**<= 100 - <150**	**<= 150 - <200**	**<= 200 - <250**	**<= 250 - <300**	**<= 300 - <350**	**<= 350 - <400**	**<= 400 - <450**	**<= 450 - <500**	**<= 500 - <550**	**<= 550 - <600**	**<= 600 - <650**	**<= 650 - <700**	**<= 700**	**all classes**
0 - 20	865.9	140.6	83.1	27.2	6.4	1.6	1.6	0	0	0	0	0	0	0	0	1,126.4
21 - 40	117.8	255.0	266.8	256.8	226.8	198.2	103.9	95.7	81.4	27.3	27.1	6.4	11.1	14.4	4.8	1,693.7
41 - 60	46.4	86.6	181.9	223.4	284.2	274.6	309.9	207.9	171.0	139.1	68.6	49.5	41.6	30.5	46.4	2,161.6
61 - 80	14.4	57.5	85.0	153.3	174.3	167.9	188.8	188.6	147.0	136.0	97.4	92.8	59.2	36.9	110.7	1,709.6
81 – 100	14.3	24.0	60.8	78.5	115.4	172.3	153.8	121.3	152.0	126.2	125.2	92.9	62.3	62.2	196.7	1,558.1
101 - 120	1.6	30.4	33.7	49.5	80.2	107.4	106.9	90.9	108.8	91.5	78.4	67.3	54.6	44.8	134.7	1,080.8
121 - 140		4.8	20.8	33.7	25.6	46.3	59.2	36.8	54.2	51.1	44.7	33.8	32.1	25.5	73.8	542.5
141 - 160	3.3	6.4	14.4	11.1	17.6	19.2	27.2	33.4	28.7	14.4	22.4	22.5	11.2	9.6	23.9	265.3
> 160	6.4	3.2	9.6	11.2	15.9	9.7	9.6	4.8	9.5	8.0	4.8	8.0	12.8	8.0	14.4	135.9
total	1,070.1	608.7	756.1	844.8	946.2	997.1	960.9	779.6	752.7	593.6	468.6	373.0	284.9	232.0	605.4	10,273.9

Table I-2: EFs [t CO_2-eq.ha^{-1} a^{-1}] during the RP by forest classes, living biomass (trees, above- and belowground, rounded values)

	volume class [m³ ha^{-1}]															
age class [y]	**0 - <50**	**<= 50 - <100**	**<= 100 - <150**	**<= 150 - <200**	**<= 200 - <250**	**<= 250 - <300**	**<= 300 - <350**	**<= 350 - <400**	**<= 400 - <450**	**<= 450 - <500**	**<= 500 - <550**	**<= 550 - <600**	**<= 600 - <650**	**<= 650 - <700**	**<= 700**	**all classes**
0 - 20	16.0	17.3	13.9	10.6	-2.2	16.3	13.2	0	0	0	0	0	0	0	0	15.8
21 - 40	18.6	16.5	14.2	13.1	12.4	11.9	2.9	5.3	-2.0	10.7	11.5	6.8	32.6	12.7	22.3	12.2
41 - 60	14.4	16.1	14.6	11.0	8.2	6.8	7.2	7.5	5.4	1.1	-2.3	-3.8	1.1	11.9	-22.8	7.0
61 - 80	6.6	8.9	5.8	7.4	6.2	7.1	3.9	4.8	-3.0	-3.6	-2.2	-3.7	-6.4	-5.4	-17.9	1.2
81 - 100	9.9	11.6	10.4	10.0	7.1	5.2	3.1	0.7	-1.5	2.9	-9.4	-12.9	-11.6	-13.8	-25.0	-3.0
101 - 120	-4.2	5.1	5.8	4.2	0.2	5.9	5.9	-1.0	3.1	-6.3	-3.6	-11.0	-6.5	-15.3	-25.3	-3.7
121 - 140	0	-6.0	12.2	4.7	10.0	5.8	8.6	-9.8	-0.3	0.4	-0.9	-8.8	-13.1	-20.0	-34.1	-5.0
141 - 160	-3.2	18.0	6.3	-6.2	-0.5	6.8	5.4	3.0	6.6	0.4	-5.1	-26.7	13.9	-34.7	-25.0	-3.0
> 160	-1.3	7.0	2.2	12.6	-3.0	-13.0	-6.7	-10.6	-8.2	-6.7	-45.8	-3.3	-2.7	-10.0	-4.2	-4.9
total	15.8	14.9	12.3	10.0	7.6	7.3	5.2	3.4	0.7	-0.5	-4.0	-9.0	-4.7	-9.1	-23.8	4.2

Table I-3: Harvest [Mio. m³ a^{-1} (over bark)] from final felling or thinning during the RP by stratum

	volume class [m³ ha^{-1}]															
age class [y]	**0 - <50**	**<= 50 - <100**	**<= 100 - <150**	**<= 150 - <200**	**<= 200 - <250**	**<= 250 - <300**	**<= 300 - <350**	**<= 350 - <400**	**<= 400 - <450**	**<= 450 - <500**	**<= 500 - <550**	**<= 550 - <600**	**<= 600 - <650**	**<= 650 - <700**	**<= 700**	**all classes**
0 - 20	0.09	0.15	0.13	0.17	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61
21 - 40	0.07	0.28	0.73	1.21	1.46	1.61	1.55	1.12	1.75	0.25	0.42	0.18	0.10	0.15	0.02	10.88
41 - 60	0.03	0.14	0.45	0.90	1.40	1.88	2.73	2.11	1.62	2.28	1.33	0.99	0.45	0.38	1.61	18.30
61 - 80		0.09	0.33	0.76	1.05	0.96	1.31	1.62	1.86	2.02	1.23	1.59	1.22	0.58	3.89	18.52
81 - 100		0.07	0.13	0.22	0.46	0.98	1.32	1.09	1.76	1.15	2.24	2.11	1.38	1.66	7.08	21.65
101 - 120		0.08	0.10	0.25	0.65	0.55	0.62	0.95	0.95	1.44	0.99	1.16	0.57	1.07	4.26	13.64
121 - 140		0.04	0.04	0.13	0.12	0.32	0.40	0.48	0.61	0.33	0.49	0.53	0.77	0.69	2.70	7.65
141 - 160	0.01	0.00	0.06	0.04	0.18	0.12	0.12	0.07	0.12	0.22	0.24	0.55	0.05	0.25	0.48	2.52
> 160				0.02	0.06	0.07	0.09	0.06	0.09	0.07	0.08	0.05	0.14	0.19	0.15	1.08
total	0.20	0.84	1.97	3.70	5.43	6.49	8.15	7.50	8.77	7.78	7.02	7.16	4.68	4.97	20.19	94.86

Table I-4: Total net emissions [Mt CO_2-eq. a^{-1}] during the RP by forest classes, living biomass (trees, above- and belowground, rounded values)

	volume class [m³ ha^{-1}]															
age class [y]	**0 - <50**	**<= 50 - <100**	**<= 100 - <150**	**<= 150 - <200**	**<= 200 - <250**	**<= 250 - <300**	**<= 300 - <350**	**<= 350 - <400**	**<= 400 - <450**	**<= 450 - <500**	**<= 500 - <550**	**<= 550 - <600**	**<= 600 - <650**	**<= 650 - <700**	**<= 700**	**all classes**
0 - 20	-13.85	-2.43	-1.15	-0.29	0.01	-0.03	-0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-17.76
21 - 40	-2.19	-4.20	-3.79	-3.36	-2.82	-2.36	-0.31	-0.51	0.16	-0.29	-0.31	-0.04	-0.36	-0.18	-0.11	-20.68
41 - 60	-0.67	-1.40	-2.65	-2.46	-2.33	-1.87	-2.23	-1.56	-0.92	-0.16	0.16	0.19	-0.05	-0.36	1.06	-15.24
61 - 80	-0.10	-0.51	-0.49	-1.13	-1.08	-1.19	-0.74	-0.90	0.45	0.49	0.21	0.34	0.38	0.20	1.98	-2.09
81 - 100	-0.14	-0.28	-0.63	-0.79	-0.82	-0.89	-0.47	-0.09	0.23	-0.37	1.18	1.20	0.72	0.86	4.93	4.64
101 - 120	0.01	-0.15	-0.20	-0.21	-0.01	-0.64	-0.63	0.09	-0.34	0.58	0.28	0.74	0.36	0.69	3.41	3.97
121 - 140		0.03	-0.25	-0.16	-0.26	-0.27	-0.51	0.36	0.02	-0.02	0.04	0.30	0.42	0.51	2.52	2.73
141 - 160	0.01	-0.12	-0.09	0.07	0.01	-0.13	-0.15	-0.10	-0.19	-0.01	0.12	0.60	-0.16	0.33	0.60	0.80
> 160	0.01	-0.02	-0.02	-0.14	0.05	0.13	0.06	0.05	0.08	0.05	0.22	0.03	0.03	0.08	0.06	0.67
Total	-16.93	-9.08	-9.28	-8.47	-7.24	-7.25	-4.98	-2.66	-0.51	0.29	1.89	3.35	1.35	2.12	14.44	-42.97

I.III Application of emission factors for compliance period to reproduce historical management

The RP is set as 2000-2009. The CPs are 2021-2025 and 2026-2030. In the time between the RP and the first CP forests are changing due to management and dynamic age-related factors (forest characteristics, area distribution of classes). For construction of the FRL (consistent with the stock-difference approach of the German GHGI) the situation at the beginning of the CP is taken into account by using the forest area distribution by strata as shown by the NFI closest to the beginning of the CP. To date, the most recent available data on forest area is the NFI 2012 (Table I-5). When data from the CI 2017 are available, there will be a technical correction.

Table I-5: Area [kha] distribution of forests classes at beginning of the CP (NFI 2012)

	volume class [m³ ha⁻¹]															
age class [y]	**0 - <50**	**<= 50 - <100**	**<= 100 - <150**	**<= 150 - <200**	**<= 200 - <250**	**<= 250 - <300**	**<= 300 - <350**	**<= 350 - <400**	**<= 400 - <450**	**<= 450 - <500**	**<= 500 - <550**	**<= 550 - <600**	**<= 600 - <650**	**<= 650 - <700**	**<= 700**	**all classes**
0 - 20	816.9	92.5	60.7	23.8	12.7	1.6	1.6	0	0	0	0	0	0	0	0	1,009.9
21 - 40	156.2	225.1	253.5	209.2	223.0	153.1	126.1	94.4	57.5	45.0	20.7	20.7	6.4	7.9	8.0	1,606.9
41 - 60	60.5	105.5	159.2	218.7	258.5	292.0	263.2	216.8	148.4	156.2	123.1	84.6	58.9	38.3	98.9	2,282.8
61 - 80	19.3	63.8	110.3	136.9	199.3	185.2	187.1	223.5	193.0	137.2	107.0	75.0	78.5	50.9	124.8	1,891.8
81 - 100	4.8	28.7	62.2	79.8	145.4	154.8	168.1	161.6	145.6	138.8	112.4	97.6	68.9	67.1	172.5	1,608.4
101 - 120	4.7	27.1	28.7	65.8	91.4	105.9	116.8	135.6	126.3	97.4	99.0	81.5	63.9	57.5	160.2	1,261.9
121 - 140	0	9.6	19.2	38.3	36.7	39.9	60.7	60.8	54.3	49.6	76.8	48.0	35.1	35.4	93.0	657.6
141 - 160	1.6	3.2	11.2	17.5	27.1	11.2	20.8	30.3	43.1	22.3	20.9	14.4	19.3	16.1	38.3	297.3
> 160	4.8	8.0	9.6	12.7	12.8	12.8	22.4	23.9	14.3	4.8	8.0	11.2	12.8	16.0	17.5	191.5
total	1,068.9	563.7	714.6	802.7	1,007.0	956.5	966.8	946.9	782.5	651.4	567.9	433.0	343.9	289.2	713.2	10,808.0

Table I-6: Harvest [Mio. m³ a^{-1} (over bark)] from final felling or thinning during the CP by stratum

	volume class [m³ ha^{-1}]														
age class [y]	**0 - <50**	**<= 50 - <100**	**<= 100 - <150**	**<= 150 - <200**	**<= 200 - <250**	**<= 250 - <300**	**<= 300 - <350**	**<= 350 - <400**	**<= 400 - <450**	**<= 450 - <500**	**<= 500 - <550**	**<= 550 - <600**	**<= 600 - <650**	**<= 650 - <700**	**<= 700**	**all classes**
0 - 20	0.09	0.10	0.10	0.15	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.56
21 - 40	0.09	0.24	0.69	0.98	1.43	1.24	1.88	1.10	1.23	0.41	0.32	0.60	0.06	0.08	0.04	10.40
41 - 60	0.04	0.17	0.39	0.88	1.27	2.00	2.32	2.21	1.41	2.56	2.39	1.69	0.64	0.48	3.42	21.87
61 - 80	0.00	0.10	0.42	0.68	1.20	1.06	1.30	1.92	2.44	2.04	1.35	1.28	1.61	0.80	4.38	20.61
81 - 100	0.00	0.08	0.14	0.22	0.58	0.88	1.44	1.45	1.69	1.27	2.01	2.21	1.52	1.79	6.21	21.50
101 - 120	0.00	0.07	0.08	0.34	0.74	0.54	0.68	1.41	1.10	1.54	1.25	1.41	0.67	1.37	5.06	16.27
121 - 140	0.00	0.08	0.04	0.15	0.17	0.28	0.41	0.79	0.61	0.32	0.84	0.75	0.85	0.96	3.40	9.64
141 - 160	0.01	0.00	0.05	0.06	0.27	0.07	0.10	0.07	0.18	0.34	0.23	0.35	0.09	0.41	0.78	2.99
> 160	0.00	0.00	0.00	0.02	0.04	0.09	0.22	0.28	0.14	0.04	0.14	0.07	0.14	0.39	0.19	1.77
Total	0.22	0.84	1.91	3.49	5.84	6.17	8.34	9.23	8.81	8.53	8.52	8.37	5.58	6.28	23.48	105.61

This distribution of forest area into the strata (Table I-5) is combined with the historical EFs per class (Table I-2) in order to derive a new weighted average EF or the expected (reference) emission for the CP for the above- and belowground living biomass pools. For the first CP, the modelled average annual net emissions from the living biomass pool are -36.183 Mio t CO_2-eq.

For HWP an assumed harvest rate is derived by calculating the timber removals as an average of the removals per ha of the strata (Table I-3) weighed by the area in each stratum at the start of the projection (using data from the NFI 2012 – Table I-5 – or CI 2017, respectively). This leads to an adjusted overall harvest rate within the CP taking into consideration the development of age-related dynamic characteristics since the RP (Table I-6). A constant ratio between solid and energy use of forest biomass as documented in the period from 2000 to 2009 is ensured. During the RP, the annual harvest for the purpose of the use of wood as material was 47.814 Mio. m^3 (46.2% of the total removals of wood from the forest). The complementary 53.8% are assumed to be used as wood for energy. The amount of wood harvested for the purpose of the use of wood as material during the CP is projected to be 43.73 Mio. m^3 a^{-1}.

I.IV Summary

The approach described above proposes the construction of FRL with forest models easy to understand.

It maps the historical forest development and therefore the historical forest net emissions/removals resulting from this during the reference period into the compliance period using differentiated emission factors by forest classes. These are used as proxy to reflect the impact of forest management to a defined class of forests. Changing characteristics of forests due to changed class distribution or influences of forest management before the start of the compliance period are taken into account by using the latest available area distribution of forest classes towards the beginning of the compliance period.

This ensures also the compatibility of the resulting FRL with regard to reproduction of historical GHG inventory data and methodology.

National Forest Accounting Plan for Germany – Annex II

Modelling framework for projecting the Forest Reference Level

Part II: Litter and soil

II.I Background

For forest lands, mineral and organic soils are treated differently. For mineral soils, the projection of litter and soil carbon pools and related net emissions is based on findings from Ziche et al. (2019). In this study, a soil model (YASSO15) was used to project carbon stocks based on data from two National Forest Soil Inventories (NFSI) and in case of litter fall on Intensive Forest Monitoring plots (Level II).

The 1st NFSI was conducted between 1987 and 1994 with over 1900 sample plots distributed in an 8km by 8km grid throughout Germany. In appr. 65% of the samples, mineral soil was taken to a depth of 90cm, while – due to solid bedrock – in 10% of cases the sampling depth was only 60cm, and only down to 30cm in the remaining appr. 25%. In the 2nd NFSI ca. 1,300 plots were re-sampled and appr. 600 plots were replaced. Stand characteristics of the surrounding forests were only sampled in the 2nd NFSI.

For organic soils, which are not included in the NFSI estimates, the emission factors for the RP are taken from the NIR 2018 (net CO_2-emissions from organic soils, N2O and CH4-emissions as CO_2-equivalent) and the average is applied as part of the FRL. The same approach is applied for emissions from forest fires.

II.II Modelling

The projected soil and litter carbon stocks were taken from Ziche et al. (2019). In this study, YASSO15 was used for projecting soil carbon and litter based on the German NFSI findings and climate data (measured data from the German Weather Office (DWD) for 1961 – 2014, regionalized ECHAM6 data for 2014 – 2030, see Ziche et al. (2019) for details). Litter input from living trees was assumed to be constant over the projection period, while input from management activities and natural mortality was simulated based on the stand inventories, harvest ratios, and timber assortment structure from data till 2014. For the projection, the average input per plot from 2009 – 2013 was used in this study. This is a deviation from the

RP set by the Regulation, but this study was not intended as part of the FRL construction. However, the differences in litter fall between this period and the RP are small, as far as the factors that determine litter fall are concerned.

II.III Reproduction of historical data

The modelled carbon balance (0.25 ± 0.10 Mg C ha^{-1} a^{-1}) was lower than the measured value of the NFSI (0.39 ± 0.11 Mg C ha^{-1} a^{-1}) (Grüneberg et al. 2014) for the organic layer and mineral soil down to a depth of 30 cm (Ziche et al. 2019). The values are within their reciprocal confidence intervals and the difference between these average values is not statistically significant.

II.IV Stratification of managed forest land

The simulations of litter and soil (to a depth of 90cm) were conducted on the level of the single inventory plot and then aggregated according to the soil stratification used in the GHG inventory and reporting (see NIR 2018 for details) and by 22 forest types (to reflect differences in litter input).

II.V Projected net emissions from soil and litter

The projections resulted in mean annual net emissions as shown in Table II-1.

Table II-1: Projected net emissions from the soil and litter pools [Mio. t CO_2-eq. a^{-1}] during the CP

	Unit	2021 - 2025
Mineral soil and litter	[Mio. t CO_2 a^{-1}]	3.961
Organic soils	[Mio. t CO_2-eq. a^{-1}]	1.102
Total	**[Mio. t CO_2-eq. a^{-1}]**	**5.063**

References

Grüneberg, E., D. Ziche and N. Wellbrock (2014): Organic carbon stocks and sequestration rates of forest soils in Germany. Global Change Biology 20(8): 2644-2662.

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