NATIONAL FORESTRY ACCOUNTING PLAN OF BELGIUM

Submitted under Regulation EU/2018/841 of the European Parliament and the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU

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Content

Chapter 1: General introduction

1.1: General description of the forest reference level for Belgium

The Belgian Forest Reference Level is the result of simulation work by Gembloux Agro-Biotech (University of Liège) based upon data from the regional administrations. Specific data were used for each of the Belgian regions, but the modeling approach and methodology are identical for the entire country.

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

1.2.1. Annex IV A

Each of the criteria of annex IV.A is commented hereunder.

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

The current forest management in Belgium is designed to maintain and enhance the equilibrium between forest growth and removals in the long term. The forest codes adopted in the 3 regions reflect this guiding principle. Further information on the forest long term strategy is presented in section 2.3.

According to the current FRL projections, the continuation of the forest management practices applied during the reference period would lead to a slight increase of the forest sink in 2050. The average annual sink in 2000-2009 is -1009 kt CO_2/yr and would increase to -1180 kt CO_2/yr in 2040-2050.

The ”Species change” projections are based on the same data, but assume that the current trend regarding the change in species is continued. This scenario would lead to a further increase of the sink, reaching on average -1466 kt CO_2/yr in 2040-2050.
Those projections do not take into account the possible impacts of natural disturbances. The impact of natural disturbances is very limited for the time being, but the uncertainty regarding potential future impacts is large on this time scale. Nevertheless, the current FRL shows an enhancement of the sink towards 2050 and is hence fully 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.

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

This principle is embedded in the FRL approach, as the accounting will reflect net changes in forest carbon stocks, rather than accounting for total existing carbon stocks in forests.

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

All carbon pools are considered in a consistent manner between the inventory and the FRL and the construction of the FRL excludes any policy assumption, with a view to that all emission and removals resulting from biomass use are properly accounted for.

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

For the period 2021-2025, the forest reference level for Belgium is -1.369.009 tons CO_2 eq, in which the HWP pool constitutes of **-133.368** tons CO_2 eq. If instantaneous oxidation of HWP was assumed, the FRL would be **-1.235.641** tons CO_2 eq.

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

A constant ratio between solid and energy use of forest biomass as documented in the period from 2000 to 2009 has been applied for the projection of the HWP pool (section 3.3.4).

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

Current forest management as reflected in the FRL includes measures adopted to preserve the ecological stability of the forests, such as the implementation of systems of forest certification.

On 18 November 2005, the Federal Government concluded an agreement relating to a circular on sustainable wood (also see OB-A01). This circular required that as of March 2006 under their procurement policy, the federal authorities may only buy certified wood coming from forests under sustainable management. For this purpose, the circular sets criteria which must be satisfied under the wood certification systems. A number of actions have been taken by the Federal Government to prevent importing and marketing of wood felled illegally and to strengthen the controls and penalties imposed on this trade.

The Walloon Region is committed to PEFC certification of sustainable forest management. Certification is a tool to permanently improve management at the regional level and the practices on the ground. It makes it possible for the diverse interested actors to meet and form a consensus on forest management: owners, industrialists, scientists, environmentalists and users. Certification also makes it possible to provide a guarantee to the consumer that use of the wood goes hand in hand with good management of the forest. In January 2014, about 54% of the Walloon forest area were PEFC certified (more than 90% of the publicly-owned forests managed by the Department of Nature and Forests are PEFC certified).

In the Brussels Capital Region, the Sonian Forest (Forêt de Soignes/Zoniënwoud) is FSC certified. Its management aims to ensure ecological stability. In addition to ensuring the ability to regenerate, biodiversity and ecological and social aspects are taken into account.

The Flemish authorities have developed various instruments to ensure biodiversity and sustainable use of natural resources (protection of vegetation and landscapes). FSC certification started in mid 1990s in a few large public forests as a case-by-case exercise (Zoniënwoud; Meerdaalwoud & Heverleebos). Since 2008 this has been turned into a group certificate managed by the Agency Nature & Forests (Agentschap Natuur & Bos - ANB) with a certified surface of 22.177 ha at the end of 2017.

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

Regarding forest management, the last projections submitted under Regulation 525/2013 in March 2019 were not based on the model used for the FRL, as the NFAP had not been subject to the technical assessment at that time and was still subject to technical adaptations

The projections for the LULUCF sector were based upon the 2016 version of the EU Reference scenario prepared for the Directorate-General for Energy, the Directorate-General for Climate Action and the Directorate-General for Mobility and Transport (EU Reference Scenario 2016) for CO_2-emissions and sinks,, where the projections for forest management were based on the G4M model.

So far, the projections were not consistent with the current LULUCF GHG inventory either. Many corrections were brought on the LULUCF GHG inventory in the 15/3/19 submission, but were impossible to include in the national projections, as both reporting were due on the same deadline.

For future reporting of projections under Regulation 525/2013, it is planned to use the model used for the preparation of the FRL. However, it will be adapted in order to reflect the actual forest management practices, in a "Species change" scenario. The FRL scenario is constrained by the forest management practices in the reference period and is thus a benchmark rather than the most likely evolution of the forest.

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

The consistency of the FRL with GHG inventories is presented and discussed in section 4.2 of this report.

1.2.2. Annex IV B

The equivalence table (Table 1) indicates where the different elements of Annex IV B. of the Regulation EC/2018/841 are found in the present report

Table 1 : equivalence table with Annex IV B.

(a) A general description of the determination of the forest reference level.	Section 3.1
(a) Description of how the criteria in LULUCF Regulation were taken into account.	Present equivalent table
(b) Identification of the carbon pools and greenhouse gases which have been included in the forest reference level.	Section 2.1
(b) Reasons for omitting a carbon pool from the forest reference level determination.	Section 2.1
(b) Demonstration of the consistency between the carbon pools included in the forest reference level.	Section 2.2
(c) A description of approaches, methods and models, including quantitative information, used in the determination of the forest reference level, consistent with the most recently submitted national inventory report.	Section 4.2

(c) A description of documentary information on sustainable forest management practices and intensity.	Sections 2.4.1 and 3.2.3
(c) A description of adopted national policies.	Section 2.4.1
(d) Information on how harvesting rates are expected to develop under different policy scenarios.	Section 2.4.3
(e) A description of how the following element was considered in the determination of the forest reference level:	
(i) • The area under forest management	Section 3.2.1
(ii) • Emissions and removals from forests and harvested wood products as shown in greenhouse gas inventories and relevant historical data	Section 4.2
(iii) • Forest characteristics, including: - dynamic age-related forest characteristics - increments - rotation length and - other information on forest management activities under 'business as usual'	Section 3.2.3
(iv) • Historical and future harvesting rates disaggregated between energy and non-energy uses	Section 3.3.4.

Chapter 2: Preamble for the forest reference level

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

The following three pools are included within the forest reference level, in accordance with article 5(4) of regulation EC/841/2018 :

- Above-ground biomass
- Below-ground biomass
- Harvested wood products

The three other pools (Litter, Deadwood and Soil organic carbon) are considered, but assumed stable, according to the Tier1 approach of the IPCC guidelines, which is applied both in the annual LULUCF inventory and the FRL.

2.2: Treatment of Natural Disturbances in the forest reference level

Natural disturbances are not considered in the FRL for the time being. Belgium may decide to apply the provision later, depending on potential future evolution of disturbances. If this is the case a technical correction will be applied to the FRL to include the natural disturbances background level.
No climate change driver is considered in the FRL (e.g. no temperature or rain trends), considering the relatively short term of the projections.

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

The carbon pools included in the FRL are the same as those considered in the annual LULUCF inventories.

2.4: Description of the long-term forest strategy

2.4.1: Overall description of the regional and national forest policies

The first Belgian Forest Code was published in 1854 (https://wallex.wallonie.be/PdfLoader.php?type=doc&linkpdf=7357-6626-1763).

It was progressively amended and replaced by regional laws.

In **Wallonia**, the Forest Code (Decree of 15 July 2008) has introduced a certain number of constraints in favor of forest conservation and the maintenance of ligneous materials and carbon, including:

- the abolition of inheritance duties on the stumpage value, which encourages more ecological forestry choices (maintaining the material, greater possibility to choose species with a long life cycle and to apply continuous cover, etc.);
- the restriction of clear-cutting;

- the obligation to plant species suited to the site, which contributes to limiting the risks of blowdown and dieback and improves resistance to climate change;
- the creation of integral reserves;
- the limitation on drainage (which encourages preservation of organic matter);
- incentives for production of high quality wood and therefore use of wood in long-term applications with gains in CO_2 linked to substitution by other materials.

The designation of 1.500 km^2 of forests in Natura 2000 under special fixed rules of management also contributes to these various objectives.

Three recent measures adopted for the management of public forest also contribute to the long-term strategy:

- Thinning standard in even-aged spruce stands of 2009: This new standard is part of more dynamic forestry than that practiced in many places. The aim behind the desire for renewed dynamism in forestry regarding the main coniferous species existing in Wallonia is mainly to produce timber in stable, healthy stands, with higher biodiversity and a shorter life-cycle. In the context of global warming, these advantages linked to the dynamism of the clearings can only be beneficial to production, by limiting the disadvantages suffered from pronounced droughts or more numerous beetle populations, for example.[1] In addition, increasing the dynamism of forestry of both coniferous and deciduous trees contributes to increasing the proportion of wood in long-term uses and therefore storage in wood products.

- Higher mix of species to increase biodiversity and resilience (biodiversity standard[2])

- Permanent Forest Cover management : the aim is to increase biodiversity and resilience, and reduce windstorm disturbances (Pro silva standard[3])

On the long term, the Walloon Forest Code foresees a balance between increment and removals and between coniferous and deciduous species. A working group on the preparation of a regional forest program has been set up in 2017, with the aim to start a brainstorming with the stakeholders on the future challenges and objectives of the forest management. Updated recommendations to the forest owners regarding adaptation to climate change have also been published in 2017[4].

Finally, a lot of research programs and many elements of the Framework Agreement on Forest Research[5] are directly related to the preservation and long-term improvement of forest resources, in a context of climate change :

[1] de Potter B., 2011. Prise en compte des changements globaux pour la gestion des pessières en Wallonie [Taking into account global changes in the management of spruce in Wallonia]. Forêt Wallonne 114: 17-25

[2] http://environnement.wallonie.be/publi/dnf/normes.pdf

[3] https://www.foretwallonne.be/images/stories/librairie/infoPS-NEW.pdf

[4] Le changement climatique et ses impacts sur les forêts wallonnes. Recommandations aux décideurs et aux propriétaires et gestionnaires. Himpens et al, 2017. http://biodiversite.wallonie.be/servlet/Repository/changements-climatiques-brochure-recommandations-2017.pdf?ID=38830&saveFile=true

[5] https://www.foretnature.be/images/stories/AteliersForestiers/ProgrammeAC2019.pdf

- The suitability of species at stations is essential, in order to improve productivity but also the resilience of forests. In 2017, a new version of the Ecological Tree Species File has been published and is a decision support tool for planting, serving forest and natural area managers.
- Intensity of biomass removal (e.g. for energy use) must be compatible with the long-term preservation of soil fertility. This will be determined in particular by a quantification of the mineral exports accompanying the farms.
- The response of trees to repeated stress (insect attacks, frosts, droughts, soil quality, etc.) is being studied to better manage forests, for example by reducing the density of trees for better access to resources (water and nutrients) or by planting them in suitable stations, along with other species (mixing).
- Research is underway on the search for species that should better withstand a drier and warmer climate, in particular by examining the responses of species planted in the arboretums to the various climatic stresses (drought, frosts, etc.), with a view to identify more drought-resistant species that produce quality timber in order to maintain species diversity and good timber production in the future.
- Modeling of forest growth is continuing, to identify the most appropriate management modes that will enhance forest resilience in the face of future environmental uncertainties. This concerns, for example, forest management of mixed stands, aimed in particular at increasing the resilience of beech or oak forests, with more diversified forests that are better adapted to climate change. The Permanent Regional Forest Inventory is a key element to deliver data for the modeling.
- Bark beetle (Ips typographe and Chalcographe) epidemics have been particularly important in recent years, following the storm-related damage caused by the storms Eleanor and David in 2017 and the climatic conditions of 2018 and 2019, which are particularly favorable for the proliferation of the insect. In this context, the Walloon Forest Health Observatory was created in 2011 and aims to centralize data and knowledge on forest health relative to the levels of the Walloon and Brussels territories. Its main missions are the production of a periodic report on the health of forest stands, the detection and identification of pathogenic insects and pathogenic fungi responsible for diseases, and the participation in the development of biotic and abiotic health risk maps, based on the state of vulnerability of the forest species and the stations.

In the **Brussels Capital Region**, the Sonian Forest is protected (no deforestation allowed) and FSC certified. Its management aims to ensure ecological stability and a long-term balance in the distribution of forest age. In addition to ensuring the ability to regenerate, biodiversity and ecological and social aspects are taken into account.

In **Flanders**, the objective of the Forest Decree introduced on 13 June 1990 was to regulate the preservation, protection, management, restoration of forests and their natural environment and afforestation. It applies to both public forests and private forests. Central to the strategy is the objective for forest management in Flanders to safeguard the forest area and maintain the different societal functions of the forest ecosystem: the economic, the social and educational, the environmental protective, and the ecological functions.

Since its conception other policies have intervened and work synergistically or complementary: e.g. Decree concerning nature conservation and the natural environment (21/10/1997), Decree on the organization of spatial planning (18/05/1999),… At the moment the forest and nature conservation legislation is being integrated to promote synergy and increase efficiency of policy measures updating the objective to integrated management taking into account the ecological, economic and social functions (since 28/10/2017).

To support and steer this objective a range of policy measures is being used:

- A system of management planning with financial support tailored to specific social (e.g. recreation) and ecological (e.g. Natura 2000) goals;
- The prohibition of deforestation and compensation rules;
- The protection of (general or regional) protected vegetations and species,…
- Nature reserves (including forest ecosystems);
- Principles for sustainable management (linked to independent certification);
- Stand-still principle (e.g. no exotic tree species after indigenous deciduous species);
- Rules for sustainable harvesting (e.g. without management plan an extensive system of licensing is in operation) and (for public forests) the sale of wood;
- Public access to forests.

As a general rule, deforestation is prohibited. There are a number of exceptions, but an exemption is required in each case and this exemption will be granted only in exchange for compensation. The obligation for compensation consists of the planting of a forest of equal size or larger (depending on the forest type) at another location within the Flemish Region. The compensation can also be financial in the form of a forest maintenance contribution to the Forests Compensation Fund.

2.4.2: Overall description of the forests and forest management in Belgium

In Belgium, forest covers about 21% of the territory (Table 2). The distribution of the forest over the regions is respectively 77,0%, 22,8% and 0,2% for Wallonia, Flanders and Brussels (Table 1). The proportion of the two categories of owners differs between regions with respectively 51%, 59% and 0% of private owners for Wallonia, Flanders and Brussels. At the national scale, the proportion of private owners is 53% versus 47% for the public owners.

Table 2: Forest cover in Belgium (Belgian FRA 2015). The proportion of the forest cover according to ownership type is mentioned between brackets (public/private).The ownership ratio has been updated for Flanders according to the last inventory data.

	Total area (km²)	**Forest cover (%)**	**% of the Belgian forest area**
Wallonia	16.844	31,2 (49/51)	77,0
Flanders	13.522	11,5 (41/59)	22,8
Brussels	162	10,5 (100/0)	0,2
Belgium	**30.528**	**22,4 (47,3/52,7)**	

Five main tree species represents 76% of the total growing stock of 157,4 million cubic meters in 2000 (i.e. 120 Mm^3). These main species are, by decreasing order: Norway spruce, native oaks (Q. petraea and Q. robur), common beech, Scots pine and hybrid poplar (Table 3). The forest composition is very different between the regions. The two main tree species are Norway spruce and native oaks in Wallonia, Scots pine and hybrid poplar in Flanders, and common beech in Brussels.

Figure 1: Forest cover in the three regions of Belgium.

Table 3: Main species encountered in the forest growing stock of Belgium in 2000 (Belgian FRA 2015).

Species	**Wallonia**		**Flanders**		**Total**	
	Mm³	**%**	**Mm³**	**%**	**Mm³**	**%**
Picea abies	52,5	41,8	0,5	1,6	**53**	**33,7**
Q. robur & *Q. petraea*	25,2	20,0	3,6	11,4	**28,8**	**18,3**
Fagus sylvatica	16,3	13,0	2,4	7,6	**18,7**	**11,9**
Pinus sylvestris	2,9	2,3	8,6	27,1	**11,5**	**7,3**
Hybrid poplar	2,8	2,2	5,1	16,1	**7,9**	**5,0**
Others	26	20,7	11,5	36,3	**37,5**	**23,8**
Total	**125,7**	**100**	**31,7**	**100**	**157,4**	**100**

Most of the Belgian forest belongs to private owners: 55%. With an average surface area of ~2,5 ha per owner and more than 100.000 owners, the private forest is characterized by a relatively large fragmentation and a large diversity of owners. These private forests are either managed directly by their owners or by a manager or a cooperative chosen by them.

Management is governed by specific legislation:

- the Forest Code in the Walloon Region
- Bosdecreet in the Flemish Region
- the Forest Code in the Brussels Region.

Public owners are managing 45% of the forest: they are the State-owned forests belonging to the Regions (11%), its communes (28%) and its provinces, public welfare centers, churches factories (3%). These forests are subject to the forest regime and managed by the forest administration:

- the Department of Nature and Forests (DNF) in the Walloon Region
- Agentschap voor Natuur en Bos (ANB) in the Flemish Region
- the Environment and Energy Administration (Brussels Environment) in the Brussels Region.

In the field, forest administrations are divided into:

- Regional directorates, each covering +/- 30.000 ha
- Cantonments (+/- 9.000 ha) and yards (+/- 750 ha)

In Flanders, the administration is organized through “Terrain management” entities (Terreinbeheer West/Terreinbeheer Oost/Terreinbeheer Koepel), which are subdivided in 15 “management regions” (beheerregio’s).

Given the diversity of soils (sand, silt, clay) and climates (from 0 to 700 m altitude, 700 to 1.400 mm precipitation), a large number of species are adapted to the Belgian territory. The figures in appendix 1 provide details on elevation, average precipitation and average annual temperatures respectively.

2.4.3: Description of future harvesting rates under different policy scenarios

Considering that management plans are prepared at the local (stand/property) level and that the current forest policies do not foresee any decision on the future harvest rate, only one alternative policy scenario has been built.

The policy scenario tested is the ”Species change” scenario, which is based on the forest management practices between the two last Regional Forest Inventories which were used on the first RFIs data and projected up to 2030 (Figure 2 and Table 4). The SIMREG forest simulator detailed in section 3.3.1 was used for the projection. In contrast to the Forest Reference Level scenario, the trend of the forest composition change between the RFIs was taken into account. The other assumptions for the simulation are the same as for the FRL scenario: a constant forest management practice, a constant forest land area, absence of major disturbances (e.g.: windstorms) and no climate change drivers (considering the relatively short term of the projections).

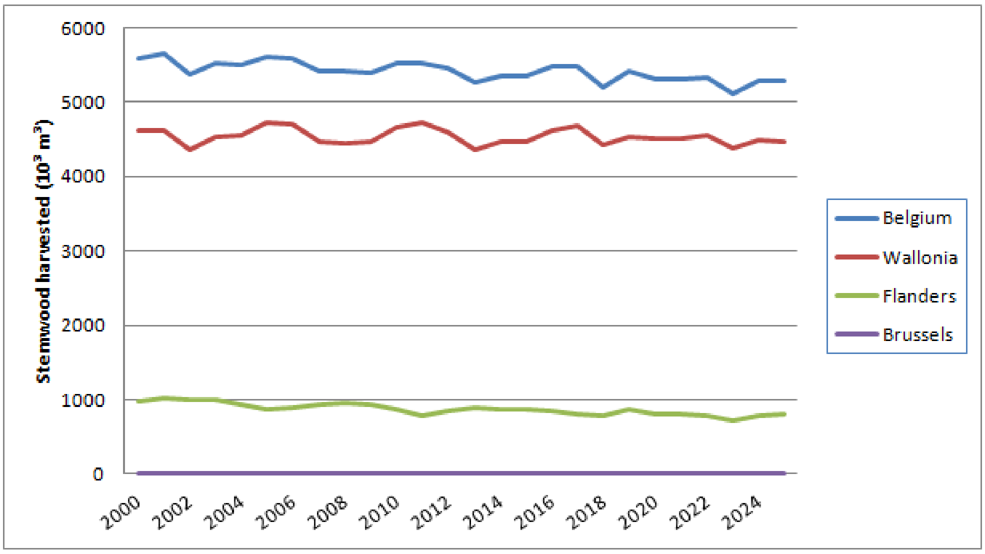

Figure 2 : Stem wood harvested (volume from the bottom of the stem up to 7 cm of the diameter) in a "Species change scenario". The forest management practices applied on the simulation are the practices observed in-between two RFIs. Due to the scale of the graph, the data for Brussels are difficult to read. These can be found in Table 4.

Table 4: Stem wood removed (volume from the bottom of the stem up to 7 cm of the diameter). in a "Species change scenario". The forest management practices applied on the simulation are the practices observed in-between two RFIs. Stem wood removed is the sum of the volume harvested and the new volume of dead trees (mortality). Based on the Walloon RFI, 5% of the volume removed is dead trees

Date	Stem wood removed (x 1.000 m³)			
	Belgium	Wallonia	Flanders	Brussels
2012	5454	4596	858	0
2013	5265	4369	889	7
2014	5357	4469	877	11
2015	5350	4463	875	11
2016	5483	4623	849	11
2017	5486	4684	795	6
2018	5211	4418	786	7
2019	5416	4544	861	11
2020	5323	4515	797	10
2021	5316	4506	798	11
2022	5328	4548	773	7
2023	5114	4392	715	7
2024	5283	4499	774	10
2025	5288	4469	808	11
2026	5370	4571	788	11
2027	5326	4528	792	7
2028	5202	4416	779	7
2029	5431	4693	729	10
2030	5420	4658	751	11

Chapter 3: Description of the modelling approach

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

The simulation of the forest evolution in Belgium has to be able to deal with the small-scale intensive forest management and the wide range of compositions and structures occurring in the country. The living biomass and the carbon in soils are the two most important forest carbon pools in Belgium (Latte et al., 2013). Unlike the carbon soil pool, living biomass stock might quickly change in the forest. Therefore, the evolution of the living biomass has to be simulated on an annual basis and including some periodical forest management practices as thinnings and clearcuts. In order to meet the peculiarities of the Belgian forest and the living biomass pool, the forest reference level of living biomass will be simulated with the forest simulation software SIMREG (Perin et al., in progress; Perin et al., 2017). A so called 'carbon pool variation module' is then applied on the living biomass results in order to obtain the variation of the other carbon forest pools (see section 2.3.4.3 in Forsell et al., 2018).

The FRL scenario includes the following good practices:

- Projection of the age-related effects (or diameter structure effect) within the stands,
- Constant stand composition (no species changes),
- Constant forest management practices (same forest management practices as in the Reference Period),
- Constant forest area (Afforestation and deforestation are not modeled)
- No climate change drivers for a short term simulation

A "Species change" scenario , has also been built, which is based on the forest management practices observed between the two last Regional Forest Inventories. The same SIMREG forest simulator detailed in section 3.3.1 for the FRL was used for this projection. In contrast to the Forest Reference Level scenario, the trend of the forest composition change between the RFIs was taken into account in the "Species change" scenario. The other assumptions for the simulation are the same as for the FRL scenario: a constant forest management practice, a constant forest land area, absence of major disturbances and no climate change drivers.

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

3.2.1: Documentation of stratification of the managed forest land

The Belgian stratification is based on criteria which are stable throughout the time (administrative regions and ownership). Forest characteristics that might change through time (such as tree species composition) are not used for stratification and will be represented by continuous (e.g. no change in the reference period nor in the projected period) variables in the simulation of the living biomass pool.

Administrative regions

In Belgium, forest policies are conducted at the regional level (Flanders, Brussels-Capital Region, Wallonia). Political decisions on forest matters therefore have an impact at the regional scale.

The monitoring of the forest resources is mostly executed at the regional level by Regional Forest Inventories (RFI). The RFI sampling protocols applied in Flanders and Wallonia, the two largest regions, are derived from traditional national forest inventory methods while the Brussels RFI is closer to a Forest Management Inventory.

The administrative strata are also correlated with some topographic and climate parameters that follow a North-South gradient such as rainfall, temperature and topography (appendix 1).

Ownership

The ownership has a significant influence on forest management practices as described in the section 3.2.2. Moreover, the forest area managed by a public or private forest owner is considerably different. For example in Wallonia, 7% of the public forest properties have more than 500 ha of forest, which together represent 90% of the public forest area (Colson et al., 2015). These forest properties are equally distributed to public managers of the Walloon forestry department. On the other hand, the average area of a private forest property is 3 hectares. Properties of less than 5 ha represent 91% of the properties and 25% of the private forest area. Whereas properties larger than 100 ha represent less than 1% of the properties and 27% of the private forest area (Colson et al., 2015). The private forest area managed by one forest manager is therefore very variable.

3.2.2. Area under forest management

As stated in the NIR (section 10.5.1) and further detailed in section 2.3 of the present report, all forests in Belgium are managed.

In the FRL, it is assumed that the area of managed forest land does not change from 2009 onwards. A technical correction will be applied by 2026 to correct for the difference between assumed area development and actual MFL area development during the compliance period.

Wallonia

The total managed forest land in Wallonia as reported in the GHG inventory (2019 submission), according to the current Land-Use change matrix and excluding lands under conversion (afforestation and deforestation), is respectively 548.662 ha in 2001 and 542.025 ha in 2012, the latter being subject to possible adjustments in the future according to updates in the matrix (forest land remaining forest land).

The total area of forest land according to table 4.1 of the CRF table is respectively 551.516 ha in 2001 and 551.566 ha in 2012.

The area reported in the regional forest inventory in 2001 is 554.000 ha. The difference between the inventory and the matrix remains within the 95% confidence interval on the total area which is 545.136 ha – 562.864 ha (error is 1,6%) for the forest inventory. This difference could be attributed to the fact that the forest inventory data represents the estimated area within one inventory cycle (1994-2008), while the land use matrix is constructed by interpolation between two land-use covers (1990 and 2009 for this period).

This total area includes non-productive areas included in the forest such as :

• roads and firebreaks (38.500 ha);

• heathland, uncultivated and fens (13.400 ha);

• old non-replanted clearings (13.000 ha);

• ponds and rivers (2.450 ha);

• various (embankments, quarries ...) (7.150 ha).

The total area of unproductive forest is estimated at 74.500 in 2001 and 74.700 ha in 2012. Given the type of areas described above, no carbon stock change is considered for these areas, in both GHG inventory and FRL. According to recent NIR, at least 13 member States include in the total forest areas some non-productive areas, that are part of the forest management. This is also clearly stated in the EU NIR, which states "For forest administrative purposes, lands without tree cover, may be included or not within forest land, thus, additional qualitative criteria complement the forest definitions provided (i.e. treatment of forest roads, nurseries, willow crops, etc.)." The Belgian definition is also in line with the FAO definition[6] which mentions : "3.Includes forest roads, firebreaks and other small open areas; forest in national parks, nature reserves and other protected areas such as those of specific environmental, scientific, historical, cultural or spiritual interest. 4. Includes windbreaks, shelterbelts and corridors of trees with an area of more than 0,5 hectares and width of more than 20 meters."

The carbon stock change approach in the GHG inventory is calculated according to wood volumes measured in the inventory. The resulting total stock change is then reported on the total area in the CRF table (including non-productive forest), which means that the implied emission factor relates to the whole forest area. The same approach is applied in the FRL, as the SIMREG model is only applied to the productive forest (479.500ha), while no carbon stock change is considered in the non-productive forest.

Flanders

The total managed forest land in Flanders as reported in the GHG inventory in 2018, according to the current Land-Use change matrix and excluding lands under conversion (afforestation and deforestation), is respectively 148.250 ha in 1998 and 142.104 ha in 2012.

The total area of forest land according to table 4.1 of the CRF table is respectively 156.304 ha in 1998 and 157.915 ha in 2012.

Similarly to the approach used for Wallonia, the projected FRL reported in Appendix 2 gives an area of 131.950 ha (1998– based on NFI1 (1997-1999), area calculated by plot sampling) which represents the area of productive forest only, thereby excluding some areas in the forest (roads and firebreaks,

[6] http://www.fao.org/3/ap862e/ap862e00.pdf

heathland, uncultivated areas and fens, old non-replanted clearings, ponds and rivers, embankments, quarries,…).

The total area in 1997-1999 for the forest inventory is 140.302 ha (135.398 ha – 145.205 ha). Since there is no confidence interval available on the area estimated by the Land-Use change matrix, a significant difference between both estimates is uncertain.

A difference could be due to the fact that the forest inventory data represent the estimated area within one inventory cycle (1997-1999), while the land use matrix is constructed by interpolation between two land-use covers (1990 and 2009 for this period). Either way, the methodology for estimating forest area is different.

In analogy to the approach used for Wallonia, no carbon stock change is considered for unproductive areas, in both GHG inventory and FRL. It must be underlined that the carbon stock change approach in the GHG inventory is calculated according to wood volumes measured in the inventory. The resulting total stock change is then reported with the total area in the CRF table, which means that the implied emission factor relates to the whole forest area.

3.2.3: Documentation of the forest management practices during the reference period

Wallonia

Introduction

The description of the forest management practices in Wallonia is mainly based on information from the Regional Forest Inventory (RFI) of Wallonia. All the RFI information of this section is based on updated data (not yet published) from the first part of the second cycle of the permanent RFI (the reference year of RFI2 is 2012) and the results of the first cycle of the permanent RFI (the reference year of RFI1 is 2001). The period between the two RFIs (2001-2012) is close to the Reference Period (2000-2009) and was used to detail the forest management practices during the Reference Period. The description of the RFI of Wallonia and the main results from RFI1 are documented in English in the book chapter of Alderweireld et al. (2016) and more details are available in the RFI1 result report in French (Alderweireld et al., 2015) and the RFI methodological guide in French (Rondeux and Lecomte, 2010).

Forest composition

The ratio between broadleaves and conifers forest is 58:42 in 2011 and the main forest stand type in Wallonia are Norway spruce even-aged pure stand (26% of the 'productive' forest area) followed by Oaks pure stand (17%).

Based on the two successive RFI, the distribution of the some of the main forest stand types has quickly changed during the Reference Period 2000-2009. Spruce stand area has decreased by 20% in eleven years (2001-2012), Douglas stands increased by 53 % and the total area of the broadleaves stands increased by 4,5 % (Figure 3).

The forest composition of some stands might change throughout the time. For example, most of the mixed stands of Norway spruce and Douglas shift to pure Douglas stand, or some mixed stands of oaks and beech can slowly be transformed to a "pure" beech stand because of natural competition.

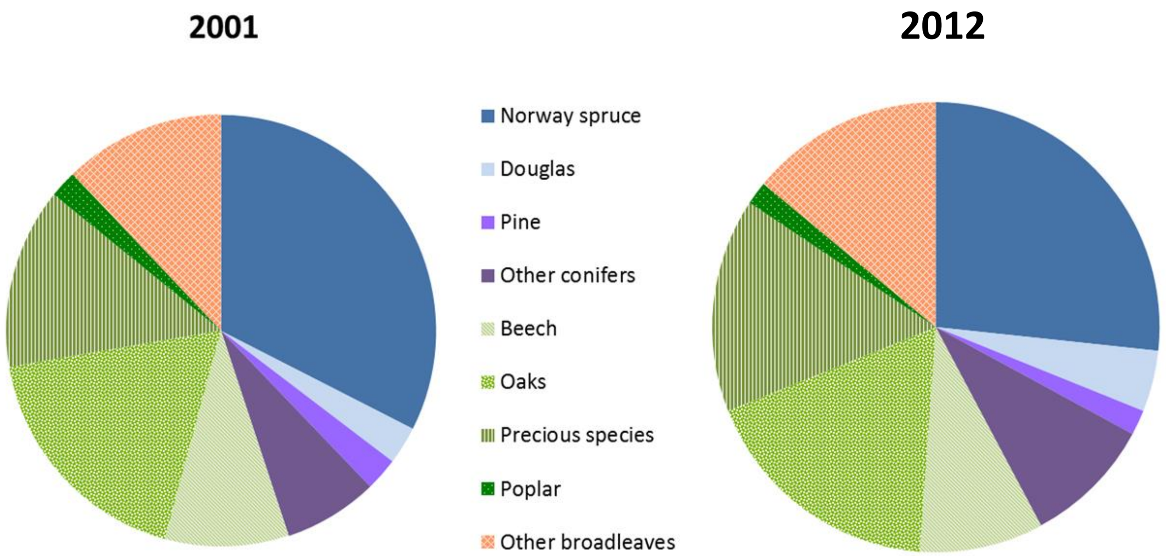

Figure 3 : Main forest types in Wallonia during the first and second permanent RFI with respectively the central year of the inventory 2001 and 2012.

The forest type distribution used in the FRL modeling of the Walloon forest is the probable distribution encountered in 2009. This probable distribution is based on a scenario which simulates the forest evolution from RFI1 up to 2009 and resulting to a forest distribution which is in between the results of the RFI1 (reference year of 2001) and RFI2 (reference year of 2012) (Figure 3).

Additional guarantee of sustainable forest management

Around 60% of the Walloon forest is ecocertified with a PEFC certification of 299.324 ha in public forest and 27.984 ha in private forest (PEFC, 2017). Natura 2000 sites cover 30% of the forest area.

Harvesting

Between the two RFIs, the total amount of solid wood volume harvested in conifer trees is 3,136 Mm^3/year and 0,876 Mm^3/year in broadleaves trees (coppice stands and coppice layers are not taken into account).

Forest operation schedule

Even-aged system

The even-aged system is applied in most of the coniferous stands in Wallonia. This system is also encountered in poplar stands, and less often in other broadleaves stands. Most coniferous stands originate from artificial regeneration (planting) but methods of natural regeneration are increasingly applied (Latte et al., 2016).

In Wallonia, most productive coniferous stands are regularly thinned. The results of RFI1 show that the thinning applied are mostly based on selective thinning methods (vs. systematic thinning, Alderweireld et al. 2015). Forest good practices in Wallonia suggest forest operation every 6 years in fast growth coniferous stands (standards 2707 from the year 2007; Perin et al. 2016) to keep the total stand basal area between 30-35 m²/ha (Hebert et al., 2002). The 6 years thinning rotation is mostly respected in public managed forests which represent 45% of the coniferous forest area of Wallonia. Based on the results of RFI1 in spruce stands, the first thinning is generally operated after the stands reach the age of 20 years (Figure 4). During the Reference Period (between the RF1 and RFI2), slight changes in sylvicultural practices were noticed in the public forest. In particular, the mean total basal area in younger coniferous stands has decreased from 38,7 m²/ha at the age of 30 years to about 35 m²/ha. In private forest, the interpretation of the thinning practices are more difficult as many factors affect the practices (economic opportunities, the ownership, the property size which change with the time: inheritance, …).

The last operation in even-aged system is clearcutting. Forest good practices suggest harvesting the whole spruce stands when the top height reaches 30 m. Following the site index of the stand, this top height is reached for an age between 55 years and 70 years (Perin et al., 2016). The image interpretation of the forest RFI plots between 2006 and 2009 shows that about half of the spruce stands are clearcut before the age of 50 years in private forest and 70 years in public forest; and 90% of the spruces stands are respectively clearcut before the age of 70 years and 90 years in private and public forests (Figure 5; Lejeune et al., 2013). The Walloon forest code forbids clearcut areas superior to 3 ha in broadleaves stands and 5 ha in conifers stands.

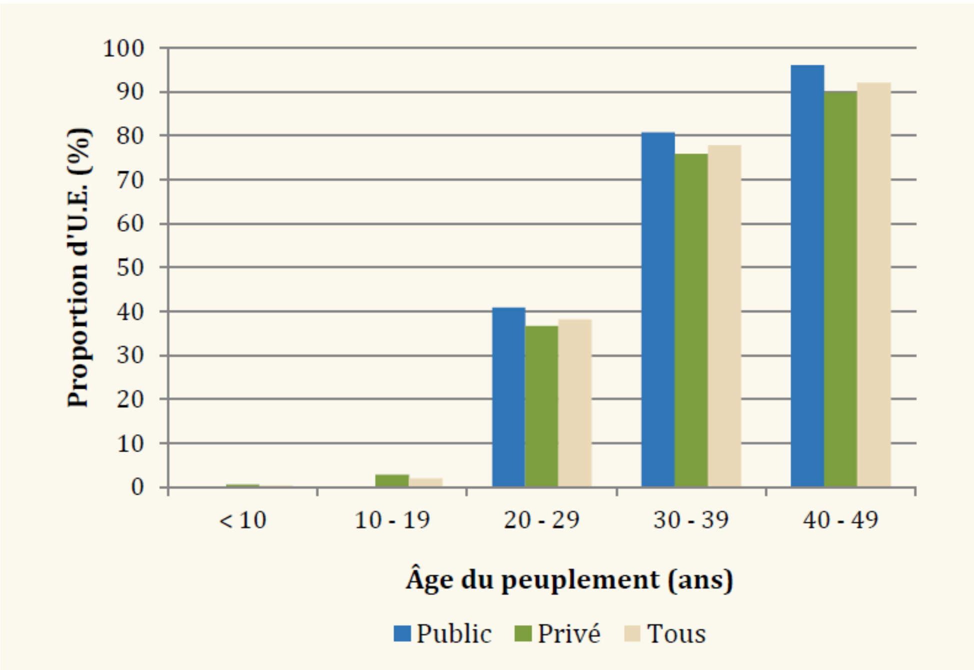

Figure 4 : Frequency of thinned stands by age class according to the spruce stand owner (Alderweireld et al., 2015).

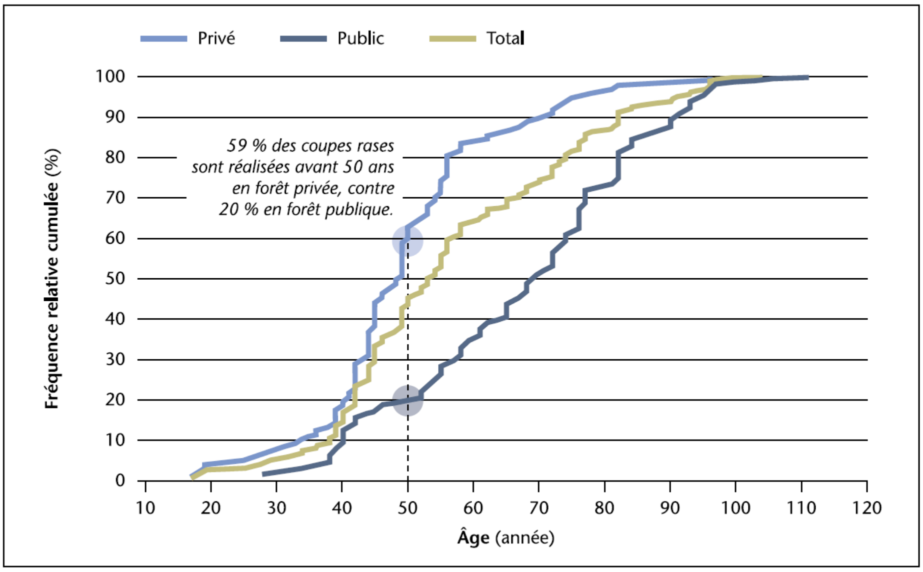

Figure 5 : Cumulative frequency of spruce stand clearcuts between 2006 and 2009 as a function of stand age and type of owner (Lejeune et al., 2013).

Other Forest structure and system

A wide gradient of forest structure are encountered in broadleaves forest in Wallonia including coppice, stands on coppice, two layers stands, one layer stands, even-aged stands and uneven-aged stands. Coppices and stand on coppices are part of an old forestry system which is slowly abandoned to a forestry based on uneven-aged stands structure, but forests with coppices still represent an important part of the broadleaves forest (32% of the Walloon forest).

In public broadleaves forest (54% of the broadleaves forest of Wallonia), the cutting cycle is 8 to 12 years following site fertility, with sometimes thinnings in mid-cycle (4 to 6 years following the stand development stage). The main criteria leading the forest operations are: i) the tree maturity (tree diameter to reach before logging) and ii) the forest density expressed in basal area per hectare. Thinning is operated in order to promote crop trees and regeneration. Unlike in the even-aged system, most of the natural regeneration develops under a continuous cover forestry system.

Good forest practices in Wallonia suggest keeping the stand basal area between 11 $m^2\ ha^{-1}$ and 18 $m^2\ ha^{-1}$ for native oaks and light demanding species (e.g. ash, cherry, alder) stands and between 17 $m^2\ ha^{-1}$ and 21 $m^2\ ha^{-1}$ for the other broadleaves stands (Alderweireld et al., 2015; Rondeux and Lecomte, 1988; Sanchez, 2016). Based on the plots with tree measured on the RFI data, the mean basal area of broadleaves stand has increased from 22,5 $m^2\ ha^{-1}$ to 23,9 $m^2\ ha^{-1}$ between the RFI1 and RFI2 (respectively 19,9 $m^2\ ha^{-1}$ and 21,1 and $m^2\ ha^{-1}$ without the coppice layer and coppice stands). The basal area and its evolution might be different following the forest type and the ownership (Table 5).

Table 5: The mean basal area of the different broadleaves forest types (in bracket, the basal area without the coppice layer and coppice stands). The estimates are computed with the plots containing at least one tree measured in the Regional Forest Inventory.

Forest type	RFI1 (m².ha-1)	RFI2 (m².ha-1)	Difference (%)
Beech	**22 (21,7)**	**22,2 (21,9)**	**1,0 (0,7)**
Public	*20,9 (20,8)*	*20,9 (20,9)*	*0,0 (0,1)*
Private	*26,3 (25,2)*	*27,1 (25,7)*	*3,1 (2)*
Oaks	**21,9 (18,5)**	**23,6 (20,2)**	**8,0 (9,2)**
Public	*21,2 (17,9)*	*23,1 (19,7)*	*9 (9,8)*
Private	*22,8 (19,4)*	*24,4 (21,1)*	*6,9 (8,8)*
Poplar	**22,6 (19,2)**	**25,4 (22)**	**12,2 (14,4)**
Public	*26,6 (22)*	*29,6 (23,1)*	*11,2 (5,2)*
Private	*22,0 (18,8)*	*24,8 (21,8)*	*12,6 (16,2)*
Precious species	**22,6 (20,4)**	**24,6 (21,7)**	**9 (6,3)**
Public	*22,3 (20,8)*	*23,6 (21,7)*	*6,2 (4,1)*
Private	*22,9 (20,1)*	*25,7 (21,8)*	*12,2 (8,8)*
Other broadleaves	**23,6 (20,2)**	**24,5 (20,7)**	**3,8 (2,8)**
Public	*22,6 (19,7)*	*23,7 (20,4)*	*4,8 (3,6)*
Private	*24,3 (20,5)*	*25,1 (21,0)*	*3,0 (2,2)*
All	**22,5 (19,9)**	**23,9 (21,1)**	**6,2 (6,0)**
Public	*21,6 (19,0)*	*22,9 (20,1)*	*5,8 (5,9)*
Private	*23,5 (18,7)*	*25,2 (20,0)*	*7,3 (7,1)*

Flanders

Introduction

The description of the forest characteristics and management practices in the Region of Flanders is based on sample measurements in the framework of the first Flemish forest inventory (RFI1, measurements 1997-1999) and interim results of the 2nd Flemish forest inventory (RFI2, 85% of the measurements processed, measurement campaign 2009-2016). The period between the two RFIs is close to the Reference Period (2000-2009) and is considered to be the best available approximation of the forest management practices during the Reference Period.

The description and results of the first RFI are documented in Waterinckx et al. (2001). The methodology of the second RFI is documented in Wouters et al. (2008). Full results of the second RFI were published in 2019 and will be used for future modeling and reporting exercises.

Forest composition

Over half of the forest in Flanders is deciduous forest. The pure, homogenous pine forests now cover about a quarter of the Flemish forests. In the past, that was almost 40%. All other mixed types of forest increased between RFI1 and RFI2. Data of the RFI show a significant increase of mixed stands, at the expense of stands dominated by coniferous species.

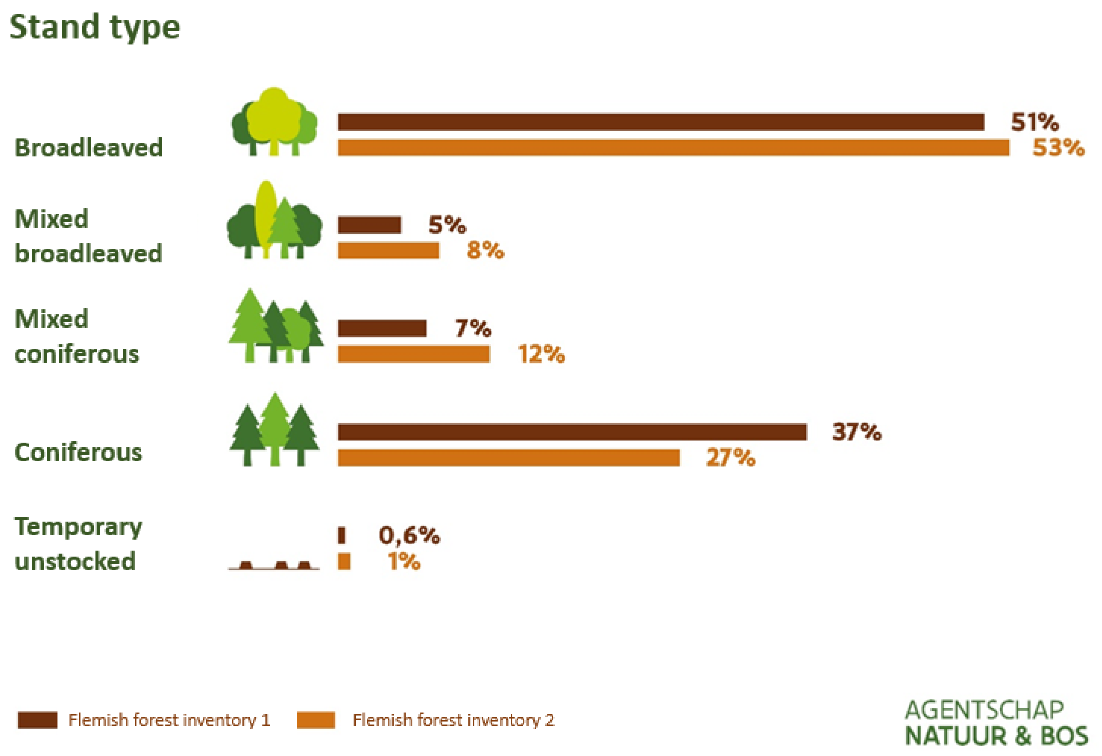

Figure 6 : Evolution of the stand types in Flanders between RFI1 and RFI2.

The share of homogeneous stands (pine, poplar and other species) has also significantly decreased in favor of the mixed forests, which now represent more than half of the Flemish forests, compared to 39% twenty years ago.

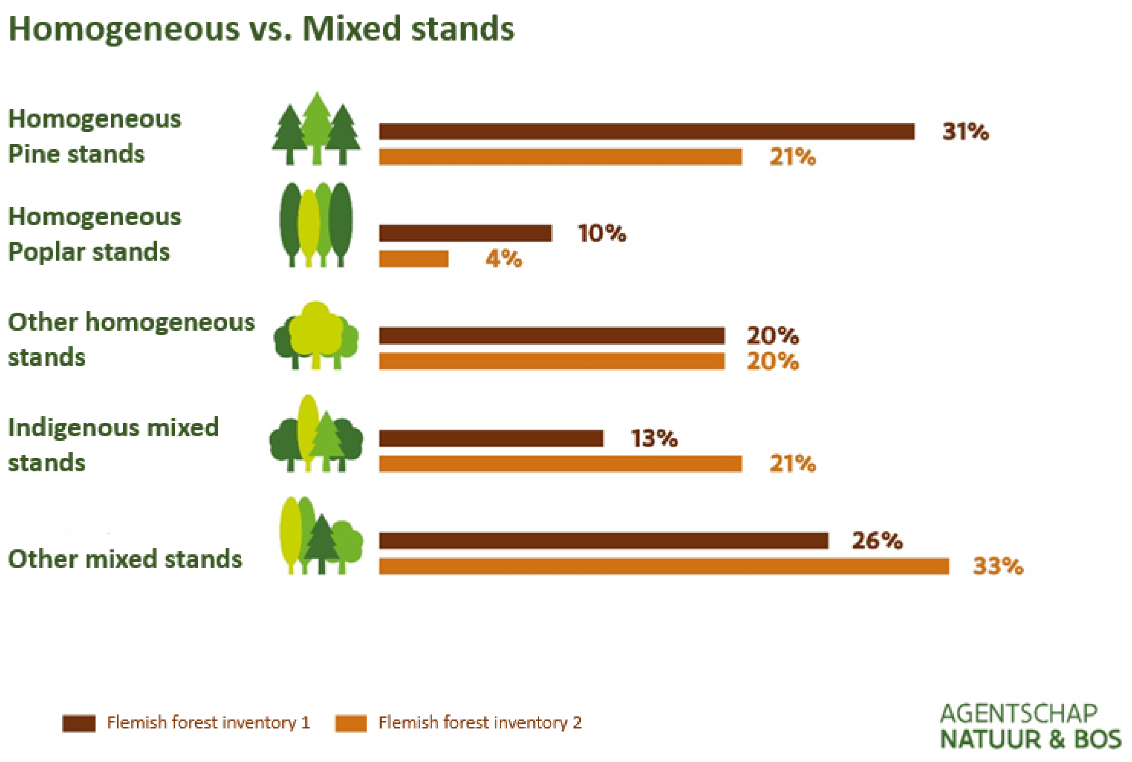

Figure 7 : Evolution of the proportion of homogeneous and mixed stands in Flanders between RFI1 and RFI2.

Scots pine is still the most common tree species in Flanders, both in volume as in number of stems, although a slight decrease from 27% to 23% (in volume) is observed. Coniferous trees as a whole account for 40% of the living wood stock, while that was still 46% at the first forest inventory.

Native oak (Quercus robur and Quercus petraea) has overtaken poplar as the most common deciduous tree species. Poplar has dropped significantly from 17% to 11% of the total volume, while the share of native oak has increased from 11% to 13%. Beech remains the number three of deciduous tree species with 8%.

Over the past twenty years, the share of indigenous tree species in Flanders has risen from 61% to 68%. The mixed native stocks have also clearly increased: from 13% to 21%.

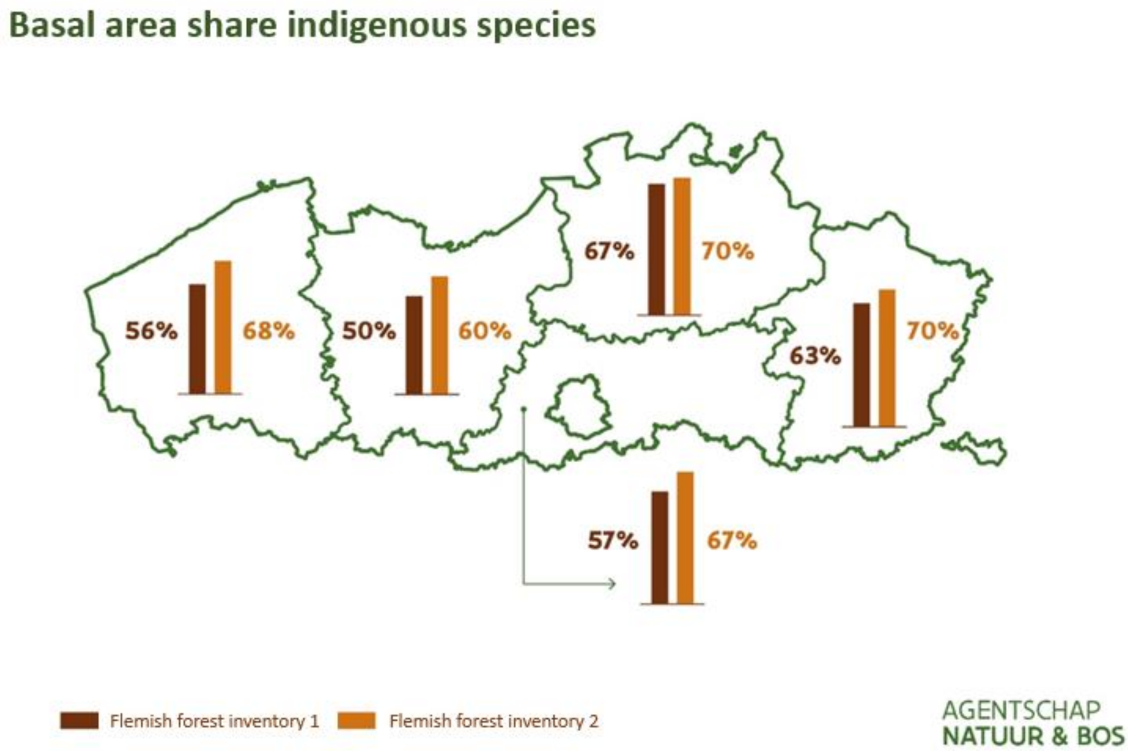

Figure 8 : Evolution of the basal area share of indigenous species in Flanders between RFI1 and RFI2.

The forest type distribution used in the FRL modeling of the Flemish forest is the probable distribution encountered in 2009. This probable distribution is based on a scenario which simulates the forest evolution from RFI1 up to 2009 and resulting to a forest distribution which is in between the results of the RFI1 (1997-1999) and RFI2 (2009-2019).

Harvesting

Table 6 gives an overview of the total volume of wood harvested in public forests managed by the Agency Nature & Forests (ANB). The non-ANB part of the timber sale is currently being mapped out.

Table 6: overview of the total volume of wood harvested in public forest managed by ANB.

	2013	2014	2015	2016	2017
Total harvested wood volume (m^3)	113.902	100.469	106.933	103.210	98.892
Coniferous (m^3)	42.413	35.057	32.110	35.878	44.002
Deciduous (m^3)	71.490	65.411	74.824	67.332	54.890

Forest operation schedule

Forest ownership is very fragmented in Flanders with about 60% privately owned and rather diverse in composition and structure. It is therefore difficult to determine a single forest operation schedule.

Comparison of RFI1 and RFI2 shows the results of the forest policy. Flemish forests change in the desired direction. They are becoming more diverse in composition, structure,…. Trees grow older and larger, although the detected changes are not always meaningful (yet). The impact of the extended forest management plans cannot be determined yet. Since the RFI2 can't spot real differences between private and public forest anymore, forest policy seems successful and the management principles and approaches as described in the Flemish criteria for sustainable forest management can be used as an approximation of general or common forest practice. More so, this document was also the guiding principle for the operations of the forest groups, cooperative associations that support mainly private forest owners in the management of their forests through advice, information, administrative support, training and coordination of management activities. In October 2017 the criteria for sustainable forest management were replaced by the criteria for integrated nature management, but basic principles are still valid.

This approach combines management based on natural processes, nature conservation measures and forest use (e.g. harvesting) that does not exceed the carrying capacity of the ecosystem. It is therefore a management vision for forests that can be sustainably used in various ways by society. This approach is summarized as the mosaic cycle concept:

- All development phases of a forest are important;
- Aiming for forests with a sufficiently large surface area (at least 50 ha and preferably larger).
- Forest management uses management units (= unit of treatment, surface with the same ecological properties);
- In large forests, a structure is strived for where all development phases (including open phase) are present;
- Time dimension: accept waiting and responding to evolution, including natural rejuvenation.

The main forestry strategy is selective high thinning before the final harvest.

Selective high thinning is variable in time: the cycle is depending on the age of the stand (Table 7).

Table 7: Typical thinning regimes

Stand type	Age	Thinning regimes
Coniferous	< 40 years	3 years
	> 40 years	6 years
	From 70 – 90 years	9 – 12 years
Deciduous	< 70 – 80 years	4 years
	> 70 – 80 years	8 years

Selective high thinning is variable in space: the thinning intensity varies per management unit or group of trees to better adapt to differences in site specific conditions, species present, accidents (e.g. wind fall) etc.

The younger coniferous stands (Scots or Corsican pine) are treated specifically. The first thinning starts at 30 – 35 years. Scots pine stands with a basal area below 14 m^2/ha and Corsican pine stands below 25 m^2/ha are not yet thinned.

The rotation period is not determined at the level of a management unit as a whole, but at the level of a group of trees or an individual tree. The rotation period is determined based on wood quality, value accruement and expected influence on surrounding trees (e.g. natural rejuvenation). The general average harvesting quantum is set at 5m^3/ha/year, but always within the average annual growth. The real production goal will be set in the forest management plans based on the local situation.

Poplar plantations clear cutting is limited to 3 ha.

Brussels-Capital Region

Introduction

The description of the forest management practices in the Brussels-Capital Region is partially based on a GIS-based forest stand description updated in 2006 and 2010 (Timal, 2006). It mainly provides data as forest-stands composition, ages, structures and surfaces for year 2010. A first Regional Forest Inventory (RFI1) with permanent sample plots (GxABT, 2007) was launched in Brussels in 2008 and lasted till 2016. The second inventory is ongoing (2017-2024). RFI1 and 2 will provide in the future valuable data as growth rates and structure/composition/surface updates.

Forest composition

The main forest stand types in the Brussels-Capital Region in 2010 were pure beech stands (59% of the forest area) followed by pure Oaks stands (12%). Broadleaves stands cover more than 92% of the forest area. Mixed stands can gather broadleaves and conifer trees.

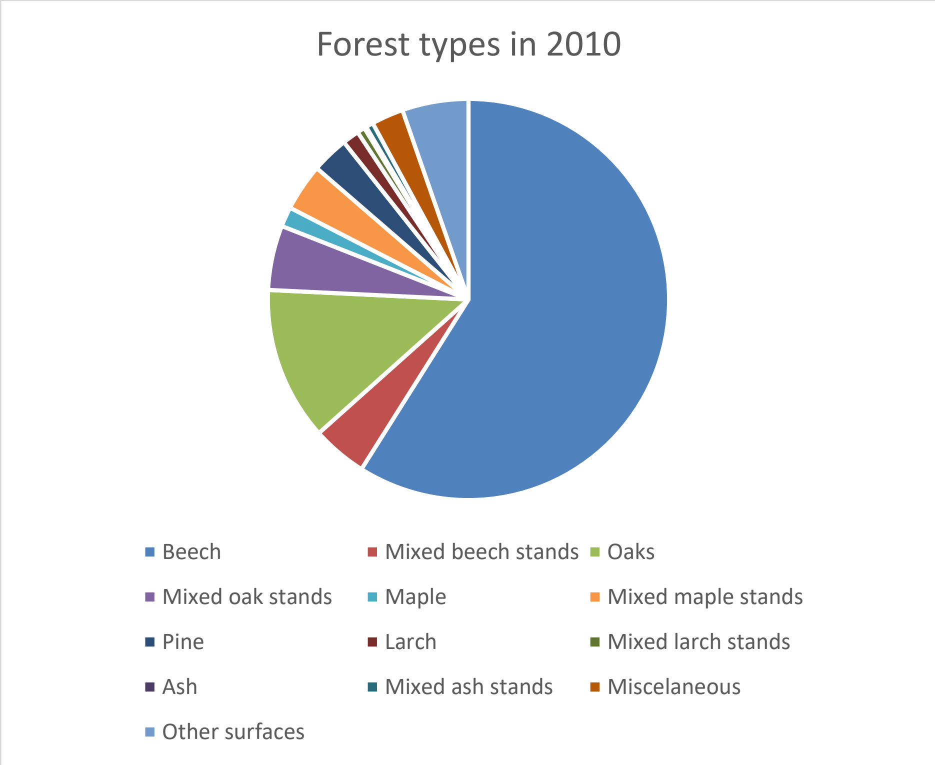

Figure 9 : Main forest types in Brussels-Capital Region based on GIS-based forest stand description (2010)

Forest eco certification

The only eco certification encountered in the Brussels Region is FSC with 1.659 ha of (public) forest certified (95,5% of Brussels forest cover). First certificate was issued in 2003 and is nowadays still on-going.

Harvesting

The total amount of solid wood volume harvested in the Brussels Region between 2004 and 2011 is described in the figure below. It has to be compared to the average annual growth rate estimated to 8,5 m³ BFT/ha by Galoux (1959). It would provide annually 13.000 m³ of wood. That old global estimated growth rate value will be confirmed and developed during the second regional forest inventory actually on its way.

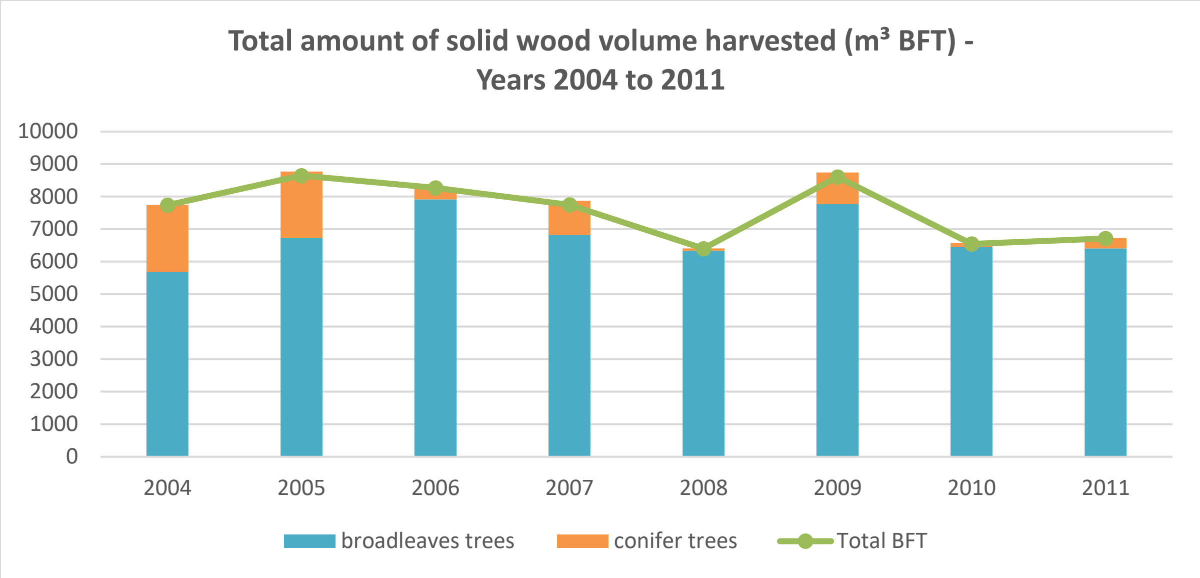

Figure 10: Total amount of solid wood volume harvested between 2004 and 2011 in Brussels.

Forest operation schedule

The Sonian Forest (95,5% of Brussels-Capital forest cover) was in 2010 mainly covered by pure beech stands (59% of the forest cover). Sylviculture was oriented there to produce "beech cathedrals", traditional forest stands characterized by 45-50 meters high beeches, with 15-20 meters branch-free trunks and vegetation-free soils.

Such a sylviculture is based on high-density plantations, conservative thinnings, 8-years rotation and a 200 years-old revolution with clearcutting. Timal (2005) developed a Forestry standard in order to help forest guards to produce traditional "beech cathedrals".

Since 2016, in response to climate change, surfaces dedicated to traditional beech cathedral production are reduced to 20% of the forest cover. Sessile oak becomes the main forest species to promote in a multi-aged, multi-layer and multi-species system.

In those broadleaves stands, the cutting cycle remains 8 years with possible forest operation in mid-cycle. The main criteria leading the forest operations are : i) the tree maturity (tree diameter to reach before logging), ii) the forest density expressed in basal area per hectare. Thinning is operated in order to promote crop trees and regeneration.

Good forest practices in Wallonia suggest keeping the stand basal area between 11 $m^2\ ha^{-1}$ and 18 $m^2\ ha^{-1}$ for native oaks stands and between 17 $m^2\ ha^{-1}$ and 21 $m^2\ ha^{-1}$ for the other broadleaves stands.

3.2.4: Documentation of data sources used for the modeling and simulation of the forest reference level

RFI data

The re-measured plots of the Regional Forest Inventories were used to develop the tree growth, the thinning and regenerations models. More methodological information on the RFI of each region is detailed in this section.

Wallonia

In the early 80s, the first regional forest inventory based upon a systematic sample with temporary plots was set up in order to get an overview of the whole forest. The first permanent systematic Regional Forest Inventory (RFI1) was launched by Wallonia in 1994 and ended in 2008. In 1997 several new parameters were integrated in the inventory especially to assess the sustainability of forest management in Wallonia (Rondeux and Lecomte 2010). The second inventory (RFI2) is in progress since 2008 using the same permanent sample plots as in the RFI1.

The ongoing inventory (RFI2) is a single-phase, non-stratified inventory using a systematic sampling design based on plots located at the intersections of a 1000 m (east-west) × 500 m (north-south) grid. This grid is covering the entire region with 33 000 sample plots of which about 11 000 are located in the forest. Each year 10 % of all plots are assessed. They are selected on a systematic basis to be evenly distributed throughout the region on a grid 10 times larger than the previous one (Alderweireld et al., 2016).

Sampling plots is composed of concentric circular plots. The larger plot with diameter at breast height (DBH) measurement is 18 m of radius (i.e. 10,18 ares) and the diameter threshold is 6,4 cm (20 cm of circumference). The following information is collected: category of property (private or public: state, region or province), municipality, forest type, stand structure and development stage, evidence of damage caused by game and the health and condition for harvest. Topography (exposition and slope), soil texture and drainage class, age (class), canopy closure, tree species, circumference at 1,5 m and total and dominant heights were also collected.

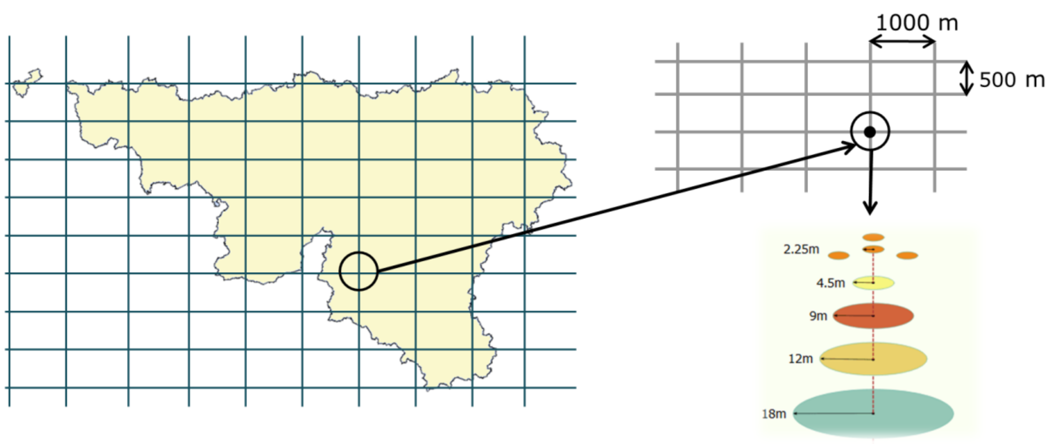

Figure 11 :Sampling design of the Regional Forest Inventory of Wallonia.

The description of the RFI of Wallonia and the main results from RFI1 are documented in English in the book chapter of Alderweireld et al. (2016) and more details information are available in the RFI1 result report in French (Alderweireld et al., 2015) and the RFI methodological guide in French (Rondeux and Lecomte, 2010).

Flanders

The first Regional Forest Inventory (RFI1) with permanent sample plots was launched in Flanders between 1997 and 1999. The second Regional Forest Inventory started in 2009 and ended in 2018. As in Wallonia, the design of the forest inventory is a single-phase, non-stratified inventory using a systematic sampling design based on plots located at the intersections of a 1000 m (east-west) × 500 m (north-south) grid with about 3.000 plots located in the forest. The larger plot with DBH measurement is 18 m of radius (i.e. 10,18 ares) and the DBH threshold is 7 cm (20 cm of circumference).

Brussels

The first Regional Forest Inventory (RFI1) with permanent sample plots was launched in Brussels between 2008 and 2015. The second inventory is ongoing. The forest inventory is a single-phase, non-stratified inventory using a systematic sampling design based on plots located at the intersections of a 200 (east-west) × 200 m (north-south) grid with 431 plots located in the forest. The larger plot with DBH measurement is 18 m of radius (i.e. 10,18 ares) and the DBH threshold is higher compare to the other regions: 12,7 cm (40 cm of circumference) instead of the 6,4 cm of the other regions.

In the Brussels Capital Region, the Sonian forest is protected (no deforestation allowed) and FSC certified from 2003 on. The management principles are defined and implemented in order to ensure ecological stability and a long-term balance in the distribution of forest ages. These principles are on the basis of the modelling exercise realized by Gembloux ABT, which was calibrated on the observations from RFI1.

Image interpretation in the Reference Period

The objectives of the image interpretation of the forest plots from the RFI's first cycles were 1) to collect data in the reference period to develop the clearcut model and 2) to update plot status (presence or absence of growing stock).

The final database of the image interpretation is composed of plot ID with the information on presence or absence of growing stock (Boolean variable).

Figure 12: Image interpretation of a time series of aerial images (within the Reference Period) for a forest plot measured in the RFI 1 of Wallonia. The forest plot was measured in 1998 and was a 41 years Norway spruce stand.

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

3.3.1 Above and below ground biomass (SIMREG)

The total living biomass (above and below ground biomass) is simulated for the Belgian forest reference level using the forest simulation software SIMREG (Perin et al., in progress; Perin et al., 2017). SIMREG is species-specific or species group specific for the minor species, the software uses tree and stand level models and requires trees and plot data coming from forest inventory as the National/Regional Forest Inventory data. SIMREG starts by computing each virtual stand on the basis of forest inventory data measured on the corresponding sample plot and then run calibrated forest sub-models of removal (thinning and clearcut), growth and regeneration (recruitment and reforestation) to predict the forest evolution (Figure 13).

The simulation of the living biomass starts by updating each plot of the RFI data up to 2009 (the last year of the Reference Period) by applying a 'Business as Usual' scenario. Then, the Forest Reference Level scenario is simulated up to 2030. The **FRL scenario includes the following good practices**: the projection of the age-related effects (or diameter structure effect) within the stands, the regeneration of clearcut with the same stand composition (no species changes), a constant forest management practice (same forest management practices as in the Reference Period) and a constant forest land area. Simulations will be executed up to the last year of the commitment period (2030). This short-term projection does not require any projection of climate change conditions.

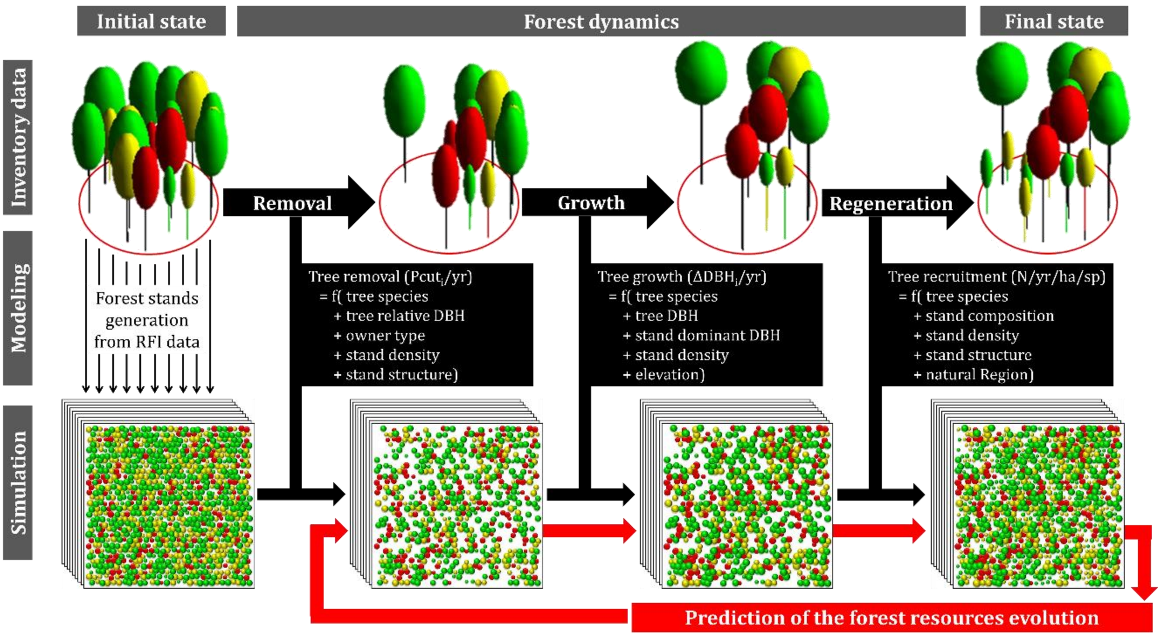

Figure 13 : Overview of the operating of the forest simulation software SIMREG.

Initialization of the simulation

The raw RFI data are processed in order to get summarized RFI data which are stored in two files: one file (stands.inv) with stand plot information (plot ID, bioclimatic region, altitude, strata, represented area, status, age, beginning and ending date of the simulation and forestry parameter such as the rotation, …) and the second file (trees.inv) with the measured trees data (plot ID, tree ID, species, extension factor per hectare, DBH, height, …).

Those files are then used to generate virtual stands representatives of each plot ID that are introduced in the simulation from the date at which the corresponding permanent sample plot was measured. The simulation is thus only full scale from the date corresponding to the end of the first inventory cycle for each Region. Before those date, we apply at each year a simple extrapolation to estimate the [Total Volume per Region] = [Total Area per Region] * [Total Simulated Volume per Region] / [Total Simulated Area per Region]. Hence, there is no extrapolation from 1997 in Flanders, 2008 in Wallonia and 2015 in Brussels.

To take into account the high fragmentation of Belgian forests, each virtual stand has a maximum area of 5 ha. This means, for example, that 10 virtual stands of 5 ha will be generated from a plot that represents 50 ha. A total of 122.696 virtual stands were generated to represent the Belgian forest. Virtual stands consist of a list of virtual trees generated from the data stored in the trees.inv initialization file. Every virtual forest stands is generated by simple extrapolation from the tree data measured in a single permanent sample plot so that each measured tree is represented by a number of simulated trees strictly equal to the number it represents at the national level. Virtual forest stands are thus perfectly representative of the RFIs data. A total of 552.159.170 virtual trees were initially generated to represent the Belgian forest. Empty virtual stands are either considered as clearcut waiting for regeneration or as unproductive forest stands depending on the status data provided in the stands.inv initialization files.

Tree species identified in the simulator

Most models integrated in the simulator are species specific. These models were calibrated for 22 different species groups: 20 for the most common tree species of Belgium and 2 default groups for the other less abundant broadleaves and conifer species. There are 14 individualized broadleaved species: Indigenous oak, Beech, Birch, Ash, Black poplar, Maple, Red oak, Alder, Hornbeam, Cherry, Chestnut, Rowan, Black cherry, Black Locust and 6 individualized conifers : Norway spruce, Scots pine, Black pine, Douglas-fir, Larch, Sitka spruce. These 20 tree species represent about 97,5% of the total forest resource of Belgium.

Tree growth model

Tree growth is estimated using non-linear tree-level distance-independent species-specific models that predict the annual girth increment as a function of individual tree girth, stand basal area, stand dominant girth and elevation as an abiotic predictor (Perin et al., in progress). The dataset used to calibrate the growth model consist of 35.124 growth segments collected between 1994 and 2016 in 3.844 permanent sample plots from the RFI databases. The methodology applied to fit those models is derived from previously published work (Perin et al., 2017).

The error distributions of each model were analyzed for each species and each predictor and no evidence of bias was found. These models explain, for each species, between 18 and 52% of the girth annual growth variance and between 28 and 72% of the basal area annual growth variance (Table 8).

Together, they account for about 48% of the girth annual growth variance and 60% of the basal area annual growth variance.

Table 8 : Summary of the growth model dataset and fitting statistics for each species group: number of growth segments (N), mean annual girth growth measured (dC, in cm/year), mean error for the annual tree girth increment estimation (cm/year), adjusted R² for the annual tree girth increment estimation (cm/year) and adjusted R² for the annual tree basal area increment estimation (cm²/year).

Species	N	Mean dC (cm/yr)	Mean error (cm/yr)	R^2 dC	R^2 dG
Indigenous oak	8391	1.0	0.01	20.1	40.1
Beech	4475	1.3	0.01	25.6	48.0
Birch	1953	0.8	-0.01	29.3	41.6
Ash	1094	1.3	0.01	28.6	53.7
Black poplar	1063	2.6	0.02	51.6	43.7
Maple	740	1.2	0.01	29.6	45.5
Red oak	677	1.9	0.01	44.8	69.0
Alder	435	0.9	-0.01	34.7	49.1
Hornbeam	303	0.9	0.00	25.5	42.9
Cherry	197	1.1	0.01	18.6	28.5
Chestnut	178	1.8	0.02	24.9	41.4
Rowan	138	0.5	0.00	29.0	54.4
Black cherry	127	1.2	0.03	50.0	47.4
Black Locust	93	1.1	0.02	39.5	55.4
Other broadleaves	368	1.3	0.01	38.2	45.8
Total broadleaves	**20232**	**1.2**	**0.01**	**46.3**	**57.3**
Norway spruce	8657	1.4	0.01	40.1	59.2
Scots pine	3130	1.0	0.01	27.9	28.5
Black pine	1116	1.2	0.02	46.0	51.4
Douglas-fir	980	2.3	0.03	52.4	72.4
Larch	798	1.4	0.00	36.8	46.4
Sitka spruce	82	2.1	-0.01	32.6	45.4
Other conifers	129	2.1	0.02	51.7	69.9
Total Conifers	**14892**	**1.4**	**0.01**	**50.2**	**65.3**
TOTAL	**35124**	**1.3**	**0.01**	**48.2**	**59.7**

Thinning model

Tree thinning is estimated using binary logistic tree-level distance-independent species-specific regressions that predict the annual probability of removal as a function of the tree relative diameter, the stand density, structure and composition and the regional owner type. Currently, these models are also used to simulate tree mortality and self-thinning in addition to thinning. The dataset used to calibrate the thinning models (Table 9) consist of 49.719 trees measured between 1994 and 2016 in 3.844 permanent sample plots from the RFI databases.

Table 9: The mean percentage of tree removing per year in Belgium (total) and at the strata scale.

		Mean %cut/an				
Species	**N**	**Total**	**Wallonia Public**	**Wallonia Private**	**Flanders Public**	**Flanders Private**
Indigenous oak	9873	2.0	2.0	1.4	3.2	3.1
Beech	5758	2.4	2.6	1.3	2.5	2.1
Birch	3089	3.4	2.7	2.9	4.5	4.4
Ash	1446	2.8	1.8	2.3	4.9	7.4
Black poplar	1513	3.4	2.5	2.4	6.8	3.6
Maple	1079	3.2	1.2	2.6	5.8	7.5
Red oak	1114	4.2	2.1	2.4	6.1	3.7
Alder	993	5.9	2.5	3.7	9.2	7.5
Hornbeam	390	2.5	2.6	2.0	6.4	3.2
Cherry	275	3.0	2.7	2.1	5.2	6.4
Chestnut	294	4.8	1.0	1.4	6.7	6.7
Rowan	287	4.8	2.9	5.5	8.2	5.9
Black cherry	629	9.6	-	-	11.2	9.0
Black Locust	121	2.3	0.0	2.0	5.0	3.5
Other broadleaves	922	6.1	3.5	3.7	9.5	10.3
Total broadleaves	**27783**	**3.1**	**2.4**	**2.2**	**5.4**	**5.3**
Norway spruce	12150	1.4	5.0	4.3	4.4	5.0
Scots pine	4923	1.0	3.4	2.6	4.1	3.6
Black pine	2107	1.2	4.3	5.7	5.3	4.6
Douglas-fir	1424	2.3	6.4	4.4	5.6	4.1
Larch	1037	1.4	4.5	2.3	3.0	2.9
Sitka spruce	121	2.1	5.5	4.5	-	-
Other conifers	174	2.1	3.2	0.8	2.6	6.3
Total Conifers	**21936**	**2.1**	**4.9**	**4.2**	**4.4**	**3.9**
TOTAL	**49719**	**2.1**	**3.5**	**3.3**	**4.9**	**4.7**

Stand clearcut probability model

Stand clearcut is estimated using a binary logistic regression that predicts the annual probability of clearcut (Figure 14) as a function of the stand composition, the dominant girth (Cdom) and the regional owner type. The dataset used to calibrate the clearcut model is based on the results of the image interpretation (see section 3.2.3) of 9.276 sample plots measured before 2007 by the RFIs.

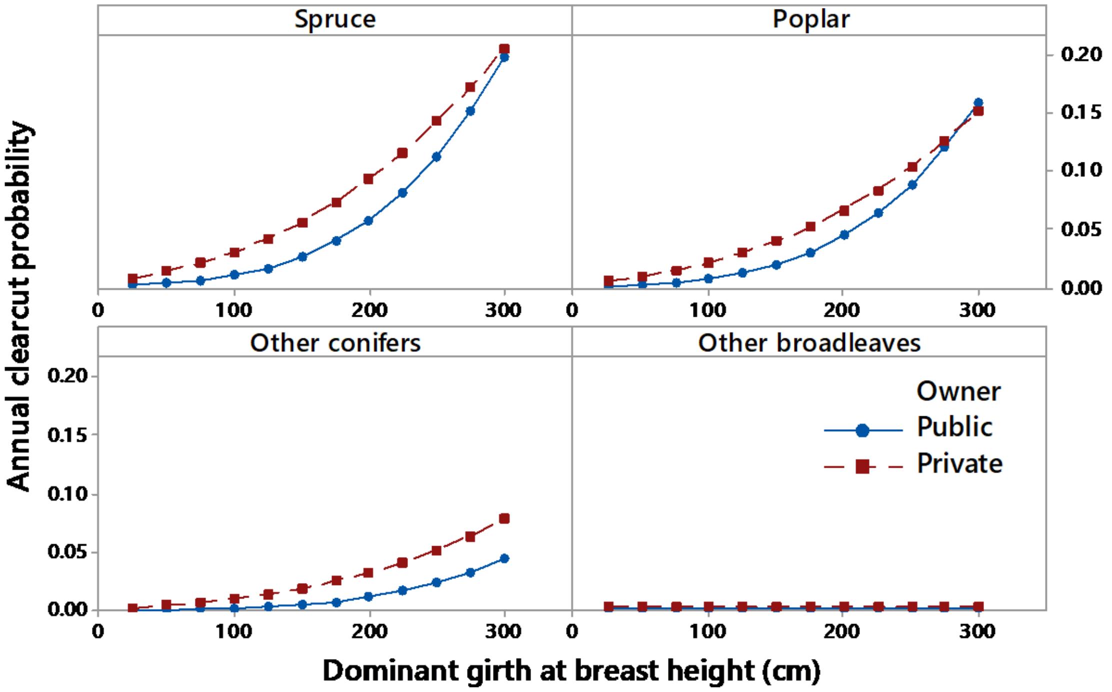

Figure 14 : Evolution of the estimated annual clearcut probability according to the stand's dominant girth in public and private forests of Wallonia for 4 different stands compositions: pure Norway spruce, pure poplar, other conifers and other broadleaves.

Regeneration model

The regeneration is simulated by generating new virtual trees at the measurement threshold (recruitment). The recruitment density is estimated using a non-linear model that predicts the number of trees recruited every year as a function of the stand structure, mean DBH, total basal area and the bioclimatic region. The dataset used to calibrate the recruitment density model consists of 3.844 permanent sample plots monitored between 1994 and 2016 by the RFIs. The recruitment composition is then estimated using a weighted probability matrix that takes into account the stand composition and the regional owner type.

3.3.2 Soil organic carbon

The net carbon stock change in mineral soil reported in the Belgian GHG inventory 2018 submission was +0,53 t C/ha.y. This stock change was derived from a study by Lettens (2005), based on 1960 and 2000 sampling plots. The drivers identified by Lettens were that forest was on average younger in 1960, containing less living biomass than in 2000, and that the biomass has increased between 1960 and 2000, leading to an increased amount of residues and progressive increase of SOC. Another driver could be the increase of below-ground biomass, leading to increased SOC from root mortality and C exsudates (Lettens, 2005).

This average stock change has been applied up to 2016 in the 2018 inventory submission. A new survey of SOC in forest is conducted in Wallonia during the current forest inventory cycle. This survey should provide results on the carbon stock change in SOC for the years between 2000 and present, but the results are not available yet. In Flanders, the current forest inventory cycle does not include soil carbon measurements. In the Brussels-Capital Region, a personal communication by the University of Ghent underlines indications of an increase in soil carbon stocks, but no quantified data are available. In Flanders, a study from 2009 (De Vos) also suggests an increase in soil carbon stocks. However, the number of samples is currently too limited and the uncertainty margin (95% confidence interval) too large to deliver significant results.

In this context, the UNFCCC review in 2018 drew the attention to the fact that the current carbon stock change applied for SOC appears to be an outlier compared to other Parties. The consultation of the EU NIR (table 6.15) confirms this assessment, as the SOC stock change is the highest of all member states: 18 member States report no change in carbon stocks and the other present a very limited sink (or source for 2 MS). Only one Member State currently reports an annual change (which is still smaller but) of the same order of magnitude (0,41 tC/ha.y). In the absence of updated values from the regional forest inventories, the currently available data and studies do not allow to extend the use of the average carbon stock change factor for the years after 2000.

As a consequence and considering that no recent information confirms that the drivers of the SOC change between 1960 and 2000 are applicable to the present forest, Belgium has revised its estimates for Soil Carbon in its 2019 submission, for the entire time series.

The available data showed an increase in carbon stocks in mineral soils between 1960 and 2000, so this pool does not appear to be a source, which means that the assumption of no stock change in SOC is conservative and in line with the Tier 1 approach of the IPCC 2006 Guidelines.

Consequently, in the absence of updated values that would allow the calculation of updated estimates, the assumption of no stock change in SOC, following IPCC 2006 Guidelines Tier1 approach is applied for the FRL and is also applied since the 2019 GHG inventory submission, to ensure consistency and avoid any expectation of undue net credits. This Tier 1 approach does not require a model.

3.3.3. Dead organic matter – Litter and deadwood

In the GHG inventory submission, Belgium applies the Tier 1 approach of the IPCC 2006 Guidelines, assuming no change in carbon stock in managed forest land, for both litter and deadwood (notation key “NO” is used in the CRF tables).

The same approach is applied for the FRL, assuming no change in carbon stock in managed forest land, for both litter and deadwood. This Tier 1 approach does not require a model.

3.3.4. Harvested Wood Products

The projected HWP pool has been estimated according to the stepwise approach described in the Technical guidance.

The projected harvest has been compared to the average historic harvest as documented in the FAO database, which is the activity data used in the annual HWP reporting. The average total harvest in 2000-2009 according to the FAO database is 4.697*10^3 m^3 per year (total for roundwood : industrial roundwood+wood fuel). The average share of wood fuel according to FAO data is 13%. The total annual harvest according to the model during the reference period is on average 5.552*10^3 m^3 per year, which is significantly higher than the FAO data.

Consultation with relevant experts revealed that the FAO data are based on regional forest inventory data where some removals are neither recorded nor considered. In particular, harvest estimates for coppice, linear stands, unmeasured and impenetrable stands are not included in the FAO data but they are simulated by our model. It should also be noted that our model does not differentiate between harvesting and mortality.

We estimated that coppice should represents 7 to 8% of the total harvest and that, based on the Walloon RFI, about 5% of the volume removed corresponds to dead trees. The rest of the difference between FAO data and simulated harvest is attributed to impenetrable and unmeasured stands. According to expert judgment, this additional harvest does not fit the typical requirements for solid wood product and we thus assume that it is used as woodfuel. As a result, the total share of woodfuel is actually significantly larger than the 13% reported in the FAO data and represents in fact 27% of the total harvest.

In order to avoid any overestimation of the industrial roundwood (IRW) entering the HWP pool, the industrial round wood has been projected from 2010 by applying the modeled trend of the total harvest (as projected by the model) on the average IRW from FAO data for the period 2000-2009. In practice, we applied the same approach as the one applied by the Netherlands7, by scaling each years' production values in each category (sawnwood, paper, wood based panels) compared to the average over the period 2000-2009 (total harvest in year divided by total harvest in the reference period 2000-2009.

Imports and exports were projected by calculating "intensity indicators" for wood imports and wood exports in the period 2000-2009 (share of import and export compared to the domestic production) and applying them to the wood production from 2010 on, for all categories.

This approach excludes the woodfuel from the HWP accounting and maintains a constant ratio between solid and energy use of forest biomass as documented in the period from 2000 to 2009, in line with Annex IV, A (e) of the LULUCF regulation.

According to the model, the total harvest in 2021-2025 varies from 5.260 to 5.418*10^3 m^3, representing a slight decrease compared to the 5.552*10^3 m^3 simulated in the reference period, with an annual harvest in 2021-2025 representing yearly 95% to 98% of the average harvest in the reference period.

We also calculated the average fD and fFM in 2000-2009 and used it to estimate the ratio of wood issued from managed forest. Figure 15 shows the consistency during the reference period (2000-2009) between the estimates for Industrial roundwood in the FAO data and the FRL model.

7 http://cdr.eionet.europa.eu/nl/eu/mmr/lulucf/envxdyfqg/NFAP-NL.pdf, equation 3.9 page 44

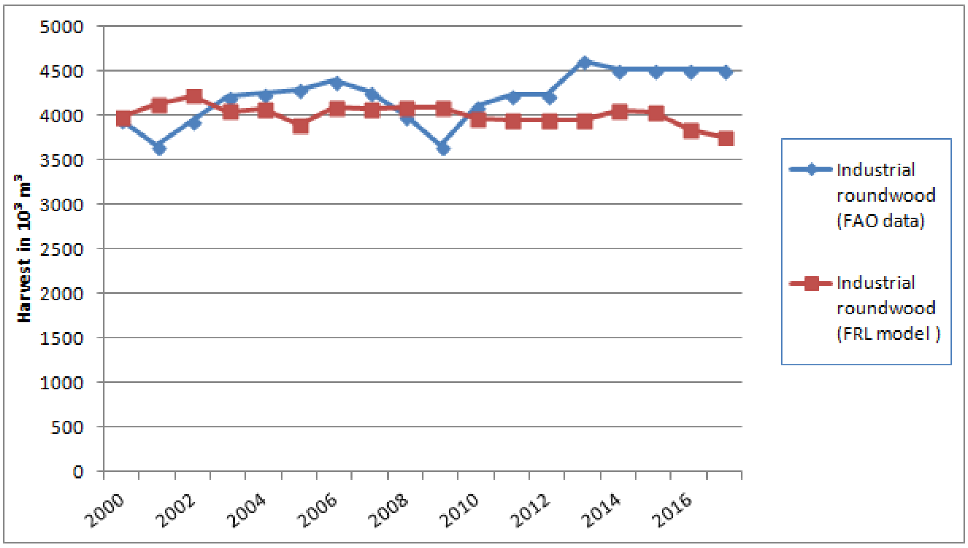

Figure 15 : Comparison of Industrial roundwood estimates : FAO data and FRL model.

The HWP have then been calculated from 2010 onwards, using the same methodology as in the current inventory. The situation at the end of the Reference Period, i.e. 2009, is considered as a starting point for the projection. This correction was applied according to the technical recommendation published in the Commission Staff Working Document SWD 2019/212. In the NFAP as submitted in January 2019, the actual available data up to 2016 were used so that the projection started in 2017, which was not in line with the Regulation and Technical Guidance.

Production of Sawn wood, Wood panels and Paper and Paperboard projected from 2010 to 2025, are multiplied by their fraction of domestic harvest (f_{IRW}, f_{PULP}) and by the share of forest management (f_{FM}) to determine the fluxes entering the HWP carbon pool. This is added to the historical HWP carbon stock, while the overall carbon stock decays, according to the specific half-lives of IRW, WP and PP (resp. 35, 25, 2 years).

Since April 2019, a slight correction had also been applied in the HWP calculation : carbon stocks of the HWP pools at initial time (period 1900-1961) are now estimated applying equation 2.8.6 of the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol, instead of equation 12.6 of the 2006 IPCC Guidelines applied in the 2019 submission (see NIR 2019 page 244). This correction will be applied in the forthcoming inventory submissions, from January 2020 on.

Table 10 : Harvest data and solid use of harvest for the average of the Reference Period and for the period 2021-2025 (FRL)

	Total harvest (10^3 m^3)	Solid use of harvest – simulated (Industrial Roundwood, 10^3 m^3)	Woodfuel – simulated (10^3 m^3)
Average 2000-2009	5552	4072 (GHGI 2000-2009 : 4069)	1483
2021	5418	3975	1443
2022	5260	3859	1401
2023	5280	3873	1406

2024	5282	3875	1407
2025	5275	3870	1405

4. Forest reference level

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

4.1.1 Living Biomass

The main raw outputs of the simulator SIMREG are the species, the DBH (and the height) of each tree in each RFIs plot for each year simulated.

The stem volume (solid wood volume, V_{stem}) are estimated using the 13 species volume equations of Dagnelie et al. (2013). For each species without a species volume equation, a morphological correspondence between one of the 13 species equations and the focused species has been done.

The stem volume is converted into total above ground volume (AGV) by using the DBH and height dependent volume expansion factor (VEF) of Longuetaud et al. (2013) on which we add the volume of the stump (equations 1,2,3 and 4). In Table 11, an average ratio AGV/V_{stem} per species has been computed (BEF1) with the second Walloon RFI to summarize the conversion of V_{stem} to AGV.

The stump volume is estimated as a cylinder with a diameter equal to the diameter of the beginning of the bole and a height of 10 cm (the mean stump height in the dataset of Dagnelie et al., 2013, equation 4). The diameter of the beginning of the bole, D_0, is estimated by using the taper curves of Dagnelie et al. (2013, equation 5).

$$AGV = v_{stem} \cdot VEF + v_{stump}$$ *Equation 1*

$$V_{stem} = f(dbh)$$ *Equation 2*

$$VEF = f(dbh, h)$$ *Equation 3*

$$V_{stump} = D_0 \cdot 0.1$$ *Equation 4*

$$D_0 = f(dbh, h)$$ *Equation 5*

The below ground volume is estimated by using the below biomass expansion factors (BEF2) of Vande Walle et al. (2005, equation 6).

The total volume of the tree is then converted into biomass by using the species mean basal wood density of 40 species in Belgium (equation 6 and 7). The mean basal wood density was computed from the worldwide dryad database (Chave et al., 2009; Zanne et al., 2009) and the wood density (WD) data of Wagenführ and Schreiber (1985) which were converted into basic wood density (Latte et al., 2013). The biomass is converted in carbon by using the default IPCC conversion factor CC: 0.5 (Eggleston et al., 2006, equation 8).

$BGV = AGV \cdot BEF2$ *Equation 6*

$TV = AGV + BGV$ *Equation 7*

$TC = TV \cdot WD \cdot CC$ *Equation 8*

The yearly carbon stock change of the Belgian forest is converted in equivalent CO_2 using the molecular weight ratio 44/12.

Table 11: Species or genus having a species/genus Dagnelie et al. (2013) stem volume equation and/or a Longuetaud et al. (2013) VEF.
BEF1 is the mean ratio AGV/V_{stem}, AGV is the above ground volume which includes the volume of the stump, the stem and the branches (only non italic BEF1 are based on Longuetaud et al. (2013) genus specific equations). BEF2 are the constant below ground biomass expansion factor of Vande Walle et al. (2005). The basic wood density is computed as the average of the species basic wood density from Chave et al. (2009) and Wagenführ and Schreiber (1985).

Species/genus	**Stem volume equation**	**Mean BEF1 in the RFIW2**	**BEF2**	**Mean basic wood density (g/m³)**
Quercus petraea & robur	x	1.35	0.21	0.562
Quercus rubra	x	*1.3*	0.21	0.516
Fagus sylvatica	x	1.38	0.21	0.586
Betula pendula & pubescens	x	1.33	0.21	0.528
Acer pseudoplatanus	x	*1.37*	0.21	0.514
Fraxinus excelsior	x	1.25	0.21	0.563
Prunus avium	x	*1.4*	0.21	0.496
Ulmus campestris & glabra	x	*1.43*	0.21	0.518
Carpinus sp.		1.53	0.21	0.685
Larix decidua & kaempferi	x	1.11	0.2	0.458
Picea abies	x	1.14	0.2	0.380
Pinus sylvestris	x	1.12	0.16	0.422
Pseudotsuga menziesii	x	1.16	0.17	0.427
Abies sp.		1.23	0.2	0.410

4.1.2 Soil carbon

As explained in section 3.3.2, the soil carbon is deemed stable , so the FRL does not include any emission or removals in this pool.

4.1.3. Dead organic matter – Litter and deadwood

As explained in section 3.3.3, Belgium assumes no change in carbon stocks in this pool. Hence no emissions or removals are considered in the FRL.

4.1.4. Harvested wood products

The projected total HWP calculated as explained in section 3.3.4 are presented in Table 12.

Table 12 : Projected total Harvested Wood Products volumes.

	HWP (kt CO_2)
2021	-169.1
2022	-124.9
2023	-127.2
2024	-125.1
2025	-120.7

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

4.2.1. Forest management

Regional inventories were significantly revised between the 2018 and 2019 GHG inventory submission. These revisions are reflected and described in the 15th April 2019 GHG inventory submission.

Figure 15 compares the FRL to the 15th April 2019 GHGI submission.

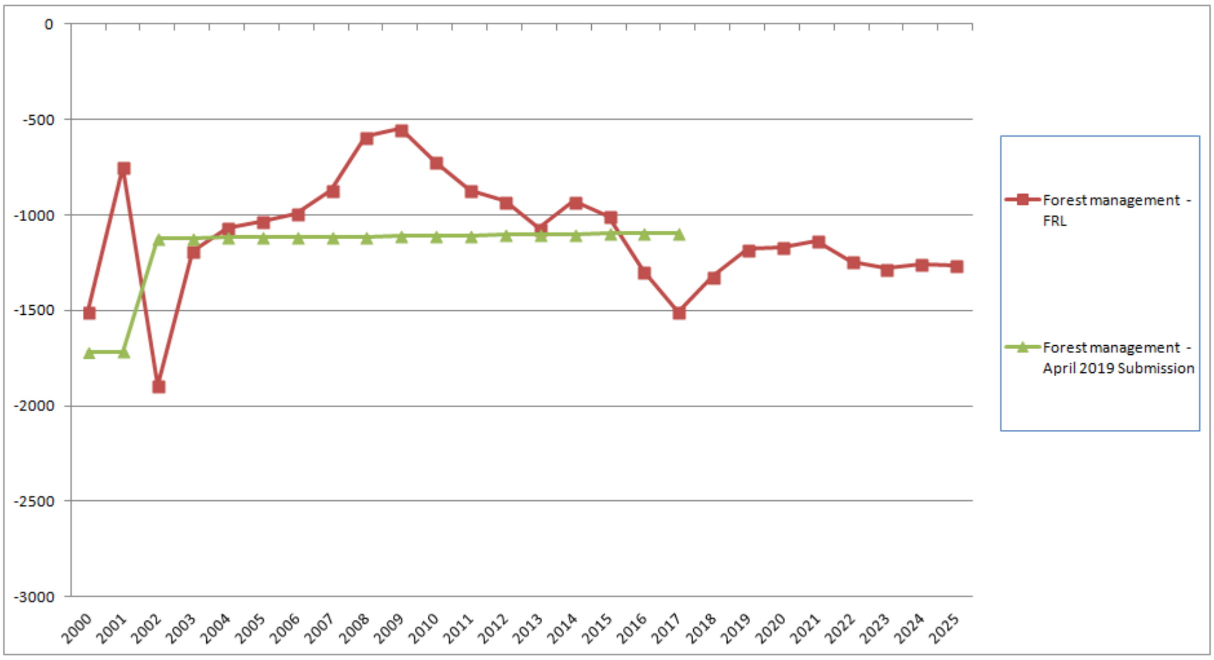

Figure 15 : CO_2 equivalent emission and removals the Belgian forest simulated with the FRL scenario and GHGI data (April 2019 submission) using the stock change approach.

Historical data used for the consistency analysis

The consistency is here analyzed with regard to the 15th April 2019 submission data.

According to the technical Guidance, section 2.4.1, "*Historical data here refers to the period 2000-20XX; where 20XX is the latest inventory year available in the national GHGI at time the FRL is constructed.* (As publicly available by the time of submission of the FRL.)" In this regard, Belgium underlines that the 15th April submission, is the latest submission and is publicly available on the EIONET Central Data Repository (https://cdr.eionet.europa.eu/be/eu/mmr/art07_inventory/ghg_inventory/).

Consistency with GHG inventory

Phase 1 / consistency of management practices

As described in section 3.2.2, the management practices applied in the model are based on the actual management observed in the reference period, inferred from the direct interpretation of the forest inventory sampling plots, as measured in 2001 and 2012 in Wallonia, 1998-2012 in Flanders and 2006-2010 in Brussels Capital Region.

The GHG inventory is based on the same results of the regional forest inventories for these central years, using a carbon stock change approach which includes all actual increments and removals in managed forest.

In this regard, the management practices used in the FRL are fully consistent with the practices measured in the reference period.

The thinning model developed for Flanders and described in Table 9 has been revised since January 2019 because it led to an overestimation of the total volume removed in the FRL. We assume that the methodological differences (eg protocol and equipment) between the first and the second RFI resulted in some technical mismatches that were wrongly identified as removals during our modelling process. It seems reasonable to expect that the thinning applied in forest stands of identical composition, structure and owner type is comparable in all regions. The thinning values presented for Wallonia in Table 9 have therefore been applied to all regions as was suggested during the review process by the LULUCFEG. The FRL generated using the adapted thinning figures is presented in Figure 15 and clearly shows that this approach brings the FRL and GHG inventory closer to each other.

Phase 2/ Consistency of emissions and removals estimates

The total stock change and average annual values of the FRL and the GHG inventory are compared in the table and figure below. The years 2000 and 2001 are not considered here : 2001 is the central year of the Walloon forest inventory and the GHG inventory data, prepared using a stock change approach, show a clear jump in the estimate and consequently these years are not relevant for this comparison. Taking into account these elements, the period 2002-2009 is deemed the most relevant for the comparison.

Table 13 : Belgium - Comparison between FRL and GHG inventory (April 2019)

	Average annual removal in the period 2002-2009 (kt CO_2)
FRL	-1022
GHG Inventory April 2019 (95% confidence interval)	-1116 (-875/ -1357)

The average values of FRL and GHG inventory are very close and the FRL values lies within the GHG inventory 95% confidence interval[8], which suggest a good consistency. This is in line with the Commission recommendation, as recorded in the minutes of the WG5 meeting on 2-3 October 2019 “However, the most important part is the third step – consistency of output data for the entire time series and total of all pools – which is where the 95% confidence interval is to be applied to check for consistency and whether ex-post adjustment is necessary”[9]

Phase 3 / Consistency of time series

[8] The 95 confidence interval is calculated on the basis of an uncertainty of 21,6% for the category Forest land remaining forest land, as reported in the NIR 2019 (page 352).

[9] https://ec.europa.eu/transparency/regexpert/index.cfm?do=groupDetail.groupMeetingDoc&docid=36319

The consistency analysis described in section 2.4.4. of the Technical Guidance is not applicable, considering the use of a stock change approach, which does not allow to analyse a short term trend.

4.2.2. Harvested Wood Products

Figure 16 compares the projected HWP from the FRL (see section 3.3.4) and the HWP as reported April 2019 GHGI submission. The correction applied since April 2019 is also represented (carbon stocks of the HWP pools for the period 1900-1961 are now estimated applying equation 2.8.6 of the 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol, instead of equation 12.6 of the 2006 IPCC Guidelines applied in the 2019 submission).

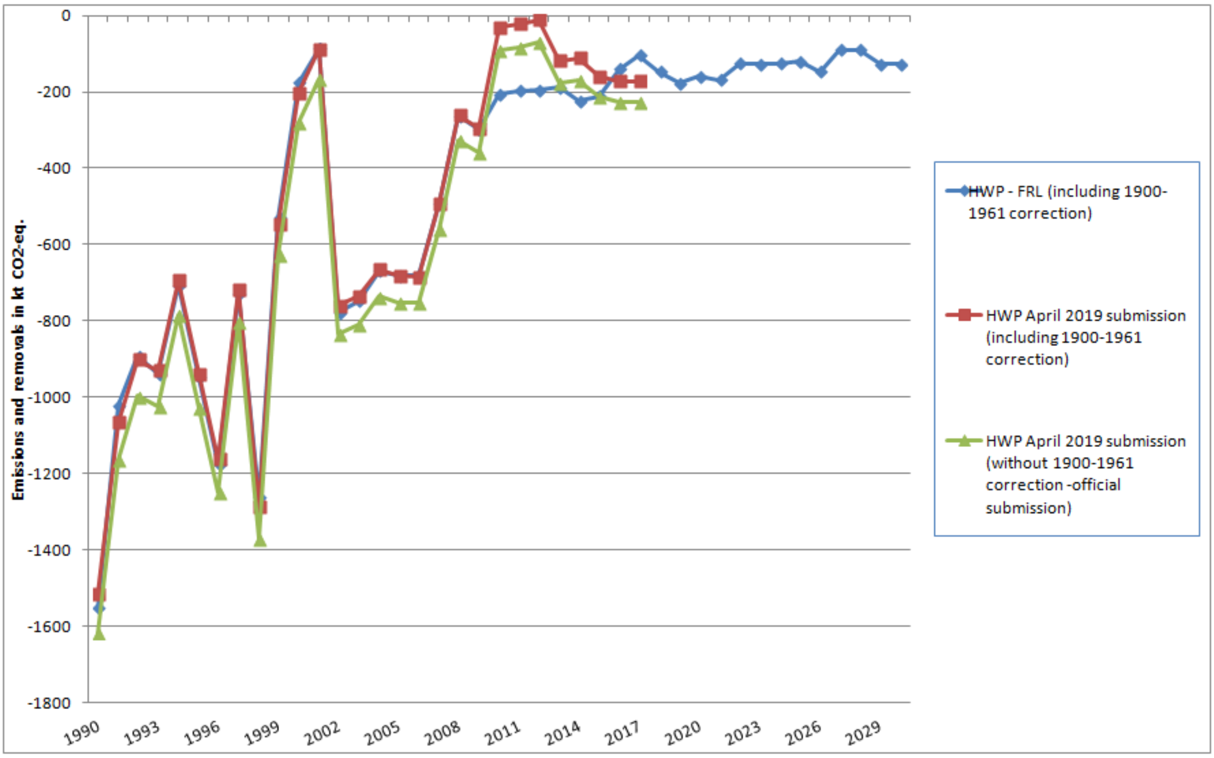

Figure 17 : HWP emissions and removals : April 2019 submission, corrected April 2019 submission and FRL

Figure 17 shows that the HWP pool is calculated using the same methodology for the reference period. The projected level differs from the current GHG inventory for the years 2010-2017, due to various rationales:

- the recent evolution of sawnwood and wood panels production, as observed in 2010-2017 according to the FAO database, with an increase of sawnwood and a decrease of wood panels, is not reflected in the FRL projections which are purely based on projected harvests.
- Industrial Roundwood production according to the FAO database for 2010-2017 is slightly higher than the projected FRL value.

4.3: Calculated carbon pools and greenhouse gases for the forest reference Level

4.3.1 Living Biomass

Following the FRL scenario, the living biomass stock increases during the commitment period from a mean carbon stock of 60,560Tg in the 5 first years of the commitment period (2021-2025) to an average of 62,298Tg of carbon in the second half of the commitment period (2026-2030, Table 14 and Figure 16 and Figure 17 and 21)[10]. The sink of the Belgian forest is slightly increasing during the commitment period with an absorption of around 1.236 ktons of CO_2-eq. The stem volume removed from the living biomass of the forest is slightly decreasing and close to 5,3 Mm^3.

After clearcut, between 15 and 25 years (depending on the species) are generally required for the next forest stand to leave the juvenile stage and reach its production phase. The Walloon forest inventory data shows that the annual clearcutting rate is currently decreasing (and has done so for the last 20 years) while the rate at which juvenile stands reach their production phase is increasing. This is obviously linked to the current renewal of our softwood resources that has been observed since the 1990s. This essentially leads to an actual increase of the share of the total productive forest area that is in its production phase. In addition, we observed between 1995 and 2009 that the total area occupied by pure douglas-fir stands and mixed douglas-fir - Norway spruce stands increased from 16 500 ha to 31 000 ha. Thus, a significant proportion of these new plantations are composed of species that are more productive than the one they replaced. We believe these elements are the key driver for the overall simulated trends in growth and harvest.

Table 14: The mean value of the living biomass in the forest reference level scenario before and during the commitment period.

Period	Annual carbon stock (kt C)	Average annual balance (negative values stand for removals) (kt CO_2eq)	Average annual stem volume harvested (10^3 m^3)
2011-2015	57336	-960.0	5442
2016-2020	58873	-1293.8	5289
2021-2025	60560	-1235.6	5303
2026-2030	62298	-1327.6	5269

Table 15: Increment of the main species in Belgium

Species	Increment (m^3 ha^{-1} $year^{-1}$)		
	Wallonia	Flanders	Brussels
Oaks	5,4	5,5	5,7
Beech	8,9	8,3	8,3
Birch	6,3	5,7	6,5
Ash	8,4	8,4	8,4

[10] Data for 2026-2030 are included in this section for information only and do not represent any official submission of the FRL for 2026-2030.

Poplar	7,6	6,9	-
Other broadleaves	12,2	9,7	10,1
Norway spruce	17,0	15,0	10,4
Douglas	21,8	16,3	13,8
Scot pine	5,7	6,7	5,7
Black pine	8,9	10,7	9,2
Larches	9,4	9,7	7,9
Other conifers	21,8	20,8	16,0

Table 17 : Regional FRL

Annual balance (kt CO2)	Belgium	Wallonia	Flanders	Brussels
2021-2025	1235.6	968.8	260.8	6.0

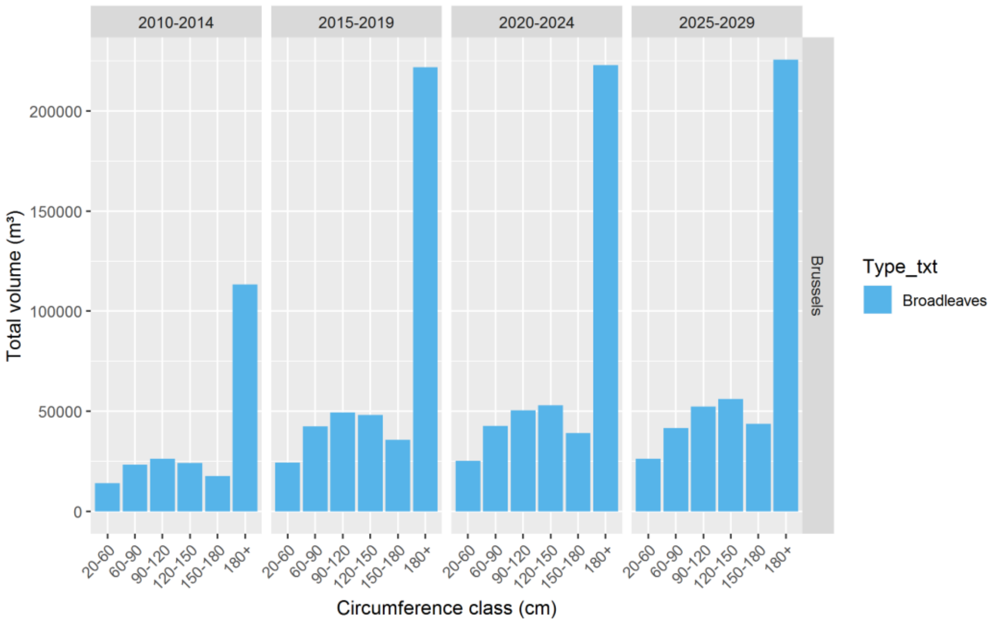

Figure 16 : Forest structure evolution in Brussels

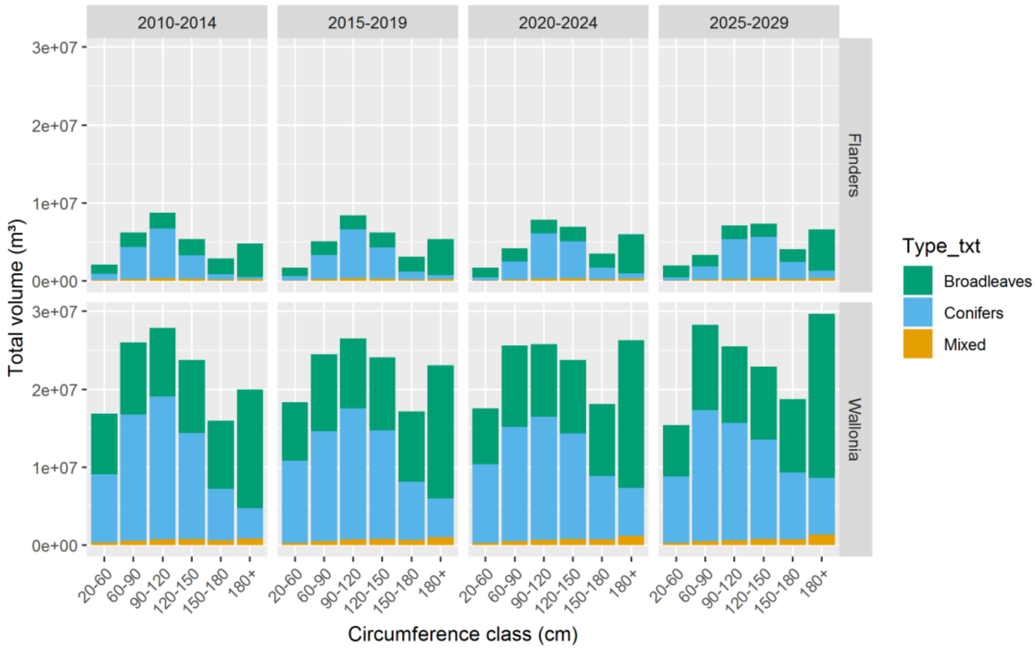

Figure 17: Forest structure evolution in Flanders and Wallonia by periods of 5 years.

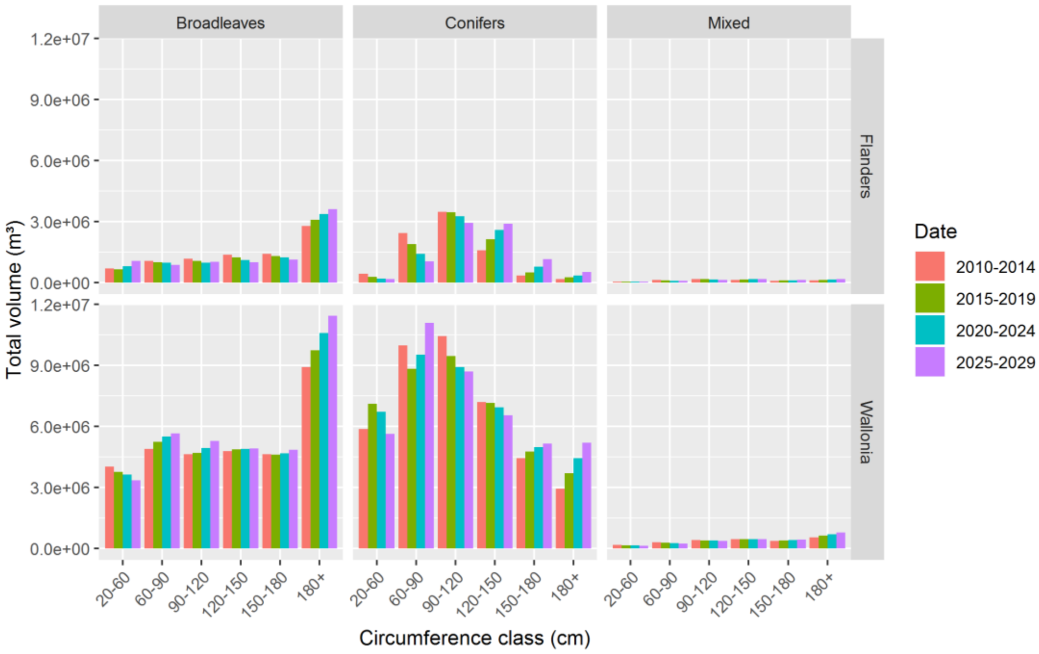

Figure 18: Forest structure evolution in Flanders and Wallonia by forest type group.

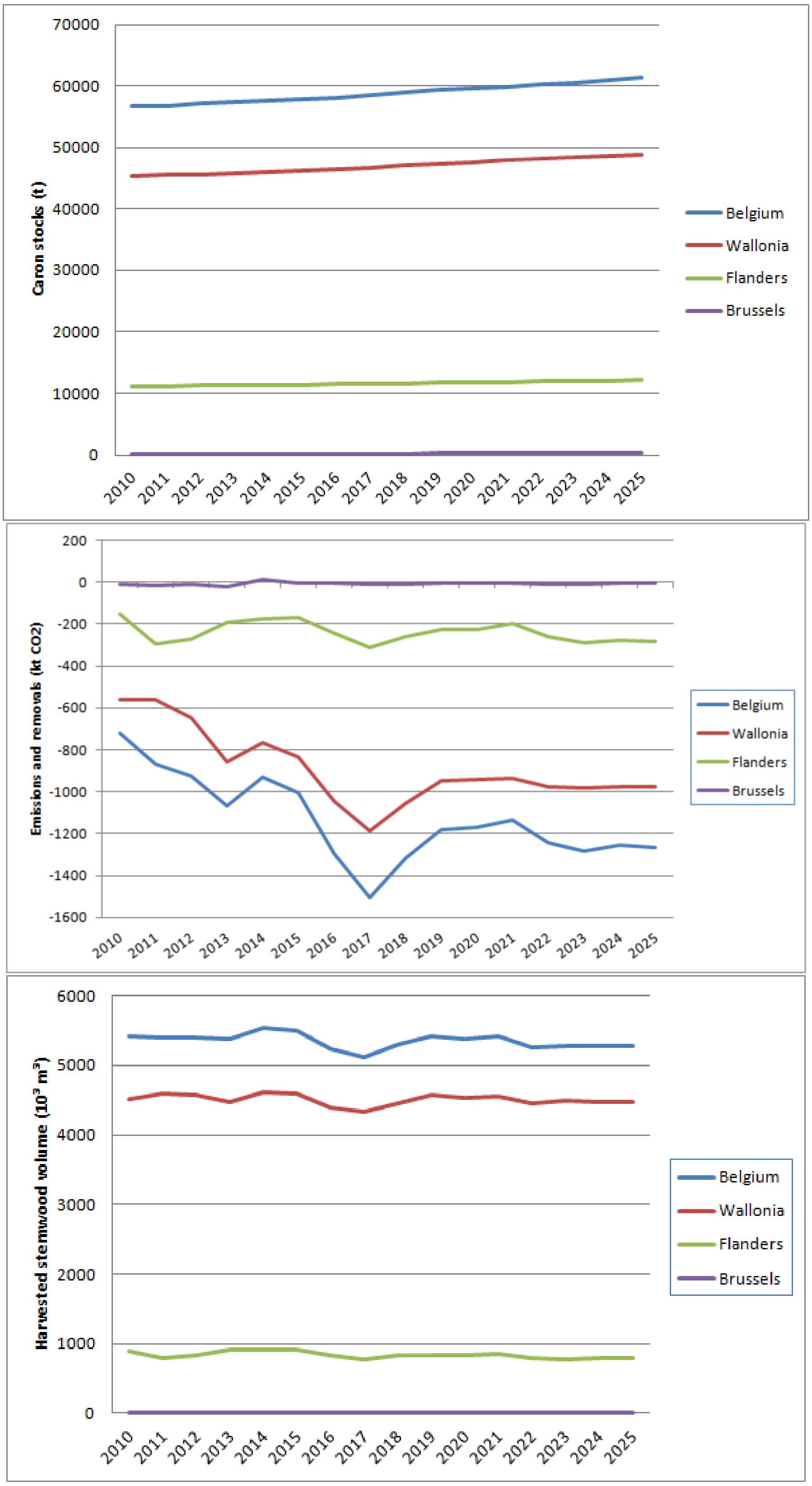

Figure 19 : The forest reference level of the living biomass before and during the commitment period. Due to the scale of the graphs, the data for Brussels are difficult to read.

4.3.2. Harvested wood products

The projected total HWP calculated for the FRL are presented in Table 16.

Table 16 : Projected total Harvested Wood Products volumes.

	HWP ($kt\ CO_2$)
2021	-169.1
2022	-124.9
2023	-127.2
2024	-125.1
2025	-120.7
Average 2021-2025	-133.4

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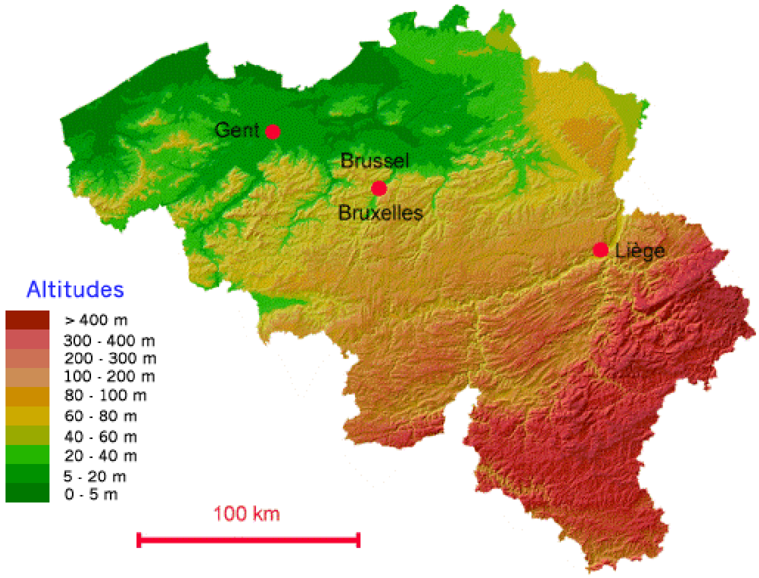
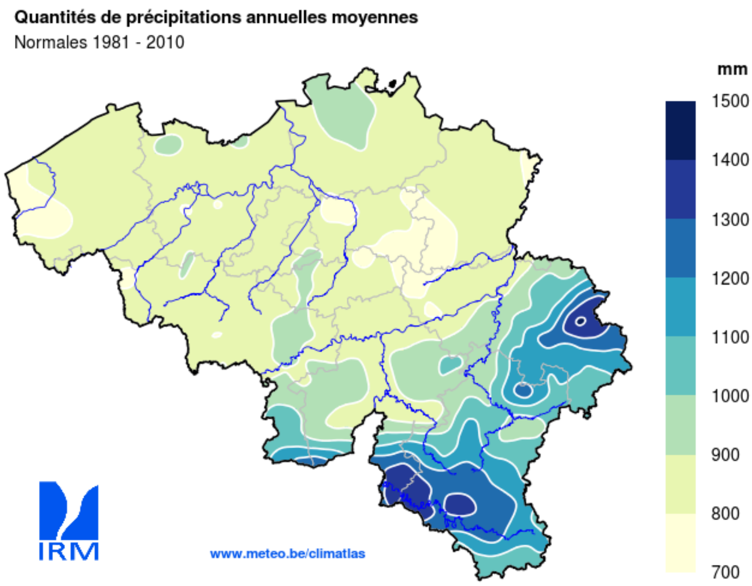
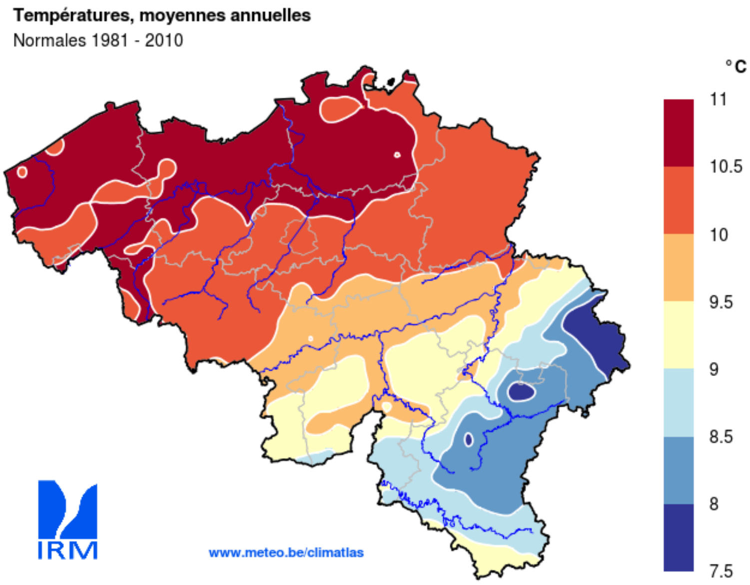
Appendixes

Appendix 1: Relief and climate in Belgium







Appendix 2: National FRL data

Date	Region	Area	Carbons stock	Emissions /removals	Growing stock	Stem volume removed	Above-ground biomass removed	Carbon density
		(ha)	(Mg)	(kt eCO_2)	(m^3)	(10^3 m^3)	(Mg dry matter)	(Mg C/ha)
2000	Belgium	612978	53831690	-1504	149663893	5439	2892197	88
2001	Belgium	612978	54237499	-747	151474824	5638	2973012	88
2002	Belgium	612978	54436882	-1892	152365193	5761	3034583	89
2003	Belgium	612978	54948551	-1188	153409545	5520	2919888	90
2004	Belgium	612978	55268300	-1067	154003370	5552	2949184	90
2005	Belgium	612978	55555044	-1031	154918324	5309	2824210	91
2006	Belgium	612978	55831887	-992	155392687	5577	2968723	91
2007	Belgium	612978	56098151	-871	155639030	5559	2966078	92
2008	Belgium	612978	56330238	-588	155798974	5576	2989993	92
2009	Belgium	612978	56481118	-547	156101389	5584	2992159	92
2010	Belgium	612978	56630385	-722	156423390	5419	2913222	92
2011	Belgium	612978	56827174	-870	156928288	5393	2879580	93
2012	Belgium	612978	57064412	-927	157461413	5396	2896287	93
2013	Belgium	612978	57317160	-1069	158000154	5381	2898623	94
2014	Belgium	612978	57608651	-928	158573816	5537	2978015	94
2015	Belgium	612978	57861728	-1006	158979307	5504	2955639	94
2016	Belgium	612978	58136207	-1294	159444786	5247	2848680	95
2017	Belgium	612978	58489154	-1507	160184516	5119	2775293	95
2018	Belgium	612978	58900019	-1320	161071792	5290	2871106	96

2019	Belgium	612978	59259983	-1178	161801681	5419	2926485	97
2020	Belgium	612978	59581364	-1170	162407909	5369	2916564	97
2021	Belgium	612978	59900469	-1133	163072533	5418	2924865	98
2022	Belgium	612978	60209579	-1244	163696620	5260	2873004	98
2023	Belgium	612978	60548916	-1281	164485847	5280	2862554	99
2024	Belgium	612978	60898302	-1256	165264142	5282	2875590	99
2025	Belgium	612978	61240754	-1264	166052155	5275	2879056	100

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