NATIONAL FOREST 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 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.

(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 **6.891.772** tons CO_2 eq, in which the HWP pool constitutes of **1.059.100** tons CO_2 eq. If instantaneous oxidation of HWP was assumed, the FRL would be **5.832.672** 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;

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

However, regarding forest management, the last projections submitted under Regulation 525/2013 in March 2017 were not based on the model used for the FRL, as this model was not in place at that time. These projections were based on the EU reference scenario 2016, where the projections for forest management were based on the G4M model.

For future reporting of projections under Regulation 525/2013, it is planned to use the model used for the preparation of the FRL, although it will likely be adapted in order to reflect the actual forest management practices, in a BAU scenario.

(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 – not applicable, as all carbon pools have been included.
(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 2.3.1 and 3.2.2
(c) A description of adopted national policies.	Section 2.3.1
(d) Information on how harvesting rates are expected to develop under different policy scenarios.	Section 2.3.2
(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	Section 3.2.2

- increments - rotation length and - other information on forest management activities under 'business as usual'	
(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 six pools are considered within the forest reference level, in accordance with article 5(4) of regulation EC/841/2018 :

- Above-ground biomass
- Below-ground biomass
- Litter
- Dead wood
- Soil organic carbon
- Harvested wood products

2.2: 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.

2.3: Description of the long-term forest strategy

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 maintenance 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 contributes 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. Finally, recommendations to the forest owners regarding adaptation to climate change have been published in 2017[4]

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

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[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

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.

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

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.

2.3.2: 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, no alternative policy scenario has been built.

The only policy scenario tested is the "Business as usual" 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).

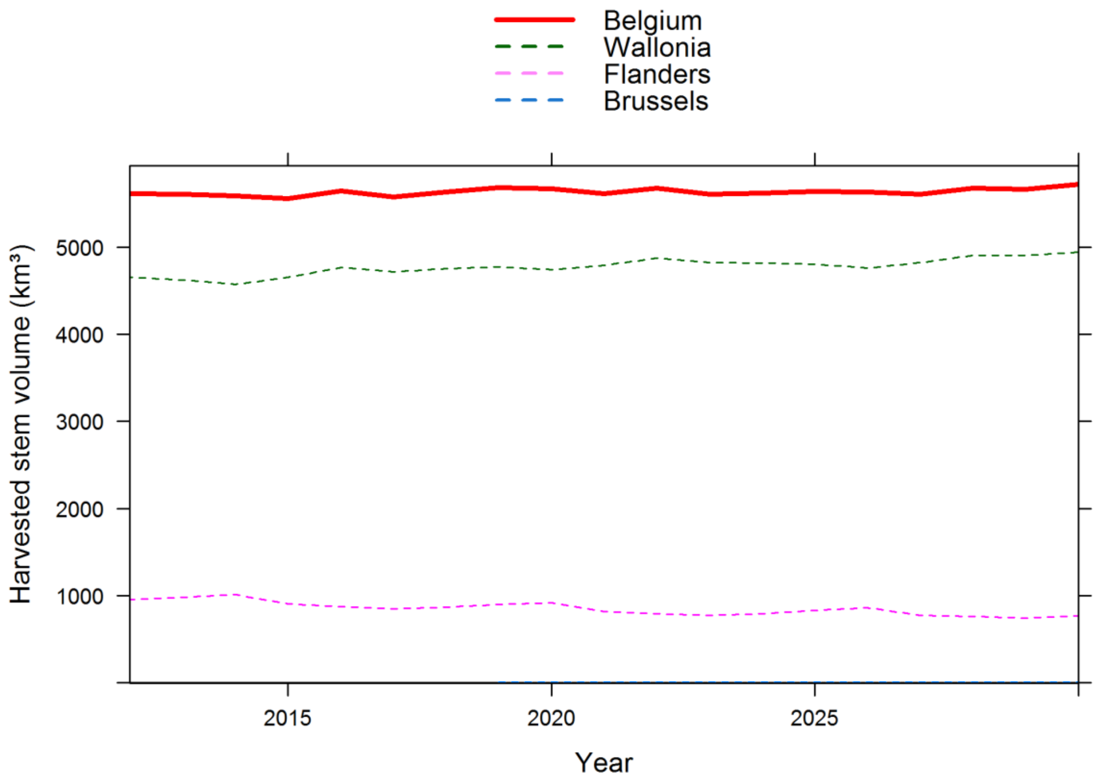

Figure 2 : Stem wood harvested (volume from the bottom of the stem up to 7 cm of the diameter) in a "business as usual scenario". The forest management practices applied on the simulation are the practices observed in-between two RFIs. Due to the scale of the graph, the data for Brussels are difficult 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 "business as usual 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	5.609	4.654	956	NA
2013	5.606	4.623	983	NA
2014	5.584	4.572	1.012	NA
2015	5.554	4.649	904	NA
2016	5.645	4.766	876	NA
2017	5.573	4.717	851	NA
2018	5.632	4.753	872	NA
2019	5.678	4.771	898	10
2020	5.669	4.741	919	10
2021	5.614	4.787	817	10
2022	5.674	4.870	795	10
2023	5.603	4.820	773	10
2024	5.619	4.814	796	9
2025	5.640	4.801	829	9
2026	5.631	4.760	862	9
2027	5.608	4.824	775	9
2028	5.674	4.904	760	9
2029	5.659	4.906	744	9
2030	5.720	4.942	769	9

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

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 represents 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.

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.

Wallonia

The total managed forest land in Wallonia as reported in the GHG inventory, 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.

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).

The projected FRL as reported in Appendix 2 gives an area of 479.500 ha, which represents the area of productive forest only, excluding other 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 area as described above, no carbon stock change is considered for these 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.

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, 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.

3.2.2: 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.

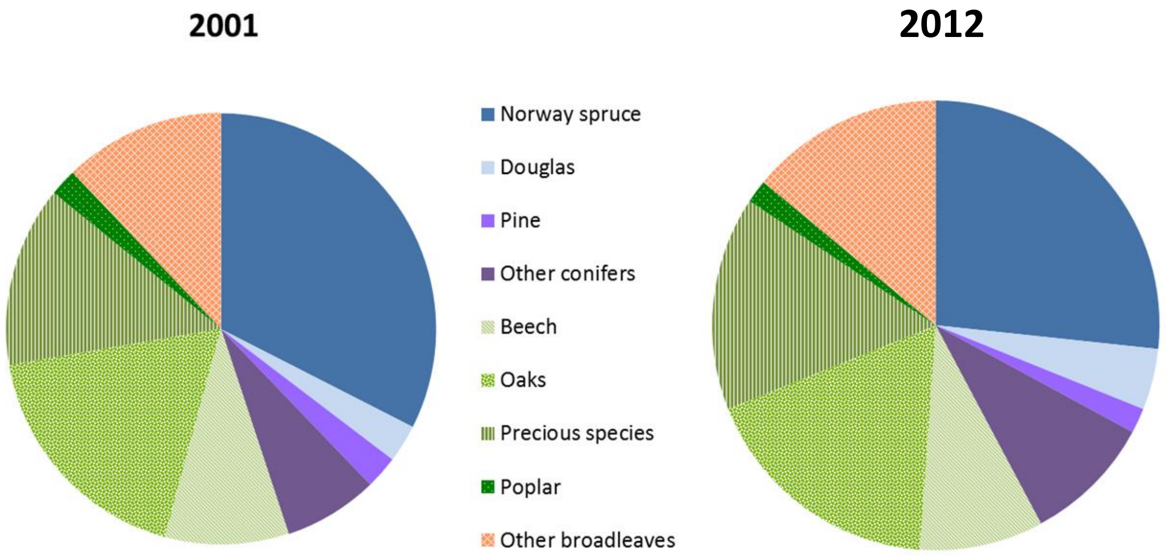

Figure 3 : Main forest types in Wallonia during the first and second permanent RFI with respectively the central year of the inventory 2001 and 2012.

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 BAU 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 m^2/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 m^2/ha at the age of 30 years to about 35 m^2/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.

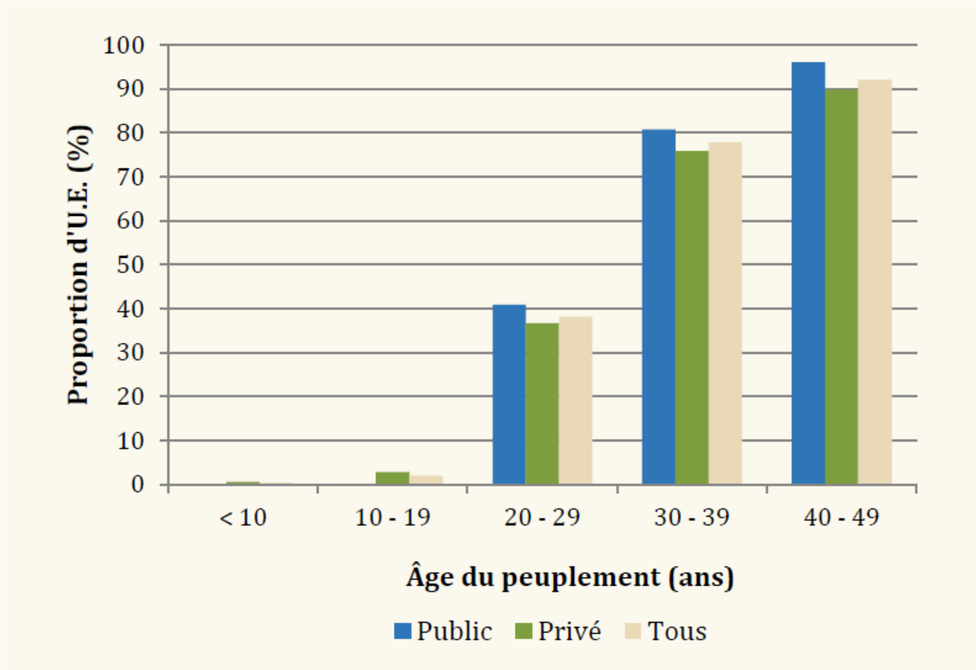

Figure 4 : Frequency of thinned stands by age class according to the spruce stand owner (Alderweireld et al., 2015).

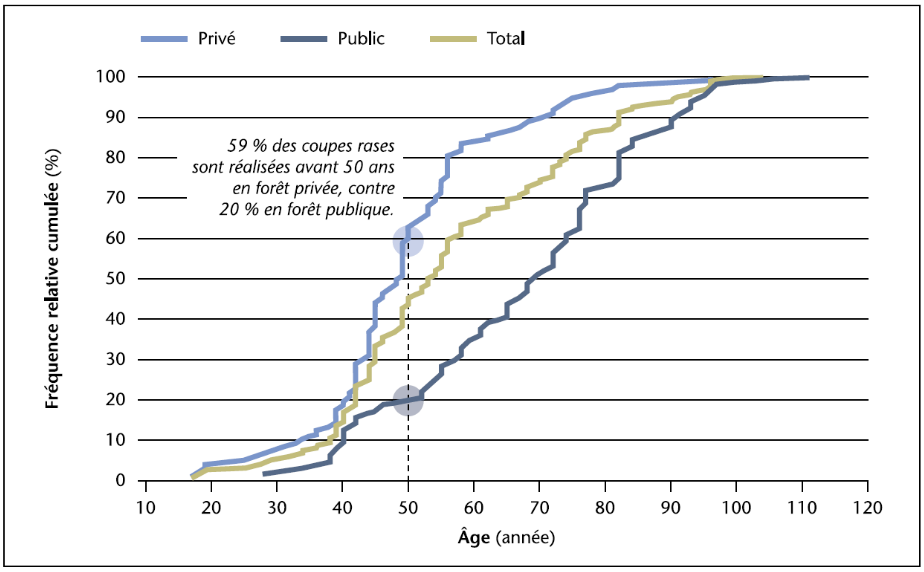

Figure 5 : Cumulative frequency of spruce stand clearcuts between 2006 and 2009 as a function of stand age and type of owner (Lejeune et al., 2013).

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 (m^2.ha-1)	RFI2 (m^2.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 will be published in 2019.

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.

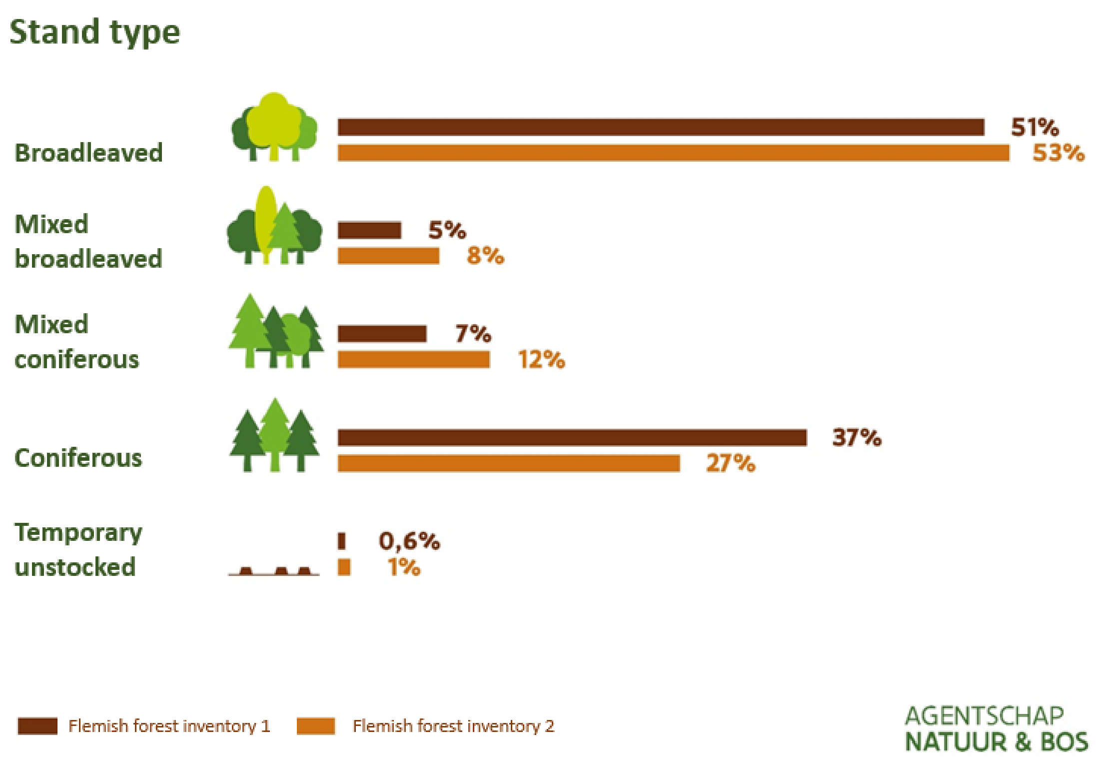

Figure 6 : Evolution of the stand types in Flanders between RFI1 and RFI2.

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.

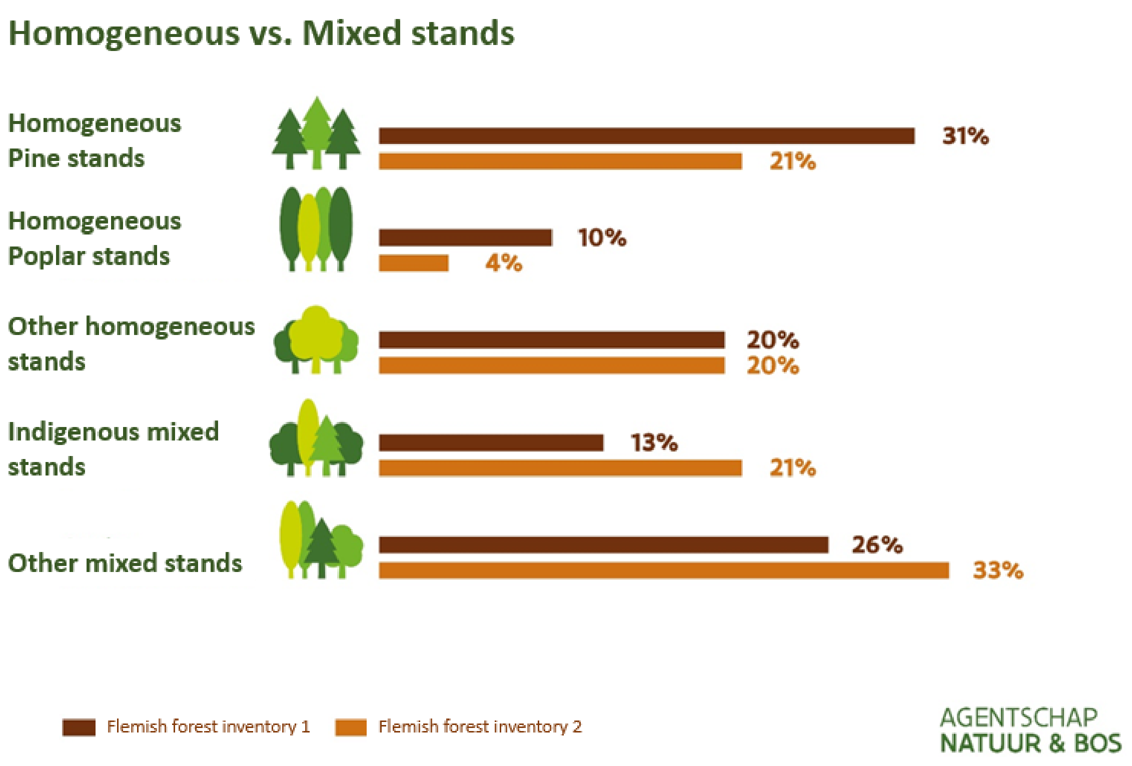

Figure 7 : Evolution of the proportion of homogeneous and mixed stands in Flanders between RFI1 and RFI2.

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%.

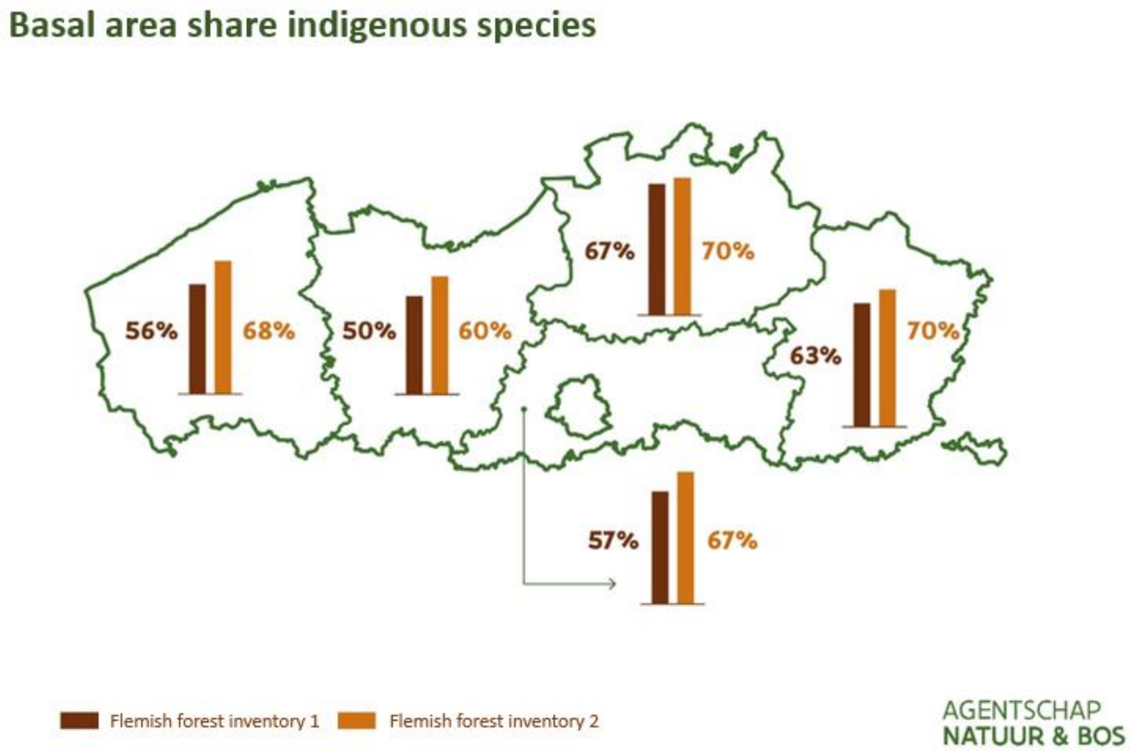

Figure 8 : Evolution of the basal area share of indigenous species in Flanders between RFI1 and RFI2.

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 BAU 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 (m³)	113.902	100.469	106.933	103.210	98.892
Coniferous (m³)	42.413	35.057	32.110	35.878	44.002
Deciduous (m³)	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.

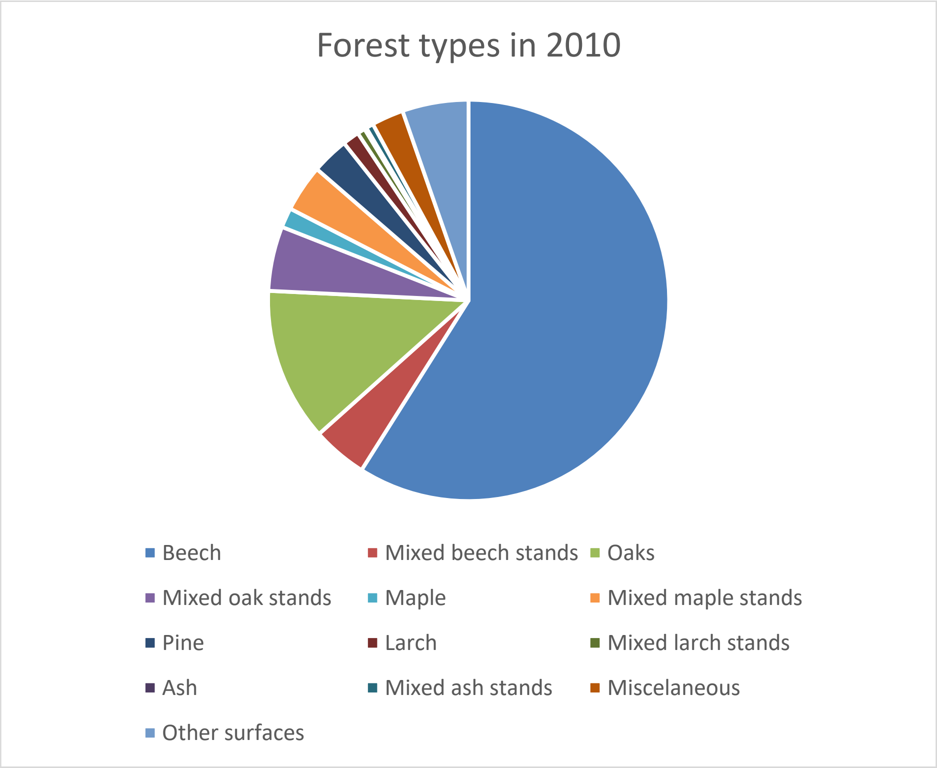

Figure 9 : Main forest types in Brussels-Capital Region based on GIS-based forest stand description (2010)

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.

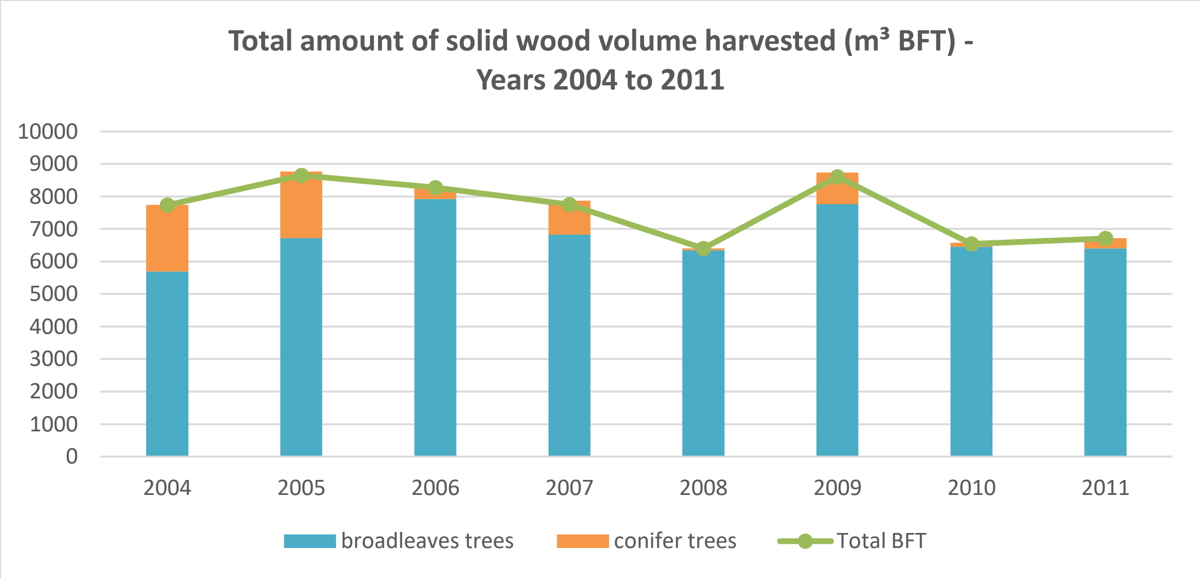

Figure 10: Total amount of solid wood volume harvested between 2004 and 2011 in Brussels.

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.

3.2.3: 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.

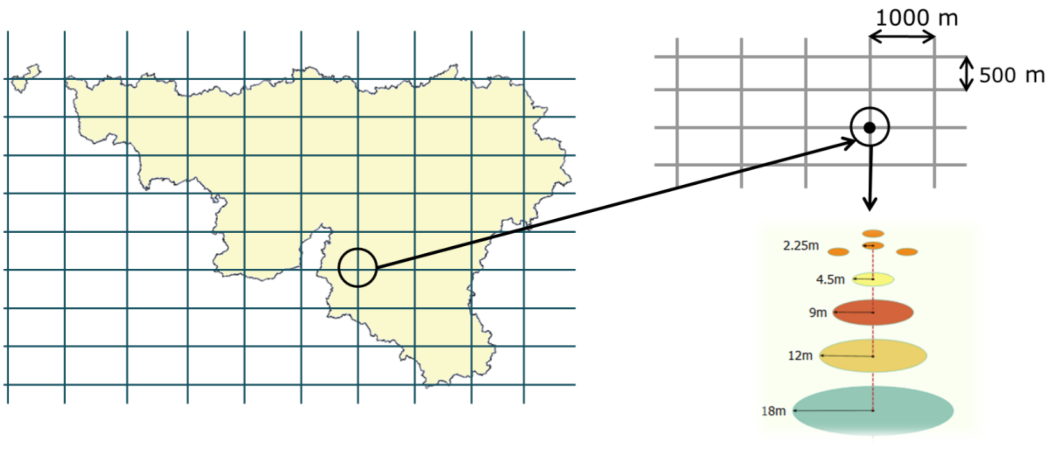

Figure 11 :Sampling design of the Regional Forest Inventory of Wallonia.

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.

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 virtual stands on the basis of forest inventory data and then, four simulation modules run 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.

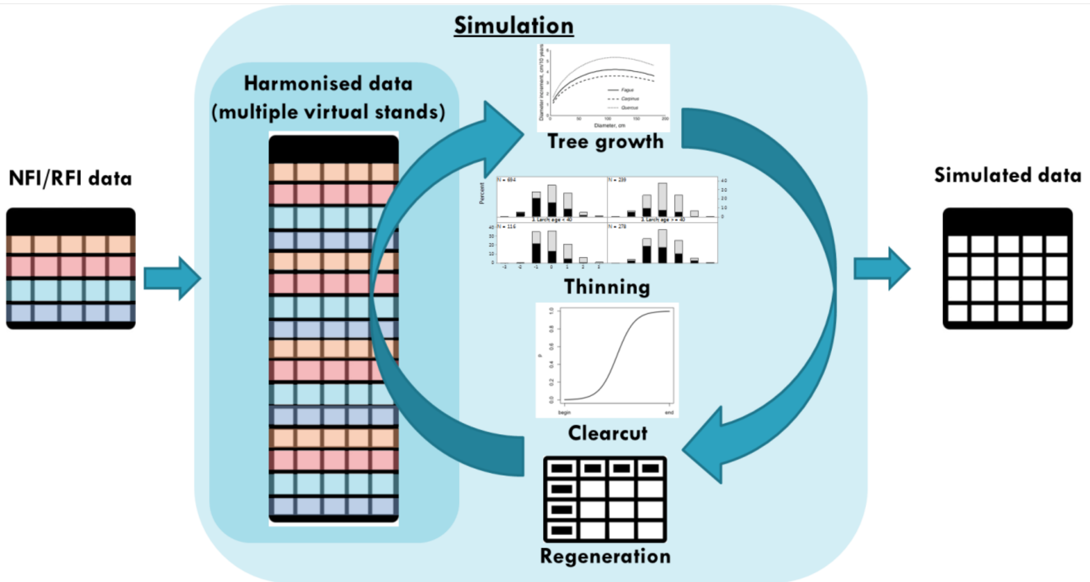

Figure 13 : Overview of the operating forest simulation software SIMREG.

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. 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.

Most virtual stands consist of a list of virtual trees generated from the data stored in the trees.inv initialization file. Thus, a total number of virtual trees equal to [extension factor per hectare]*[represented area] will be generated from each measured trees 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)	R² dC	R² 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.

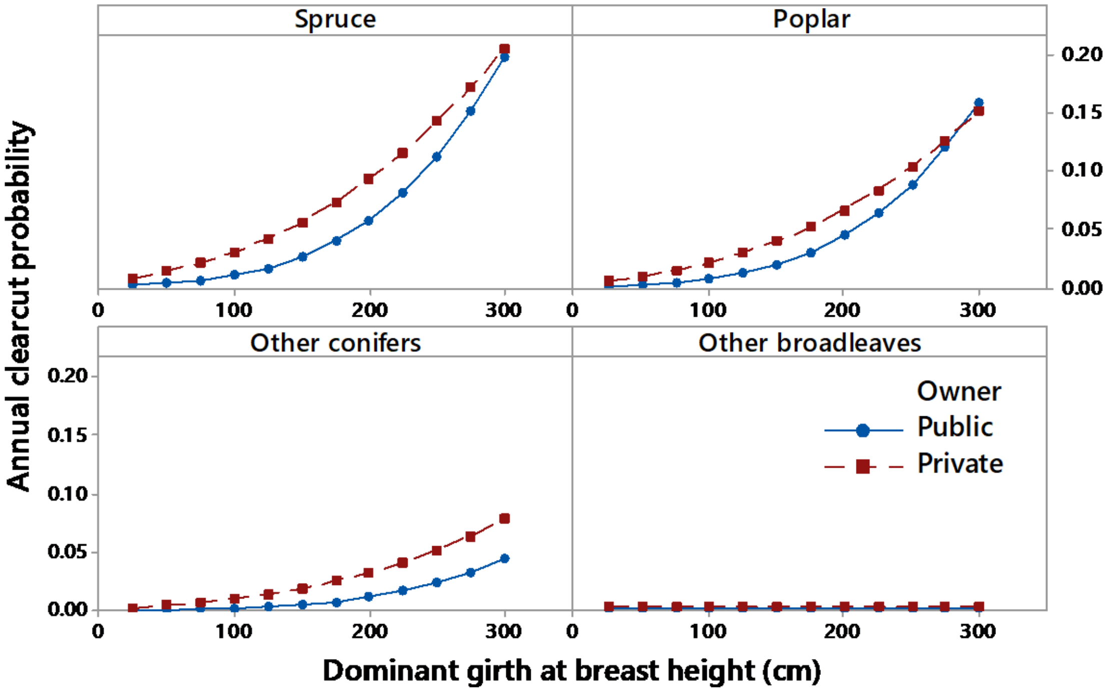

Figure 14 : Evolution of the estimated annual clearcut probability according to the stand's dominant girth in public and private forests of Wallonia for 4 different stands compositions: pure Norway spruce, pure poplar, other conifers and other broadleaves.

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 last 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).

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 plans to revise its estimates for Soil Carbon in the 2019 submission, probably for the entire time series.

In any case, 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.

The 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 a provisional assumption of no stock change in SOC seems to be conservative and therefore in line with the Tier 1 approach of the IPCC 2006 Guidelines.

Consequently, in the absence of updated values by March 2019 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 will also be applied in 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%. This average percentage has been applied to the total annual projected harvest, to exclude this share from the HWP accounting and maintain 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.

The projected annual harvest of industrial roundwood in 2021-2026 varies from 5.603 to 5.674*10^3 m^3, representing a rate of change of +3% to +5% of the reference period. These annual change rates have been applied to the average 2000-2009 data of all the defined HWP categories : industrial roundwood and wood pulp, which are used to calculate f_{IRW} and f_{PULP} (calculation of domestic fractions from SW, WBP and PP), and production of sawnwood, wood-based panels and paper and paperboard.

The average f_D and f_{FM} in 2000-2009 have also been calculated and applied for the projected HWP calculation, to estimate the ratio of wood issued from managed forest.

The HWP have then been calculated using the same methodology as in the current inventory. Production of Sawn wood, Wood panels and Paper and Paperboard projected from 2017 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. HWP in the intermediate years (2010 to 2020) and 2021-2025 have been estimated using the same approach. 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).

Table 10 : Harvest data and solid use of harvest for the average

	Total harvest (10^3 m^3)	Solid use of harvest (10^3 m^3)
Average 2000-2009	4698	4069
2021	5614	4862
2022	5674	4914
2023	5603	4853
2024	5619	4867
2025	5640	4885

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	-220,6
2022	-222,9
2023	-208,1
2024	-205,0
2025	-202,5

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

4.2.1. Belgium

The FRL is presented in *Figure 15* and compared with the 15 January 2019 submission.

As explained in the regional sections 4.2.2, 4.2.3 and 4.2.4. below, regional inventories were significantly revised since the 2018 GHG inventory submission. These revisions are partly reflected in the 15th January 2019 submission under the Monitoring Mechanism, but some corrections will only be completed in the 15th March 2019 submission.

In this regard, Figure 15 below, which compares the FRL to the 15th January submission, should be considered provisional and will be updated according to the 15th March reporting. Living biomass and soil carbon are distinguished in this figure, as no changes in soil carbon are projected for the period 2021-2025.

Considering the above elements, no general consistency check is conducted at the Belgian level for the time being. This section will updated and completed together with the 15th March 2019 inventory submission.

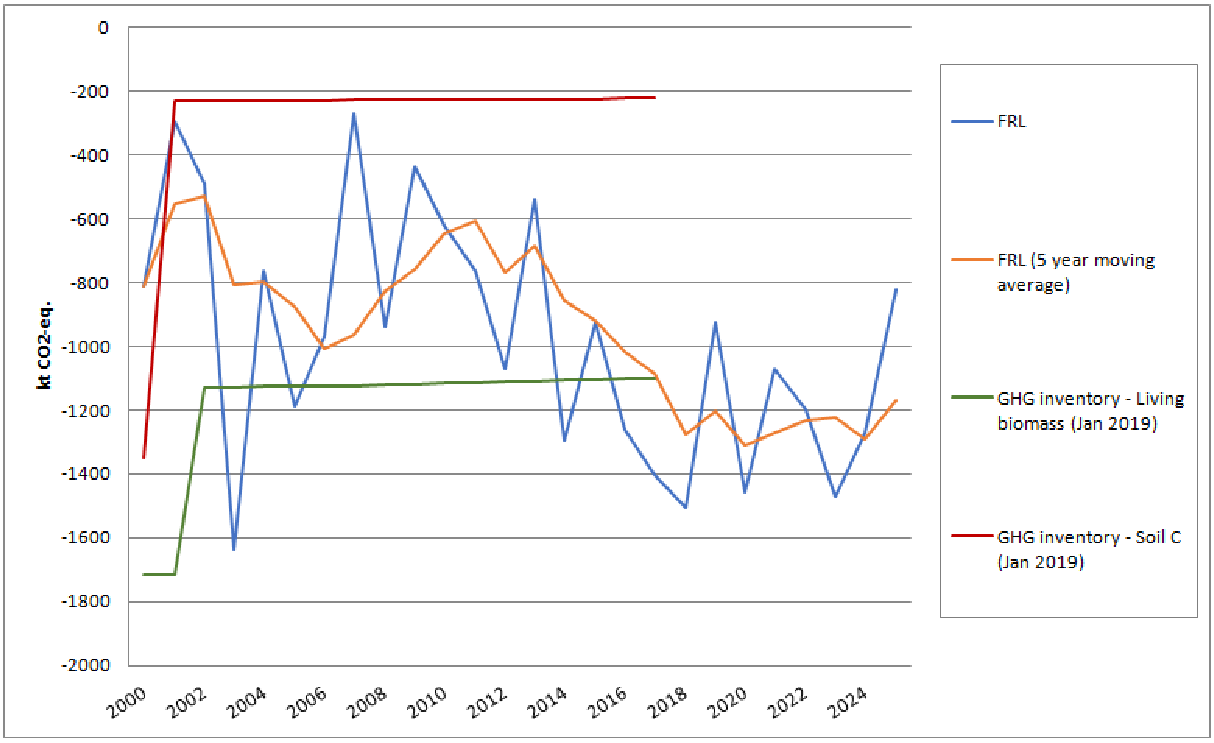

Figure 15 : CO_2 equivalent emission and removals the Belgian forest simulated with the FRL scenario and reference values reported in the NIR using the stock change approach.

4.2.2. Wallonia

Note : This section starts with a description of the recent adjustments applied to the regional forest inventory and to the GHG inventory, as they justify the use of the 2019 submission for the consistency check. The next steps of the consistency analysis are conducted according to the technical guidance.

Adjustment of the regional forest inventories

The modeling exercise highlighted some discrepancies between the 3 forest inventories cycles carried out in Wallonia. Various methodological adjustments have been made between the different forests inventories. Therefore, the results published for different periods are not always perfectly comparable. The most significant adjustments concern:

- a modification of the measurement threshold between the 1981 inventory and the permanent inventory (central years 2001 and 2012). Deciduous species under 40cm diameter were not included in high forests;

- the measure of linear forest stands only took place since the second cycle of the permanent inventory (central year 2012).

- some previously published results did not include an extrapolation of the standing stocks in inaccessible and impenetrable stands (e.g. young Norway spruce stands under 20 years old).

Thus, with regard to the method currently applied by the IPRFW, the total stocks previously published for the Walloon forest were underestimated. The DNF and Gembloux ABT are finalizing a detailed analysis of the effect of these methodological changes in order to better estimate the evolution of the standing stock, growth and removals between the different periods. The simulations carried out for Wallonia take into account the latest results of these analyses, which will be published shortly.

Although the impact of these revisions is limited regarding the total wood volume (2 to 3 % of the total volume), they do have a much more significant impact on the carbon stock change estimate according to stock difference method, as the total volume stock change between 2001 and 2012 was diminished by around 22%. These corrections ensure the consistency of both inventory cycles, but further analysis is planned regarding the linear stands, as some of them may be under the 0,5 ha area threshold.

Table 13 : Impact of volume adjustment on the stock change approach

Walloon forest inventory Stem wood Volume (10^3 m³)	**2001**	**2012**	**Difference 2001-2012**
Submission 2018	118.416	124.922	6.506
Submission 2019	122.065	127.111	5.046
Ratio 2019/2018	103,1%	101,8%	78%

According to progress of the ongoing second cycle of the permanent forest inventory and the number of sampling plots measured up to now, the central year of this cycle has been updated and is now the year 2012 and not 2011. This change also has a significant impact on the overall estimates according to carbon stock change approach.

Adjustments of the GHG inventory

Besides the adjustment of the total volume of the regional forest inventory, other adjustments on the GHG inventory were also brought on the inventory, in order to streamline the GHG inventory with the latest improvement of the forest inventory and associated biomass estimates performed by Gembloux ABT, following the approach described in Latte, 2013.

The biomass expansion factors (BEF) were revised with updated values, derived from the use of species specific equations which take into account diameter at breast height (DBH) and total height. The analysis of these results compared to the previous ones also highlighted that the BEF should be applied on the stem wood volume only, and not the total solid wood (stemwood + large branches up to 22 cm diameter), as it was the case in previous inventories, following the approach described by Van de Walle (2005), where a specific reference to the application of BEF to the total solid wood (including branches) is included. This revision has also a significant impact on the total biomass estimate. Wood density values have also been slightly updated.

Finally, as presented in section 3.3.2, the soil carbon is now reported in the 2019 submission as constant from 2000 on. Soil carbon accounted for nearly half of the total sink in previous submissions, so this has a significant impact on the overall estimate.

Altogether, the adjustments described above lead to significant recalculations of the LULUCF sector in Wallonia. It must be underlined that most of the adjustments described above were decided according to the recent development of the SIMREG model, which took place in the course of year 2018, with some results only finalized in November-December 2018, such as the adjustment to the regional forest inventory total volume and central year described above. For this reason, these changes could not be reflected in the 2018 GHG inventory submission. However, Belgium drew the attention on these potential recalculations in its presentation during the informal LULUCF meeting on 14^{th} June, 2018.

All these changes on the GHG inventory are included in the 15^{th} January 2019 submission and will be included in the 15 March and 15 April 2019 submission. Some further analysis will be conducted in the meantime, so limited adjustment of the estimates are possible. The NIR will be adapted accordingly.

Historical data used for the consistency analysis

Considering the large magnitude of the changes on the GHG inventory between 2018 and 2019, the consistency of the reference level with the inventory could not be assessed based on the 2018 submission, as this approach would have brought a rather meaningless calibration of the FRL. Hence the consistency is here analyzed with regard to the 15^{th} January 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 15^{th} January submission will be publicly available on the EIONET Central Data Repository (https://cdr.eionet.europa.eu/be/eu/mmr/art07_inventory/ghg_inventory/) by the time of the submission of the FRL.

Consistency with GHG inventory

Phase 1 / consistency of management practices

As described in section 3.2.2/Wallonia, the management practices applied in the model are based on forest good practices and the direct interpretation of the forest inventory sampling plots, as measured in 2001 and 2012.

The GHG inventory is also based on the results of the regional forest inventory for the same 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.

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.

Table 14 : Wallonia - Comparison between FRL and GHG inventory (Jan 2019)

	Total stock change over the period 2001-2012 (kt CO_2)	Average annual removal in the period 2001-2012 (kt CO_2)
FRL	-10019	-911
GHG Inventory (Jan 2019)	-9920	-902

The average values of FRL and GHG inventory are very close, which suggest a good consistency. However, a more complete analysis, including uncertainty analysis, will be conducted in March 2019, with the final results of the GHG inventory.

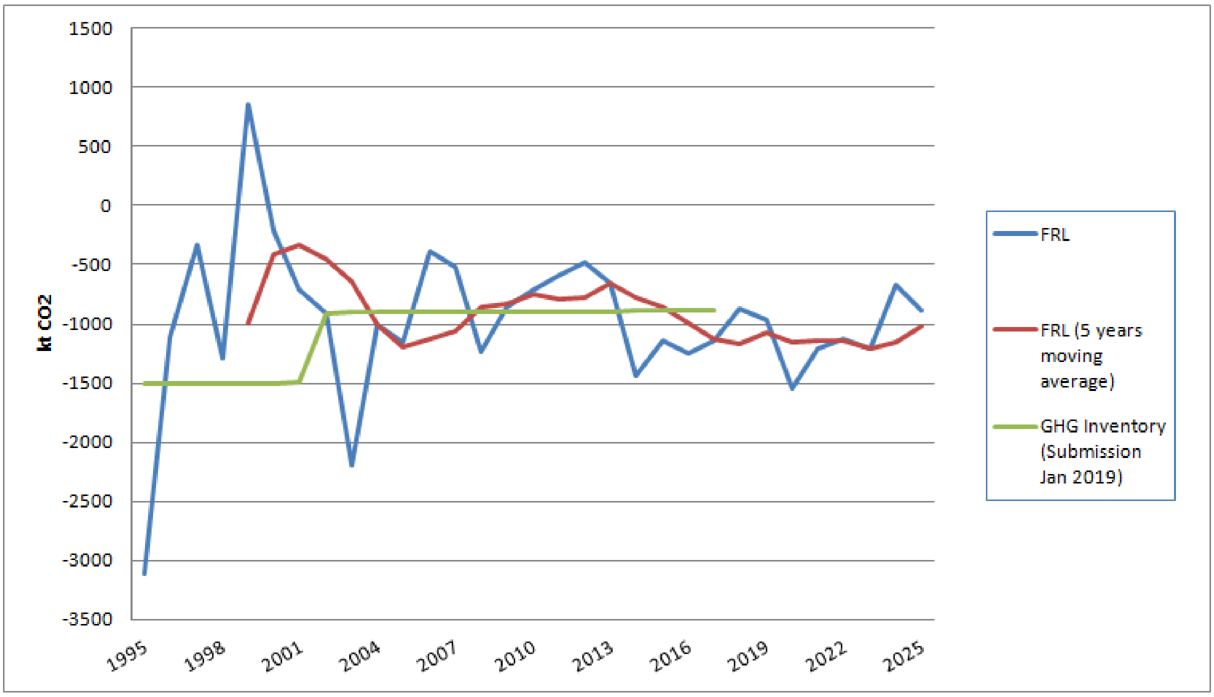

Figure 16 : Wallonia - FRL and GHG inventory trends in the reference period (GHG inventory after 2012 are provisional and will be adjusted according to future updated forest inventory data)

Phase 3 / Consistency of time series

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.

4.2.3. Flanders

Adjustments of the GHG inventory

As presented in section 3.3.2, it is anticipated that the soil carbon will be reported as constant as from the year 2000 in the 15 March and 15 April 2019 submission of the GHG Inventory and the NIR. Just like for Wallonia, this will influence the overall estimate but will not jeopardize the comparability of FRL and GHG Inventory as the consistency between the inventory and the FRL will be maintained at all times. Accordingly, as a stabilization of the carbon concentration in forest soils has been included in the FRL, the comparison below is focused on the stock changes in biomass only.

Consistency with GHG inventory

Phase 1 / consistency of management practices

As described in section 3.2.2/Flanders, the management practices applied in the model are based on forest good practices and the direct interpretation of the regional forest inventory sampling plots, as measured between 1998 (central year RFI 1) and 2012 (central year RFI 2).

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

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

Phase 2/ Consistency of emissions and removals estimates

As illustrated in Figure 17, the historic values for the FRL and GHG Inventory are within or close to each other's standard deviations for historic years. Nevertheless, the difference between both, mainly at the beginning of the reference period, induced a thorough analysis of the data used to generate both lines. This has led to the impression that the thinning model developed for Flanders and described in Table 9 may be overestimating the removals in the FRL. Most likely, a significant volume of modelled thinned stems is due to technical mismatches, caused by a slightly different protocol and different technical equipment in both RFI's (first and second RFI). Therefore, another analysis will be performed shortly based upon the full RFI that will be published in the first months of 2019. Furthermore, the third RFI that will be started as from 2019 will lead to a higher consistency as the approach used to develop thinning and growth model, used to generate the FRL will be taken into consideration from the very beginning. Apart from further improving the GHG Inventory, the data generated in the coming years will allow to quality-check the thinning model, and will allow to evaluate whether a technical correction of the FRL is needed. In the meantime, as an indication of the potential impact of an updated thinning model and as a sensitivity analysis, the FRL was generated again using the thinning figures of Wallonia listed in Table 9. This sensitivity analysis is presented in Figure 18**Erreur ! Source du renvoi introuvable.** and shows that an updated thinning model based upon the values of the third RFI would possibly bring the FRL and GHG inventory even closer to each other in the future.

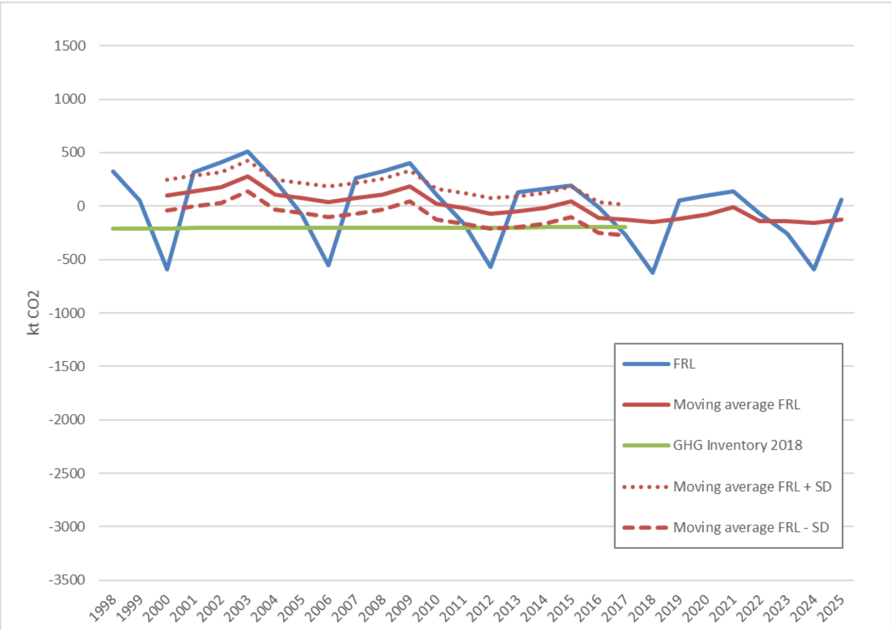

Figure 17 : Comparison of the historic emissions and removals considered for Flanders in the GHG Inventory 2018 and the FRL.

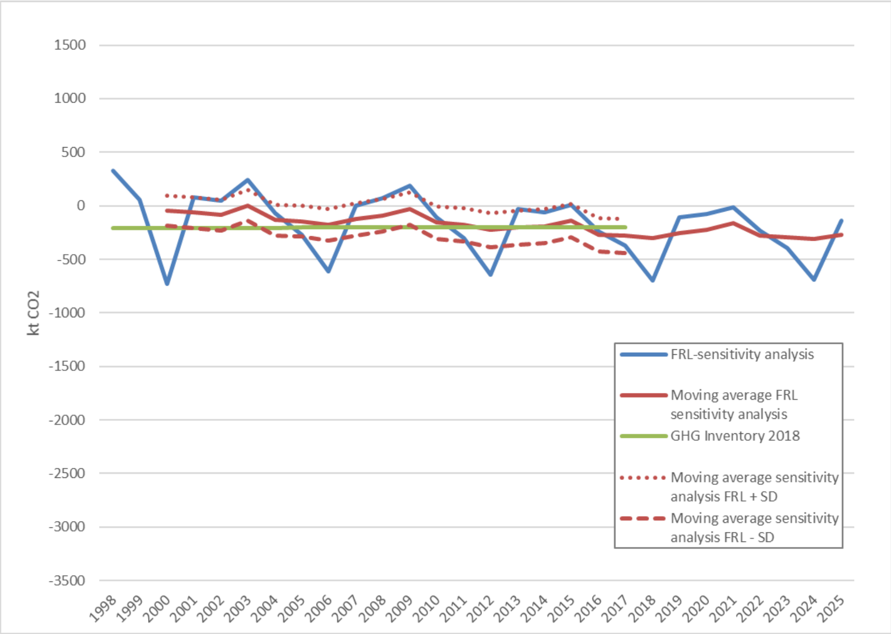

Figure 18 : Comparison of the historic emissions and removals considered for Flanders in the GHG Inventory 2018 and the FRL using the Walloon data of Table 9 for the thinning model as a sensitivity analysis.

Phase 3 / Consistency of time series

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.

4.2.4. Brussels Region

Adjustments of the GHG inventory

In the Brussels Region, the first Regional Forest Inventory (RFI1) with permanent sample plots was launched in 2008. The complete inventory cycle lasts 8 years. As stated in the NIR, up to now the emissions from biomass were estimated by applying the annual biomass increment data observed in the beech forests of Wallonia (75% of the Brussels forest is beech).

The modelling exercise realized by Gembloux ABT revealed nevertheless that from 2001 on, significant discrepancies of annual C storage rate in biomass exist for Brussels between the model results (based on RFI1) and the data from Wallonia used for the 2018 emissions inventory. As the results of the modelling exercise are more relevant for Brussels, and in order to avoid unjustifiable trend breaks in the time series, it was decided to use the new value from the modelling exercise from 2001 on in the 2019 inventory submission.

On the other hand, as presented in section 3.3.2, the soil carbon will be reported as stable in the 2019 submission.

As for Wallonia, these two changes have significant impacts on C storage levels in forest stands. They will be included in the 15th March 2019 and 15 April 2019 inventory submissions. The NIR will be adapted accordingly.

Historical data used for the consistency analysis

Considering the large magnitude of the changes on the GHG inventory between 2018 and 2019, the consistency of the reference level with the inventory could not be assessed based on the 2018 submission, as this approach would have brought a rather meaningless calibration of the FRL. Hence the consistency will be analyzed with regard to the 15th March 2019 submission data.

Consistency with GHG inventory

As stated in section 3.2, 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. The consistency with GHG inventory is ensured by using the same data from RFI1 to recalculate key parameters in the emissions calculation (inventory submission of 15th March 2019).

4.2.5. Harvested Wood Products

The overall projected level significantly differs from the current GHG inventory, due to various rationales:

- the recent evolution of sawnwood and wood panels production, as observed in 2010-2017 with an increase of sawnwood and a decrease of wood panels, is not reflected in the projections which are based on 2000-2009 data. This brings a discrepancy in the time series, with significant differences in HWP annual stock change.
- The f_{FM} in the last years is lower than in 2000-2009 (83% on average between 2010 and 2017 compared to 96% in the reference period), as according to the currently reported data[5], deforestation was higher in the period between 2010-2017 as compared to the reference period. Hence, the projected volumes of HWP, which are accounted for when they originate from managed forest land, are significantly higher than those estimated in recent years.

As a consequence, the rate of change between the first projected year (2018) and the last reported year (2016) is 252% (from -162 kt CO_2 to -570 kt CO_2) and appears as an outlier compared to the rates observed since 2010. Considering that the two rationales explained above do not reflect any changes in forest management practices nor in harvest intensity, it has been decided to calibrate the projection, to ensure the consistency of the time series.

However, the reconstruction of historic data using the SIMREG model is not possible, as the model does not estimate imported and exported Industrial Roundwood and Wood pulp, which are necessary to calculate f_{IRW} and f_{PULP}. The observed trend for recent years (2000-2016) has therefore been calculated, using linear regression. This equation has then been used to estimate the HWP for the first 5 projected years (2018-2022) and these estimates have been compared to the projected HWP, to derive the total Yi/Xi value for those years (value : 2,1) which has been used in the equation presented in the Technical Guidance, section 2.4.4. This equation has then been used to calibrate the projected HWP pool and obtain the final values used for the FRL.

[5] These figures could be subject to corrections in the coming years with updated land use cover data.

This leads to the projected total HWP presented in section 4.1.4, against which the future carbon stock changes will be compared.

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 61,45 Tg in the 5 first years of the commitment period (2021-2025) to an average of 63,13 Tg of carbon in the second half of the commitment period (2026-2030, Table 15 and Figure 19 and Figure 20 and 21)[6]. The sink of the Belgian forest is slightly increasing during the commitment period with an absorption of around 1.240 ktons of CO_2-eq. The stem volume removed from the living biomass of the forest is fairly constant and close to 5,6 Mm³.

Table 15: The mean value of the living biomass in the forest reference level scenario before and during the commitment period.

Period	Carbon stock (Mg of carbon)	Annual balance (negative values stand for removals) (tons of CO_2eq)	Stem volume harvested (m³)
2011-2015	58.154.468	-919.909	5.676.595
2016-2020	59.762.400	-1.309.445	5.612.948
2021-2025	61.449.540	-1.166.534	5.569.432
2026-2030	63.127.435	-1.316.524	5.649.101

Table 16: 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
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

[6] 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.

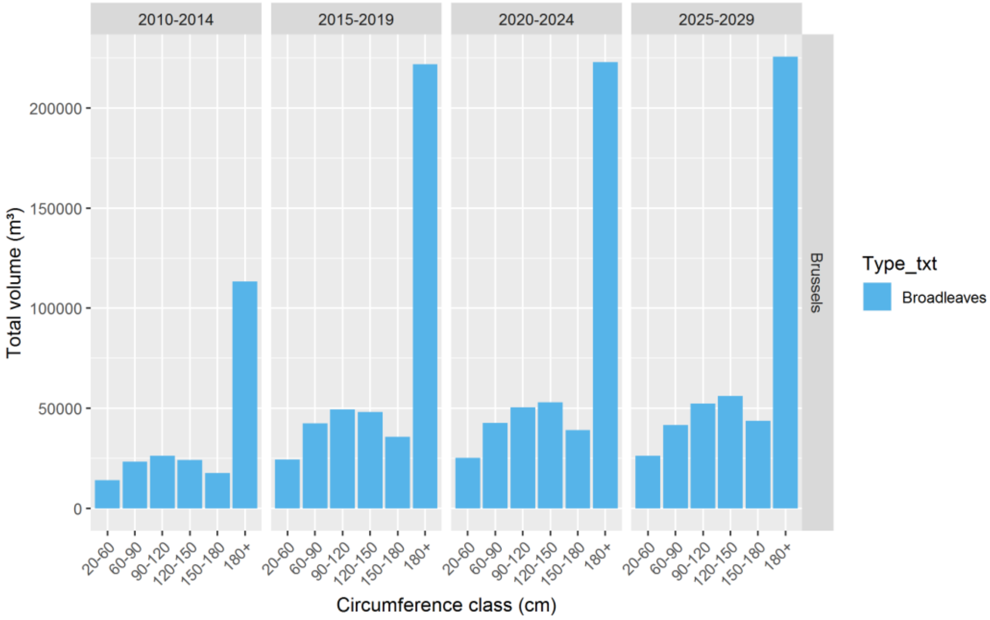

Figure 19 : Forest structure evolution in Brussels

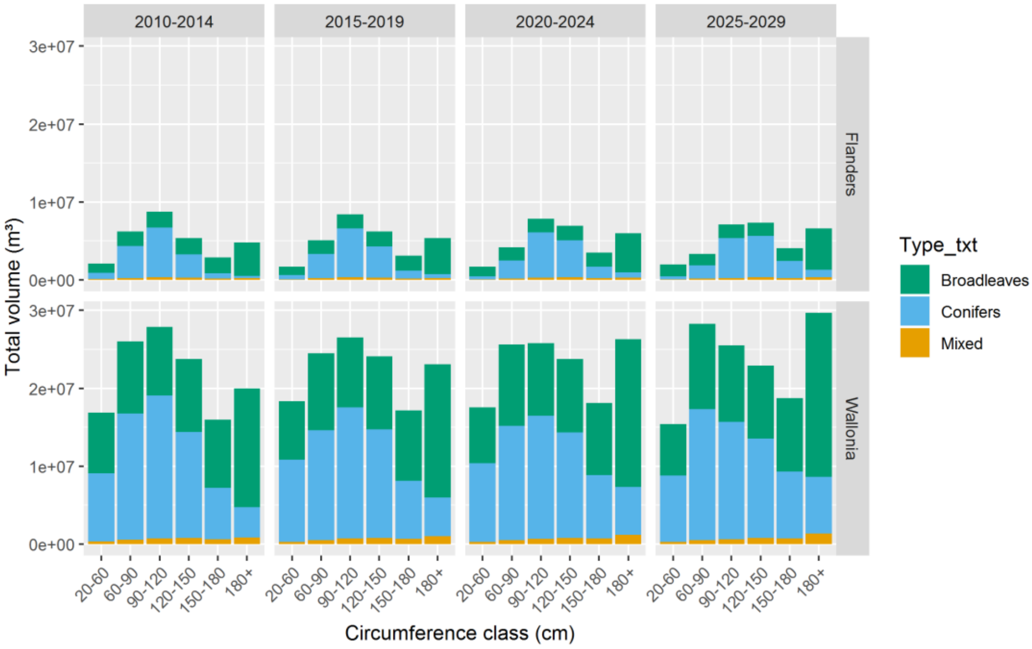

Figure 20: Forest structure evolution in Flanders and Wallonia by periods of 5 years.

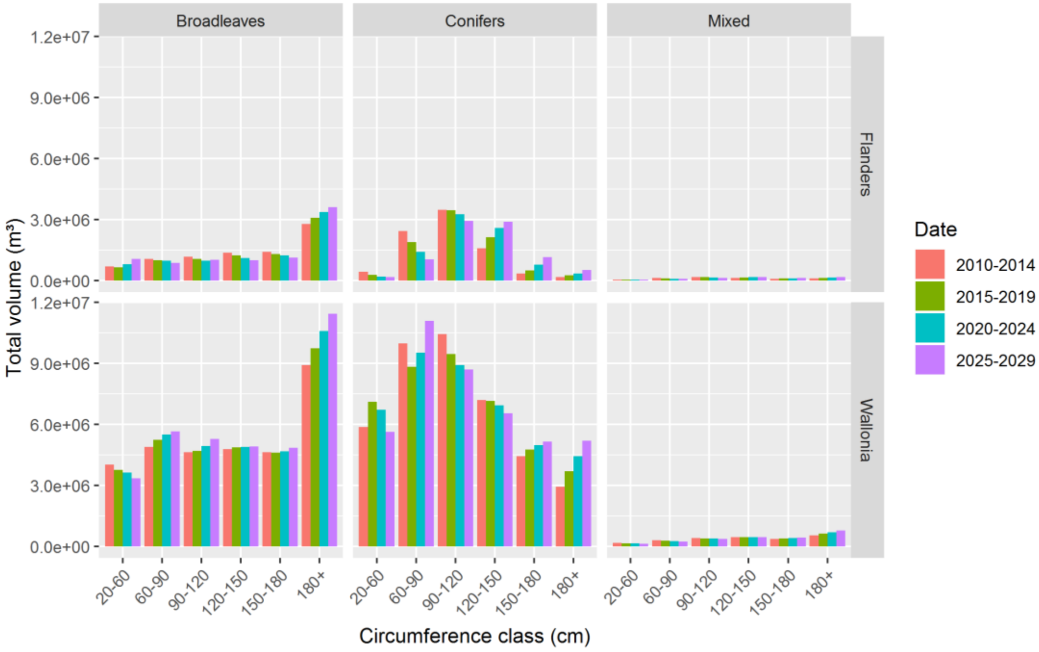

Figure 21: Forest structure evolution in Flanders and Wallonia by forest type group.

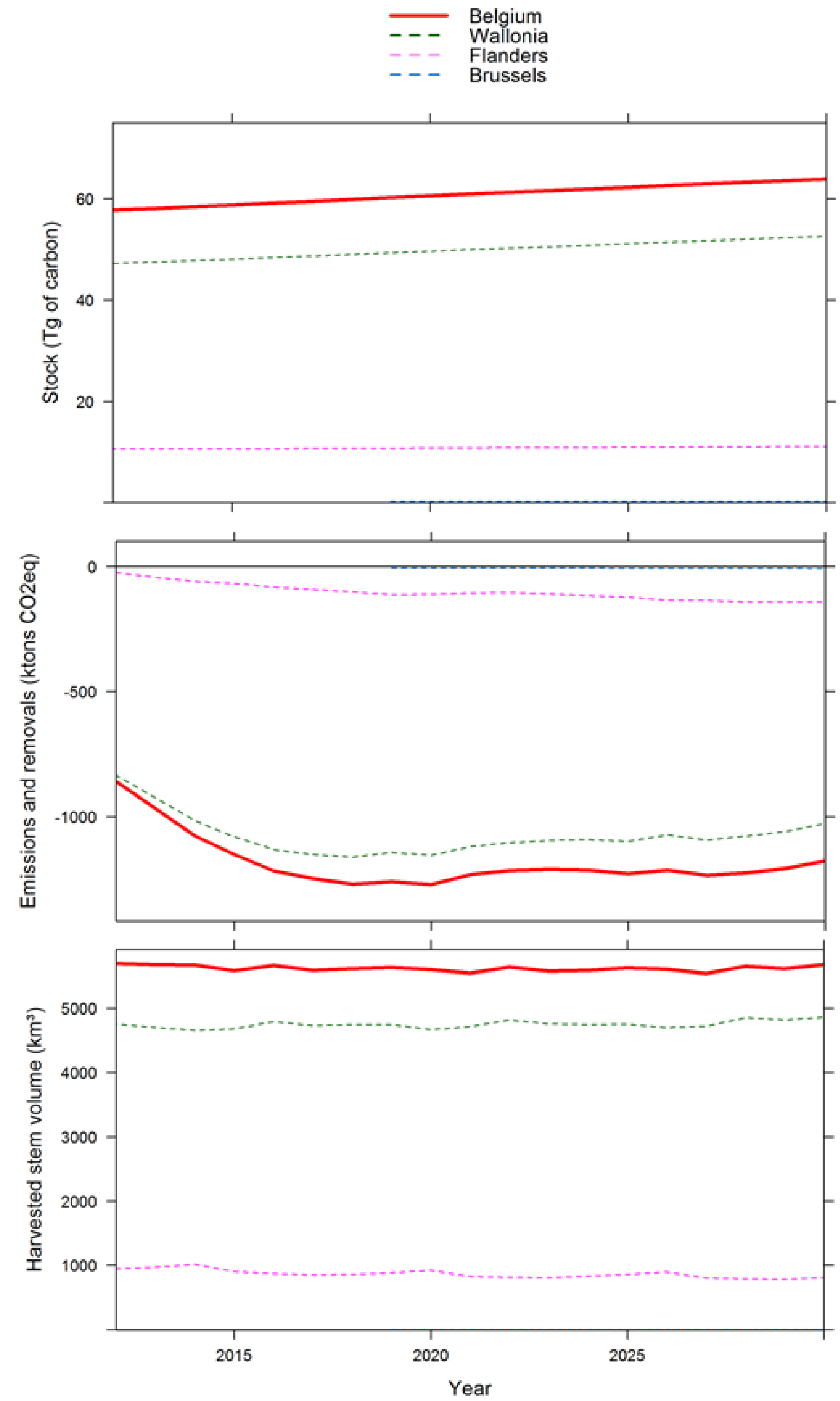

Figure 22 : The forest reference level of the living biomass before and during the commitment period. Due to the scale of the graphs, the data for Brussels are difficult to read. These can be found in Appendix 2.

4.3.2. Harvested wood products

The projected total HWP calculated for the FRL are presented in Table 17.

Table 17 : Projected total Harvested Wood Products volumes.

	HWP ($kt\ CO_2$)
2021	-221
2022	-223
2023	-208
2024	-205
2025	-203
2021-2025	-1059

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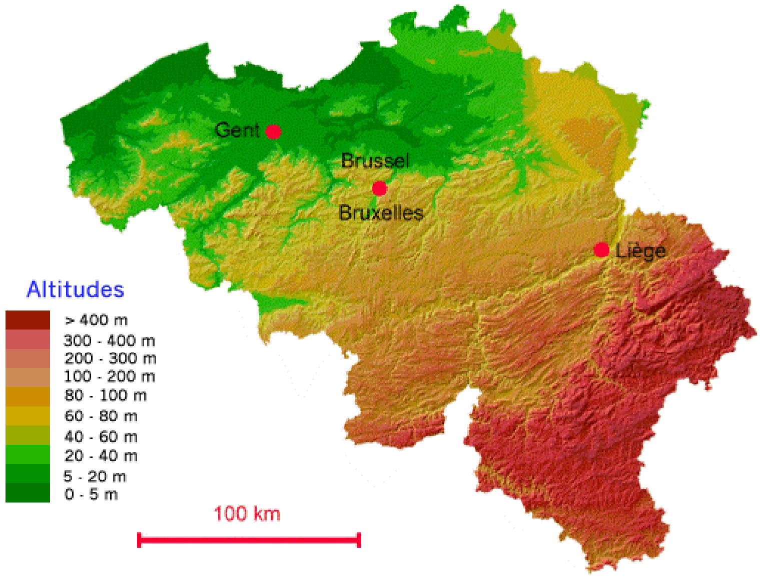
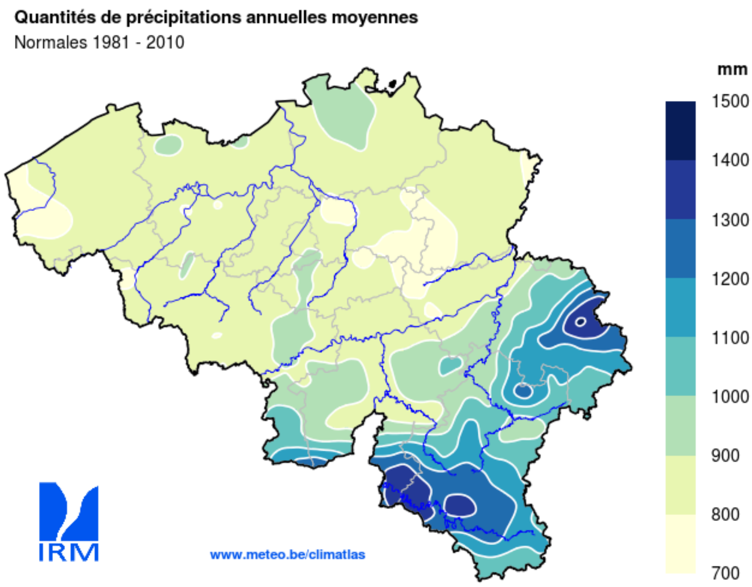
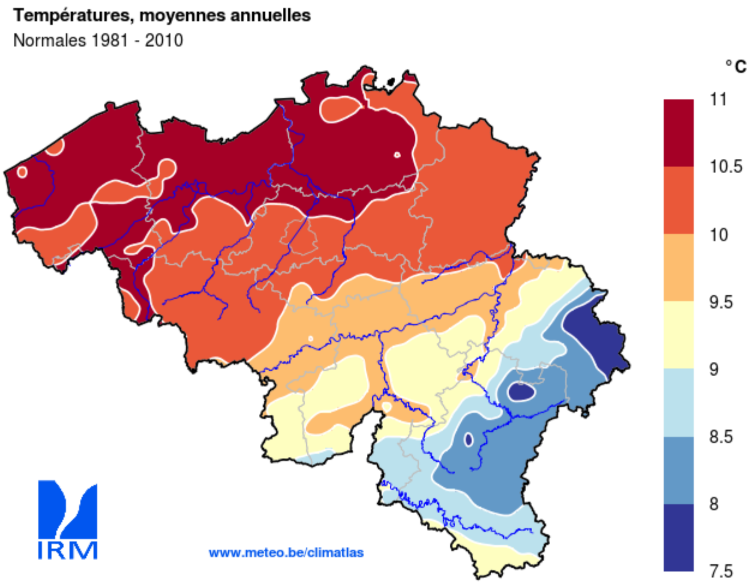
Appendixes

Appendix 1: Relief and climate in Belgium







Appendix 2: National and regional FRL data

Date	Region	Area (ha)	Carbons stock (Mg)	Emissions/removals (kt eCO_2)	Growing stock (m^3)	Stem volume removed (m^3)	Above-ground biomass removed (Mg dry matter)	Carbon density (Mg C/ha)
2000	Belgium	612978	55145534	-811	154301775	6100503	2041412	90
2001	Belgium	612978	55226210	-296	155327479	5452195	2007915	90
2002	Belgium	612978	55359395	-488	156103218	5630416	2230048	90
2003	Belgium	612978	55806484	-1639	157074503	5637281	2351919	91
2004	Belgium	612978	56014709	-763	157291167	5564861	2467415	91
2005	Belgium	612978	56338551	-1187	158322596	5534463	2543591	92
2006	Belgium	612978	56602560	-968	158647947	6207823	3105021	92
2007	Belgium	612978	56676148	-270	158362293	5678875	3018751	92
2008	Belgium	612978	56932827	-941	158641535	5904028	3187383	93
2009	Belgium	612978	57262811	-439	159339981	5767636	3097344	93
2010	Belgium	612978	57431859	-620	159815013	5695944	3039994	94
2011	Belgium	612978	57639855	-763	160368588	5545608	2947678	94
2012	Belgium	612978	57932555	-1073	161071085	5957106	3224540	95
2013	Belgium	612978	58080197	-541	161359317	5476537	2970066	95
2014	Belgium	612978	58433450	-1295	162154404	5826502	3152006	95
2015	Belgium	612978	58686281	-927	162583215	5591111	3028187	96
2016	Belgium	612978	59029909	-1260	163278299	5539542	2975768	96
2017	Belgium	612978	59412433	-1403	164033971	5521326	2944508	97
2018	Belgium	612978	59823084	-1506	164829292	5868556	3200425	98
2019	Belgium	612978	60074688	-923	165285335	5430155	2953871	98

2020	Belgium	612978	60471889	-1456	166191429	5705160	3111630	99
2021	Belgium	612978	60763980	-1071	166831842	5623379	3047163	99
2022	Belgium	612978	61090669	-1198	167558682	5368955	2919663	100
2023	Belgium	612978	61492131	-1472	168546221	5589850	3009375	100
2024	Belgium	612978	61838304	-1269	169312126	5872336	3212671	101
2025	Belgium	612978	62062617	-822	169796069	5392640	2962446	101
2009	Brussels	1528	204649	21	431173	20855	3964	134
2010	Brussels	1528	209973,7	-20	447608	14755	3894	137
2011	Brussels	1528	212419	-9	459918	10061	3460	139
2012	Brussels	1528	216900,7	-16	465471	118	52	142
2013	Brussels	1528	220321,2	-13	472848	12047	6056	144
2014	Brussels	1528	226468	-23	482996	14790	8442	148
2015	Brussels	1528	222877,7	13	471781	11340	8857	146
2016	Brussels	1528	223646,6	-3	472360	11904	9113	146
2017	Brussels	1528	224149,9	-2	472444	6526	5260	147
2018	Brussels	1528	226974,8	-10	478059	7479	6091	149
2019	Brussels	1528	229257,8	-8	482793	10992	8615	150
2020	Brussels	1528	229984,4	-3	483980	11176	8852	151
2021	Brussels	1528	230664,6	-2	485134	11987	9269	151
2022	Brussels	1528	231064,3	-1	485320	6653	5434	151
2023	Brussels	1528	233903,9	-10	490946	7388	6069	153
2024	Brussels	1528	236455	-9	496008	10738	8445	155
2025	Brussels	1528	237606,6	-4	497816	10950	8687	156
2000	Flanders	131950	10994008	-593	31758278	1418639	805012	83
2001	Flanders	131950	10907718	316	31418639	1450816	821363	83
2002	Flanders	131950	10796549	408	31024725	1482347	851944	82
2003	Flanders	131950	10656980	512	30579509	1246289	718162	81
2004	Flanders	131950	10591718	239	30352102	969156	569461	80
2005	Flanders	131950	10612427	-76	30391670	616831	355579	80
2006	Flanders	131950	10763130	-553	30781091	1210954	705581	82
2007	Flanders	131950	10691458	263	30557613	1253792	725641	81
2008	Flanders	131950	10603214	324	30273903	1285925	753712	80
2009	Flanders	131950	10492998	404	29937357	1063745	619096	80
2010	Flanders	131950	10464031	106	29808419	835783	501108	79
2011	Flanders	131950	10509141	-165	29900044	562451	328754	80
2012	Flanders	131950	10664816	-571	30262285	1075638	640364	81
2013	Flanders	131950	10629622	129	30098067	1119140	657612	81
2014	Flanders	131950	10586295	159	29876817	1131706	672796	80
2015	Flanders	131950	10532918	196	29632709	975339	576957	80
2016	Flanders	131950	10534986	-8	29544922	762658	462493	80
2017	Flanders	131950	10607329	-265	29678071	511520	304142	80
2018	Flanders	131950	10777017	-622	30079513	985266	593238	82
2019	Flanders	131950	10763402	50	30012978	1019403	606280	82

2020	Flanders	131950	10737115	96	29916506	1018102	617532	81
2021	Flanders	131950	10700043	136	29820781	876277	526978	81
2022	Flanders	131950	10719100	-70	29867777	723212	441484	81
2023	Flanders	131950	10789643	-259	30069522	490789	296825	82
2024	Flanders	131950	10951714	-594	30509204	968262	589196	83
2025	Flanders	131950	10935157	61	30470279	988989	597127	83
2000	Wallonia	479500	44151526	-218	122543497	4681864	1236400	92
2001	Wallonia	479500	44318492	-612	123908840	4001379	1186552	92
2002	Wallonia	479500	44562847	-896	125078493	4148069	1378104	93
2003	Wallonia	479500	45149503	-2151	126494993	4390992	1633757	94
2004	Wallonia	479500	45422991	-1003	126939065	4595706	1897954	95
2005	Wallonia	479500	45726124	-1111	127930926	4917632	2188012	95
2006	Wallonia	479500	45839430	-415	127866856	4996869	2399440	96
2007	Wallonia	479500	45984690	-533	127804680	4425083	2293110	96
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2009	Wallonia	479500	46565165	-864	128971451	4683036	2474284	97
2010	Wallonia	479500	46757855	-707	129558986	4845406	2534992	98
2011	Wallonia	479500	46918294	-588	130008626	4973096	2615465	98
2012	Wallonia	479500	47050839	-486	130343330	4881350	2584124	98
2013	Wallonia	479500	47230254	-658	130788402	4345350	2306398	98
2014	Wallonia	479500	47620687	-1432	131794591	4680005	2470769	99
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2020	Wallonia	479500	49504789	-1550	135790942	4675882	2485246	103
2021	Wallonia	479500	49833272	-1204	136525927	4735115	2510917	104
2022	Wallonia	479500	50140504	-1127	137205585	4639090	2472745	105
2023	Wallonia	479500	50468584	-1203	137985752	5091673	2706481	105
2024	Wallonia	479500	50650135	-666	138306914	4893335	2615031	106
2025	Wallonia	479500	50889854	-879	138827974	4392702	2356631	106

This report has been prepared by :

- Perin Jérôme, Bauwens Sébastien, Pitchugin Mikhail, Lejeune Philippe, Hébert Jacques.
  University of Liège - Gembloux Agro-Bio Tech - TERRA Research Unit - Forest is life. Passage des Déportés 2, 5030 Gembloux

- Walloon Air and Climate Agency (AWAC).
  Avenue Prince de Liège 7 5100 Jambes

- Service Public de Wallonie – DGO3 - Département de la Nature et des Forêts -Direction des Ressources Forestières - Cellule Inventaire Permanent des Ressources Forestières de Wallonie. Avenue Prince de Liège 7 5100 Jambes

- Department of Environment and Spatial Development – Departement Omgeving (dOMG)
  Koning Albert II-laan 20 box 8 1000 Brussels

- Flanders Environment Agency - Vlaamse Milieumaatschappij (VMM)
  Dokter De Moorstraat 24-26 9300 Aalst

- Agency for Nature and Forests – Agentschap voor Natuur & Bos (ANB)
  Havenlaan 88 box 75 1000 Brussels

- Brussels Environment (IBGE-BIM)
  Site de Tour & Taxis, Avenue du Port 86C/3000, 1000 Brussels