NATIONAL FORESTRY ACCOUNTING PLAN FOR SLOVENIA

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Acronyms and abbreviations

AGB	above-ground living biomass
ALUM	Agricultural Land Use Map
BAU	business-as-usual
BEF	biomass expansion factor
BGB	below-ground living biomass
CF	carbon fraction
CRF	common reporting format
DBH	diameter at breast height
FMP	forest management practice
FMAP	forest management plan
FOD	first order decay
FRL	forest reference level
GHG	greenhouse gas
GHGI	greenhouse gas inventory
GS	growing stock
HWP	harvested wood products
ICP	International Co-operative Programme
IO	instantaneous oxidation
IPCC	Intergovernmental Panel on Climate Change
IRW	industrial roundwood
IRSNC	Institute of the Republic of Slovenia for Nature Conservation
LULUCF	land use, land use change and forestry
MAFF	Ministry of Agriculture, Forestry and Food
MFL	managed forest land
NFAP	national forestry accounting plan
NFI	national forest inventory
NIR	National Inventory Report
NFP	National Forest Programme
RP	reference period
SFI	Slovenian Forestry Institute
SFM	sustainable forest management
SFS	Slovenia Forest Service
SMARS	Surveying and Mapping Authority of the Republic of Slovenia
SW	sawnwood
UNFCCC	United Nations Framework Convention on Climate Change
WBP	wood-based panels
WD	basic wood density

FOREWORD

The Slovenian National Forestry Accounting Plan (NFAP), which contains the forest reference level (FRL), has been drawn up in collaboration with the Ministry of Agriculture, Forestry and Food, the Slovenia Forest Service and the Slovenian Forestry Institute, and submitted pursuant to Article 8 of Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU.

The NFAP was further amended to take on board the comments and recommendations from the Commission Staff Working Document: Assessment of the national forestry accounting plans received in June 2019.

1 GENERAL INTRODUCTION

1.1 General description of the forest reference level for Slovenia

The forest reference level (FRL) for Slovenia for the commitment period 2021-2025 is estimated at -3,270 kt CO_2 eq. The calculated FRL includes carbon pools and corresponding CO_2 removals and emissions and other emissions of greenhouse gases that occur on managed forest land as defined in the LULUCF Regulation. According to the LULUCF Regulation, the land accounting category “managed forest land” is defined as land use reported as “forest land remaining forest land” under the UNFCCC. The FRL proposed by Slovenia consists of the following mean values for the period 2021-2025 as shown in Table 1.

Table 1: Projected mean values of GHG emissions and removals on managed forest land for the period 2021-2025

Carbon pool	Mean 2021-2025 (kt CO_2 eq)
Above-ground biomass	-2,119
Below-ground biomass	-486
Dead wood	-294
Harvested wood products (HWP)	-394
Biomass burning	22
FRL (incl. HWP)	**-3,270**
FRL (instantaneous oxidation)	**-2,877**

Almost 60% of Slovenia’s territory is covered by forest, making it one of the most forested countries in the EU and limiting its potential to increase its forest cover. The limited possibilities to balance emissions with removals, which result from specific national conditions during the reference period (highest carbon sink per forest area among the most forested countries in the EU), and unbalanced age structure of the forest (high proportion of large diameter trees) could result in sinks being counted as emissions against Slovenia’s forest reference level. Therefore, Slovenia intends to apply the maximum amount of managed forest land flexibility allocations in regulation EU REGULATION 2018/841 (Article 13, Annex VII: maximum amount of compensation available under managed forest land flexibility referred to in point (B) of article 13).

The low ratio between harvesting and increment in the reference period in Slovenia is also reflected in the country-specific carbon balance and country-specific mean forest productivity estimates expressed per unit forest area (t C ha^{-1} y^{-1}; Janssens et al., 2005) in comparison with other EU countries (TBFRA, 2000). On average, European forests annually sequester 124 g C m^{-2} forest area from the atmosphere. Countries with high forest cover tend to have a higher forest C sink per unit total land area than countries with low forest cover, and Slovenia ranks the highest, at close to 150 g C m^{-2} y^{-1}. Also, with respect to country-specific changes in terrestrial carbon stocks (sum of forests, grassland, arable soils and peatlands) expressed per unit total land area (g m^{-2} land area y^{-1}), Slovenia has one of the highest net gains in Europe for the period after 1990 (Janssens et al., 2005).

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

The FRL for Slovenia is based on and consistent with the criteria set out in Section A of Annex IV (Article 8(4)) and based on the continuation of sustainable forest management practices as documented in the reference period 2000-2009 using the best and latest available data and with regard to dynamic age-related forest characteristics in forests (Article 8(5) of the Regulation).

1.2.1 Description of how the criteria of the LULUCF Regulation were taken into account

(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 projection of the FRL for Slovenia shows that managed forest land will act as a net sink of CO_2 emissions in the periods 2021-2025 and 2026-2030. The FRL was constructed on the assumption that sustainable forest management as documented in the reference period is applied in the commitment period, taking into account the future impact of dynamic age-related forest characteristics that will enhance forest carbon sinks in the long term. As forests are ageing and the growing stock is close to optimum, the National Forest Programme (ReNFP, 2007) intensifies harvest in particular in mature forests in the period until 2050 to balance the age/diameter structure, ensure sufficient regeneration, sustain the yield and increase resistance against calamities in the long term. It is assumed that the balance between anthropogenic emissions and removals in the second half of the century will be achieved by adaptation of the tree species composition, conversions of spruce monocultures to mixed forest stands, and investments in the wood processing industry, which will enhance HWP production and replace more energy intensive materials compared to wood.

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

The FRL for Slovenia was estimated by the stock-difference method according to IPCC guidelines, and therefore the methodology is based on changes in carbon pools that are included in the FRL, not stocks. For this reason, soil organic carbon and litter were not included in the estimation of the FRL.

(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

The FRL construction is based on the same sources of emissions and removals as estimated in the GHG inventory for managed forest land, including biomass use. The latter refers to living biomass and dead wood as well as HWP, whereas the use of biomass for energy is calculated as instantaneous oxidation. These considerations will be consistently respected in the period 2021-2030, which will ensure a robust and credible accounting and environmental integrity.

(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

The FRL value includes the carbon pool of HWP and corresponding net emissions that were calculated on the basis of instantaneous oxidation and by applying the first order decay function and the default half-life values according to 2006 IPCC guidelines (see Table 1).

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

The estimation of changes in carbon stocks of HWP in the FRL for the period 2021-2030 was based on the assumption of a constant ratio between solid and energy use of forest biomass as documented in the reference period. The average carbon inflow differentiated to HWP commodities in the period 2000-2009 is multiplied by the ratio between the modelled harvest volumes in the projection and the average harvest documented in the period 2000-2009.

(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

The FRL for Slovenia is 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 (2013), Slovenia's National Forest Programme (2007), the EU Biodiversity Strategy (2011) and the Natura 2000 Management Programme for Slovenia (2015). The projection of the FRL indicates a further increase in above-ground biomass and dead wood stocks and does not foresee a change in tree species composition in the commitment period.

Biodiversity was included in forest management plans as instructed by the Decree on special protection areas (Natura 2000 areas) from 2004; Rules on forest protection from 2009 (especially Article 6 – preserving at least 3% of the growing stock for dead wood, Article 7 – identification of areas important for the conservation of wildlife and plants and Article 10 – time restraints on forestry operations); Decree on protective forests and forests with a special purpose from 2005 (defining forests of major importance for their natural development, biodiversity and protection of natural and cultural heritage); and Environmental Protection Act (Article 129 – Climate Fund finances measures to avoid deforestation and increase carbon sinks in forests).

The implementation of concrete measures to preserve species and habitat types was enhanced in 2016 with the adoption of the Management of State Forests Act (2016). According to Article 7 of the Act, one of the seven management objectives in state owned forests is to achieve nature conservation goals, particularly those associated with Natura 2000 sites. Article 20 stipulates that forest acquisitions shall be carried out such that larger contiguous state forest complexes are created. In addition, priority shall be given to the acquisition of protective forests, special purpose forests and forests in protected areas, according to the regulations on nature conservation, in order to achieve the objectives of these areas. The Management of State Forests Act also establishes (Article 33) a budgetary Forest Fund to finance, among others, measures in Natura 2000 private forests as prescribed in the Natura 2000 Management Programme for Slovenia and foreseen investments in forests, which, on the basis of the National Forest Programme, are prepared by the Slovenia Forest Service in accordance with the Forest Act.

Thirty-eight per cent of Slovenia's territory is in the Natura 2000 network. To enhance implementation of the national Natura 2000 Management Programme and to improve the conservation status of targeted habitat types and species by establishing a long-term and inclusive management approach, the LIFE integrated project for enhanced management of Natura 2000 in Slovenia (LIFE17 IPE/SI/000011 LIFE-IP NATURA.SI) was granted for the period 2018-2026. Implementation of Natura 2000 measures in forests is also part of the priority Natura 2000 projects that were determined in the Natura 2000 Management Programme 2015-2020 and funded in the framework of the Operational Programme for the Implementation of the EU Cohesion Policy in the Period 2014-2020, priority investment "Protecting and restoring biodiversity and soil and promoting ecosystem services, including through Natura 2000, and green infrastructure".

Biodiversity in forests is also improved through other projects in which Slovenia is included:

- Ursus Slovenia - Conservation of Large Carnivores in Slovenia - Phase I (Ursus Arctos) (LIFE02 NAT/SLO/008585), 2002-2005
- LIFE ManFor C.BD - Managing forests for multiple purposes: carbon, biodiversity and socio-economic wellbeing (LIFE09 ENV/IT/000078), 2010-2016
- LIFE WOLFALPS - Wolf in the Alps: Implementation of coordinated wolf conservation actions in core areas and beyond (LIFE12 NAT/IT/000807), 2013-2018
- LIFE DINALP BEAR - Population level management and conservation of brown bears in the northern Dinaric Mountains and the Alps (LIFE13 NAT/SI/000550), 2014-2019
- LIFE ARTEMIS - Awareness Raising, Training and Measures on Invasive Alien Species in Forests (LIFE15 GIE/SI/000770), 2016-2020
- LIFE Lynx - Preventing the Extinction of the Dinaric-SE Alpine Lynx Population Through Reinforcement and Long-term Conservation (LIFE16 NAT/SI/000634), 2017-2024
- LIFE SySTEMiC - Close-to-nature forest sustainable management practices under climate changes (LIFE18 ENV/IT/000124), 2019-2024

(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

To date, Slovenia has not estimated the GHG emissions and removals of the LULUCF sector as part of its national projections which are being reported under Regulation (EU) No 525/2013. However, a projection with existing measures was made for managed forest land in accordance with reporting obligations under Decision No 529/2013/EU. The level of this projection is generally consistent with the FRL, but the trend deviates to some extent because of differences in the assumptions made.

(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 FRL is consistent with Slovenian GHG inventories and relevant historical data. The model used to construct the FRL is able to reproduce historical data from the Slovenian Greenhouse Gas Inventory as the same input data (e.g. data from the NFI, definitions, C pools) and methodology were used to calculate the carbon stock changes and GHG emissions included in the FRL.

1.2.2 Description of how each of the following elements were considered in the determination of the forest reference level

(e) i The area under forest management

The area of managed forest land used in the calculation of the FRL is the projected area of managed forest land for the period 2021-2025, which equals the area under forest management consistent with Table 2 ("Forest land remaining forest land") from the latest national GHG inventory. The area of managed forest land in 2009 was used, which is the year preceding the starting point of the projection. Thus, the area of managed forest land at the end of 2009, namely 1,003,620 ha, was kept constant in the period 2021-2025.

Table 2: Area of managed forest land as reported to the EU and the UNFCCC in Submission 2019

In 1,000 ha	2000	2001	2002	2003	2004	2005
Managed forest land	995.27	996.48	997.69	998.29	998.89	999.49
In 1,000 ha	2006	2007	2008	2009		
Managed forest land	1,000.09	1,001.27	1,002.44	1,003.62		

(e) ii Emissions and removals from forests and harvested wood products as shown in greenhouse gas inventories and relevant historical data

Table 3: Emissions and removals for forest land remaining forest land as reported to the EU and the UNFCCC in Submission 2019

kt CO_2 eq	2000	2005	2010	2015	2016	2017
Living biomass	-4,583	-5,668	-5,036	-2,149	-756	27
Above-ground living biomass	-3,762	-4,565	-4,089	-1,713	-579	57
Below-ground living biomass	-821	-1,103	-947	-436	-176	-31
Dead wood	-367	-369	3	-665	-674	-684
HWP	-85	-185	-129	-129	-102	-86
Biomass burning	7	9	4	4	18	14
Total	-5,029	-6,212	-5,158	-2,939	-1,513	-730

(e) iii Forest characteristics, including dynamic age-related forest characteristics, increments, rotation length and other information on forest management activities under 'business as usual'.

The forest and forestry characteristics in Slovenia are described in Chapter 2.3.1, while information on forest management activities under "business-as-usual" is described in Chapters 3.2.1 and 3.2.2. For modelling at the national level, an average net rotation length of 130 years was used.

Table 4: Forest characteristics according to the NFI (2000, 2007, 2012, 2018)

NFI	2000	2007	2012	2018
Growing stock (m^3 ha^{-1})	283	314	334	329
Dead wood (m^3 ha^{-1})	-	19.75	19.76	23.77
Increment (m^3 ha^{-1} y^{-1})	-	-	7.92	7.58
Mortality (m^3 ha^{-1} y^{-1})	-	1.23	0.79	2.23
Harvest (m^3 ha^{-1} y^{-1})	-	-	4.10	6.04

The structure and composition of forest stands changed significantly in the observed period. The changes are reflected in the constant increase in growing stock (Table 4) and general aging of forest stands (Fig. 1). A further increase in growing stock will result in a greater number of old stands (DBH 40 + cm) which could, due to expected climate change, result in higher risks for forest management and the possible loss of biodiversity and a CO_2 sink.

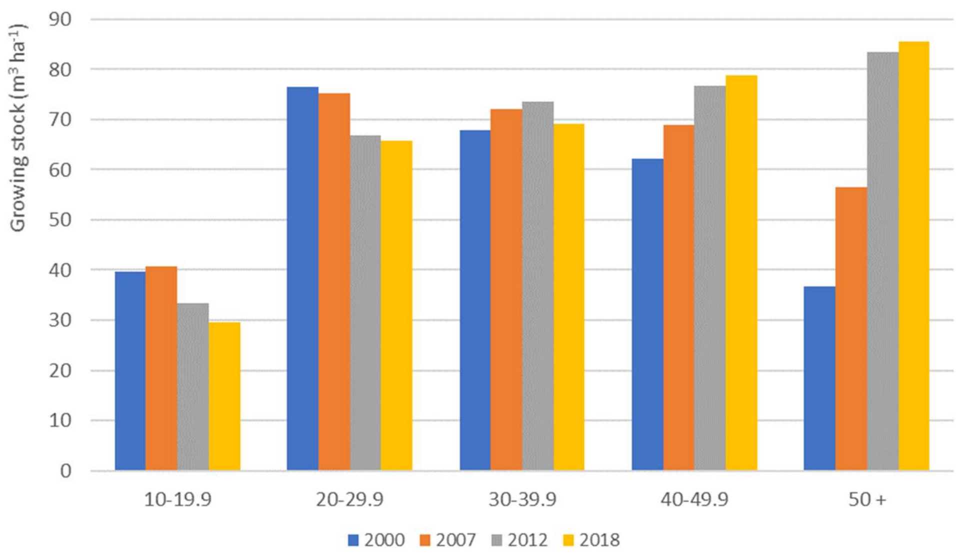

Figure 1: Changes in DBH structure show general aging of forest stands

(e) iv Historical and future harvesting rates disaggregated between energy and non-energy uses

Table 5: Harvesting rates between HWP and energy use

Year	Harvest (kt C)	HWP (kt C)	Energy + export (kt C)
2000	925.7	202.6	723.1
2001	951.8	202.2	749.6
2002	978.3	208.0	770.3
2003	1,005.1	219.7	785.5
2004	1,032.3	228.5	803.8
2005	1,059.7	236.7	823.0
2006	1,087.5	245.3	842.2
2007	1,115.6	267.5	848.2
2008	1,144.1	245.8	898.3
2009	1,172.8	231.5	941.4
2010	1,257.1	214.3	1,042.8
2011	1,273.3	202.0	1,071.3
2012	1,289.5	199.0	1,090.5
2013	1,305.7	187.8	1,117.9
2014	1,321.9	212.9	1,109.0
2015	1,338.0	219.3	1,118.7
2016	1,354.1	214.5	1,139.6
2017	1,370.2	210.1	1,160.1
2018	1,386.2	302.8	1,083.4
2019	1,402.2	306.3	1,095.9
2020	1,418.1	309.8	1,108.4
2021	1,434.0	313.2	1,120.8
2022	1,449.8	316.7	1,133.1
2023	1,465.6	320.1	1,145.4
2024	1,481.2	323.6	1,157.7
2025	1,496.9	327.0	1,169.9
2026	1,512.4	330.4	1,182.0
2027	1,527.9	333.7	1,194.1
2028	1,543.2	337.1	1,206.1
2029	1,558.6	340.5	1,218.1
2030	1,573.8	343.8	1,230.0

Table 6: Equivalence table for Slovenia. indicating where in the document the elements according to Annex IV B are addressed

Annex IV B. paragraph item		Elements of the NFAP according to Annex IV B.	Chapter in the NFAP
(a)		A general description of the determination of the forest reference level.	3.1
(a)		Description of how the criteria in LULUCF Regulation were taken into account.	1.2.1
(b)		Identification of the carbon pools and greenhouse gases which have been included in the forest reference level.	2.1
(b)		Reasons for omitting a carbon pool from the forest reference level determination.	2.1
(b)		Demonstration of the consistency between the carbon pools included in the forest reference level.	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.	3
(c)		A description of documentary information on sustainable forest management practices and intensity.	3.2.2
(c)		A description of adopted national policies.	2.3.1
(d)		Information on how harvesting rates are expected to develop under different policy scenarios.	2.3.2
(e)		A description of how each of the following elements were considered in the determination of the forest reference level:	
	(i)	• The area under forest management	1.2.2
	(ii)	• Emissions and removals from forests and harvested wood products as shown in greenhouse gas inventories and relevant historical data	1.2.2
	(iii)	• Forest characteristics, including: – dynamic age-related forest characteristics – increments – rotation length – other information on forest management activities under 'business- as- usual'	1.2.2
	(iv)	• Historical and future harvesting rates disaggregated between energy and non-energy uses	1.2.2

2 PREAMBLE FOR THE FOREST REFERENCE LEVEL

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

The NFAP contains the identification of carbon pools and greenhouse gases included in the FRL, the reasons for not including a carbon pool in the FRL determination, and a demonstration of the consistency between the carbon pools included in the FRL.

The Slovenian FRL includes the following carbon pools and greenhouse gases:

- Above-ground living biomass
- Below-ground living biomass
- Dead wood
- Harvested wood products (HWP)
- Greenhouse gases from biomass burning

Two carbon pools that were excluded from the FRL for Slovenia are litter and organic carbon in mineral soils. This is in line with current reporting under the UNFCCC and accounting under the Kyoto Protocol. A study conducted under ICP Forests (1995-1996) and the BioSoil demonstration project soil module (2004-2006, national activities) found that there were no statistically proven differences in carbon stocks in mineral soils and litter in the period 1996-2006 (NIR, 2019).

The Slovenian FRL includes all relevant greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), as defined by the LULUCF Regulation in Annex I (A). All greenhouse gases are expressed in terms of (kilo)tonnes of CO_2 equivalent.

In 2016, Slovenia began repeated sampling of forest soil in selected areas. So far, 45 sampling locations have been revisited on an 8 km x 8 km grid at the country level. After completion of forest soil monitoring at different intensity levels (grid and ICP Forests level II plots), Slovenia intends to include soil organic carbon and litter in the estimation of its FRL, which will require the country to carry out a technical correction of the FRL to ensure consistency.

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

Carbon pools included in the estimation of the FRL for Slovenia are consistent with those reported in the GHG inventory under the UNFCCC and EU. The methodology applied takes into account the same input data (living biomass, dead wood) that have been derived from the NFI since 2000 and from factors used to convert wood volume to carbon stocks (e.g. WD, BEF, R, CF, etc.).

Slovenia applies a stock-change method in the GHG inventory, and the same approach was applied in the estimation of carbon stock change in living biomass. The development of growing stock was modelled using the national approach with regard to dynamic age-related forest characteristics. The methodological approach and assumptions used to demonstrate consistency with other carbon pools are described in more detail in Chapter 3.

2.3 Description of the long-term forest strategy

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

Description of forests

The area of managed forest land in Slovenia was 1,116,239 hectares in the beginning of 2018, and total forest land accounts for about 60% of the Slovenian territory (Fig. 2). The growing stock amounted to 367 Mio. m^3 in 2018 and has been increasing sufficiently in the last decades. The increment of the growing stock was due to low intensity harvesting, which was in line with strategic forest management objectives. During the period 2007-2012, the increment was about 8.1 Mio. y^{-1}, while the annual cut was roughly 4 Mio. m^3.

There is a high diversity of forest types in Slovenia as the Alpine, Mediterranean and Continental climate types meet here, and because the orographic and geological conditions in Slovenia are very diverse. Among tree species, beech and spruce are dominant, but there are also forest types where fir, oak, pine and a number of deciduous species are represented.

Forest area, growing stock and increment have steadily increased over the past 150 years, and this rise has been especially steep during the last 50 years. For example, in the 19th century, forests covered only one third of the country, and most of the growing stock was accumulated in small diameter trees, while the latest data (Table 4 and Fig. 1) show that most of the growing stock in 2018 was accumulated in large diameter trees (DBH 40 cm and larger).

Another characteristic of Slovenian forests is that 80% of the forest land is privately owned, with the average property size amounting to only 2.6 hectares. The small property size is also one of the main reasons for the low utilization of the wood potential of Slovenian forests.

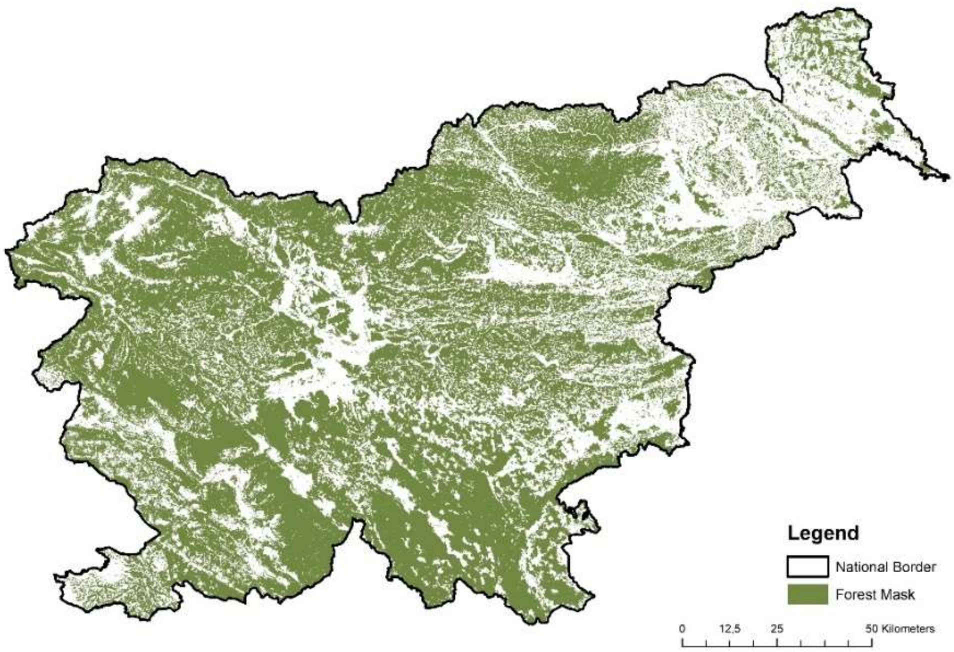

Figure 2: Forest cover of Slovenia in 2018 (SFS database 2018, SMARS 2013)

Forest Act

Forest management in Slovenia is regulated by the Forest Act of 1993 (and its subsequent amendments) and the NFP, which was prepared in 2007 and is based on the wide participation of stakeholders. The main objective of the legislation is to regulate the protection and exploitation of forests with the objective of permanently ensuring both the ecosystem integrity of the forests and their functions. The Act also regulates the conditions for managing forest trees and groups of forest trees outside forested areas.

Sustainable, close-to-nature and multi-purpose forest management is implemented in all forests irrespective of ownership. Under the Act, FMAPs are elaborated in all forests at the regional and local levels. The plans are elaborated through a participatory approach, where forest owners as well as other institutions (e.g. nature conservation, cultural heritage, water management) and the interested public (e.g. different NGOs) have the opportunity to influence the proposed measures. In this process the Institute of the Republic of Slovenia for Nature Conservation (IRSNC) prepares nature conservation guidelines that are directly integrated into the FMAP to ensure biodiversity protection in the forest. Environmental protection is ensured in the plans for all forests, regardless of ownership, as productive forests are not managed as commercial plantations with only limited biodiversity value, but promote biodiversity in accordance with the Habitats Directive and the EU Biodiversity Strategy.

Finally, silvicultural plans are prepared at the forest compartment level (on average 30 ha). These plans are based on FMPs and contain prescribed silviculture measures for direct implementation.

Forest management and forest use in Slovenia are directed by the Ministry of Agriculture, Forestry and Food (MAFF) as the supreme state institution in the field of forestry and by the SFS as a public forestry service.

National Forest Development Programme

From its adoption by the National Assembly of the Republic of Slovenia in 1996 and until the establishment of the National Forest Programme in 2007, the National Forest Development Programme (NFDP) represented the basic forestry document in Slovenia (Official gazette RS, No 14/96) and defined the national forest management policy, guidelines for conserving biodiversity and developing forests, and the conditions for wood exploitation and multi-purpose use of forests. Programme 96 proceeded from Articles 6 and 7 of the Forest Act and Slovenia's international obligations as set out in Chapter 11 of Agenda 21 adopted at the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992. Programme 96 also took into account the provisions of the Alpine Convention and resolutions adopted at the Ministerial Conferences on the Protection of Forests in Europe (Strasbourg 1991, Helsinki 1993) and the Convention on Biological Diversity (Rio de Janeiro 1992).

The NFDP established the foundations for the conservation and development of all forests and formulated a development strategy in specific fields of forest management. It was noted that in Slovenian forests the proportion of large diameter trees, which is an indicator of quality and high-value increment, as well as biodiversity and the mechanical stability of forests, was too low. According to the policies set out in the NFDP, harvest intensity was limited to 66% of the increment for coniferous trees and 50% of the increment for deciduous trees. The low harvesting rate was mainly the result of expert opinion that the growing stock should be increased to an optimal level of 330 m^3 ha^{-1}. Another reason was the decline in production in the wood processing industry after 1990, with some producers collapsing due to the loss of markets (ex-Yugoslavia) and the loss of the supply of raw materials. Furthermore, the denationalisation processes that started after 1991 led to lower harvesting rates, especially in the areas under this process. The state and private forestry sectors were confronted with structural changes, in particular after 1993 (a new forest law), new organisations (e.g. the Slovenian Forestry Service), a modified forest management system and changes in the organisation of the private forest sector.

Slovenian national forest programme (2007)

The National Forest Programme (hereafter NFP) is a fundamental strategic document aimed at determining the national policy of sustainable development of forest management. The main principles of the NFP are directed towards the preservation of forests and provision of their multipurpose role, which includes environmental, social and economic aspects. On the basis of the current situation and set goals, it contains a long-term vision of management, which besides the development guidelines limited to the forestry sector, also defines relationships from the area of environmental protection and nature conservation, economic sectors related to wood processing and all other sectors associated with forests and forest land.

With the participatory approach of the NFP document (2007), there was a national consensus to increase utilization of forest production potential. The planned harvesting rate increased to 75% of the increment, and there was a focus on forest regeneration, which resulted in a higher realization of the available cut prescribed by forest management plans from 2008 onward.

Principles of forest management in Slovenia

Forest management in Slovenia is based on the principles of sustainability, multifunctionality and management planning, as provided in the vision and core objectives of the NFP. Forest policy measures are based on an ecosystem approach and support the sustainable development of forests in terms of their biodiversity and ecological, economic and social functions. The main challenge continues to be the failure to achieve the allowable cut and carry out tending activities, which is primarily related to the large number of forest owners and small and fragmented tenure.

Forests continue to provide the number of services that are expected from them by various stakeholders in accordance with available resources. The forests considerably contribute to the maintenance of the natural environment and ecological balance of the landscape. The public forestry service in cooperation with forest owners, and with regard to their requirements and interests, determines optimal forest management measures and directs forest management.

Environmental aspects are taken into account, and established regimes are maintained in protective forests and forests with a special purpose. Guidelines for the maintenance of the favourable status of habitat types, species and their habitats in Natura 2000 areas and outside of them are taken into account. Forest management plans include conservation guidelines through which the necessary conservation measures are prescribed to ensure the favourable status of species and their habitats. As explained in Chapter 1.2 f, the implementation of concrete measures to preserve species and habitat types is being strengthened both in state owned and private forests with the help of regulations, the national budget (e.g. Forest Fund) and projects (e.g. LIFE, Operational Programme for the

Implementation of the EU Cohesion Policy in the Period 2014-2020). Despite increasing environmental burdens, including extreme weather events caused by climate change, the forest plays a key role in the conservation of biodiversity and ecological balance of nature.

The economic effects of forest management are increasing. The realization of the allowable cut is increasing in private forests, though still well below that planned. Forest operations have been modernised, and the forest road density has been improved with the support of the Rural Development Programme. The NFP acknowledges that the forest is the most important renewable source of raw materials and an important source of energy. The Action Plan "Wood is Beautiful" was endorsed and a new Wood Industry Directorate at the Ministry of Economic Development and Technology established to stimulate national wood processing and the use of domestic wood products. This led to public calls intended for the processing of wood, creating better conditions for the effective operation and development of the forest-wood supply chain.

Climate change and its consequences (e.g. forest fires, ice damage, windthrow and other extreme events), air pollution, invasive species and forest fragmentation reduce forest biodiversity and genetic diversity and threaten the adaptive potential and sustainability of European forests and their ecosystems. Approximately half of forest species have been classified as threatened. The loss of diversity makes forests less resilient, which could negatively impact future timber supply and the provision of forest ecosystem services (FAO, 2014). In addition to environmental threats, the stability of forests is threatened by the general ageing of forest stands, changed forest structure and tree species composition and unsustainable forest management practices. Thus, it is extremely important that sustainable management practices take into account specific local conditions, including harvest intensities (e.g. for a given period), changes in species composition, shorter rotation periods and other activities that could change carbon dynamics (forests are not sinks for some years), but that in the long term preserve forest cover, stability and sustainability and provide long-term climate benefits and contribute to climate mitigation. Forest management should also support the diversity of forest structure at different age phases as well as the unstructured area of the 11 forest habitat types important for Europe (NATURA, 2000).

The broader social aspect of forest management continues to be a major challenge for all involved. The social and ecological services of forests (hunting, beekeeping, gathering fruits and other forest resources, tourism and recreation, biodiversity, etc.) are increasing, but the economic effects are not. Tourism by domestic and foreign guests indirectly generates business opportunities for farms and entrepreneurs in rural areas. In certain areas, especially near major urban centres, excessive visitation has led to conflicts between forest owners and visitors.

2.3.2 Description of future harvesting rates under different policy scenarios

Three different policy scenarios were prepared to describe harvest levels until 2050. In all these scenarios the effect of climate change and natural disturbances is not taken into account. It is assumed that the area of managed forest land will remain constant and tree species composition will not change.

1. The BAU scenario is based on the continuation of the level of wood production and export, assuming adopted national policies related to forestry and the wood processing industry in the period 2000-2009.

2. The NFP scenario assumes an increase in harvest level to approximately 75% of the annual increment, which is a guiding principle defined by the National Forest Programme. The NFP scenario envisages increased forest regeneration to stem the aging of forest stands.

3. The "high harvest" scenario is based on the assumption that the harvest level will be between 90 and 100% of the annual increment. Under this scenario, the implementation of additional policies and measures related to forestry and financial investment in the wood processing industry in the near future are expected to increase the demand for wood.

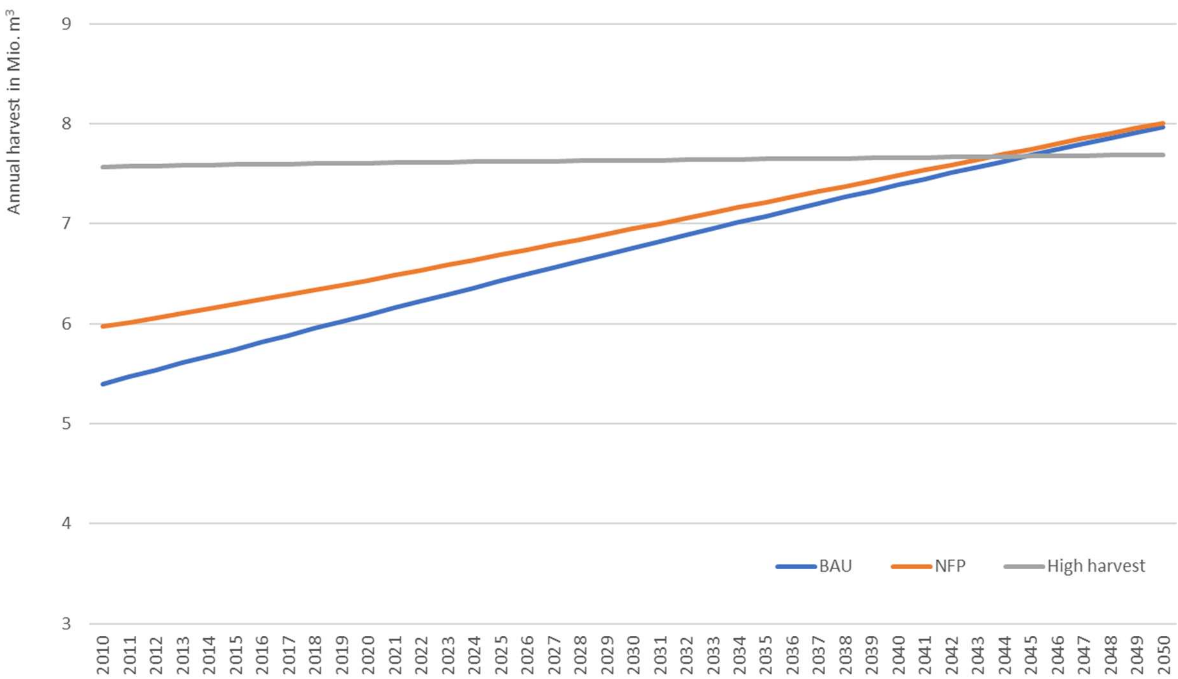

Figure 3: Harvesting levels according to three possible policy scenarios until 2050

It is expected that the annual harvest under the BAU and NFP scenarios will increase from 5.4 to 7.9 Mio. m^3 and 6.0 to 8.1 Mio. m^3 in the period 2010-2050, respectively. In the "high harvest" scenario, annual harvest will remain constant (7.6 Mio. m^3). The three scenarios described above are expected to have different effects on the development of growing stock and age/diameter structure of the forest. Low regeneration cutting in the BAU scenario is reflected in a rapid increase in growing stock (406 m^3 ha^{-1}) and large diameter trees, while in the NFP scenario the increase in growing stock (395 m^3 ha^{-1}) and large diameter trees is much slower. In the "high harvest" scenario, it is expected that the diameter structure of forests will remain constant in the period 2010-2050 and the growing stock will not exceed 340 m^3 ha^{-1} (Annex 2). As the BAU scenario does not enable balancing of the age/diameter structure of the forest, Slovenia intends to use the compensation under the managed forest land flexibility option up to the adopted level according to regulation EU REGULATION 2018/841 (Article 13, Annex VII: maximum amount of compensation available under managed forest land flexibility referred to in point (B) of article 13).

3 DESCRIPTION OF THE MODELLING APPROACH

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

The estimation of the forest reference level is based on field data from the national forest inventory (2000, 2007, 2012 and 2018 NFI) and forest management plans, which refer to the managed forest land of Slovenia. The main data provided by the NFI are growing stock, increment, drain and dead wood volume (Table 4). Determination of forest management intensity in the reference period is based on data from the forest management plans of the Slovenia Forest Service and NFI data (Table 9). The development of living biomass for the commitment period (2021-2025, 2026-2030) was modelled using a national methodological approach and the best available data in accordance with sustainable forest management practices, as documented in the period 2000-2009. Managed forest land was stratified into homogeneous forest types (i.e. strata, Table 7), for which Slovenia Forest Service data were used to describe the main characteristics of the SFM practice in the reference period (Table 8). The amount of harvested wood was used to estimate the carbon stock changes in the HWP, taking into account the ratio of HWP production from the reference period. The starting year of the projection for living biomass was 2010. The area of managed forest land was kept constant from 2010 onwards. Net emissions from carbon stock changes in dead wood and emissions from forest fires were calculated as mean values for the period 2000-2009. The effect of climate change was not taken into account in the modelling of living biomass nor in other carbon pools. Carbon stock changes and GHG emissions were estimated according to the same methods and tier levels of the 2006 IPCC guidelines that are used for the UNFCCC and EU reporting and accounting.

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

3.2.1 Documentation of stratification of managed forest land

According to the Forest Act (UL RS, No 77/16), forest is defined as land containing forest trees in the form of a stand that is capable of reaching a height of at least 5 m and that covers an area of at least 0.25 hectares. A forest is also at least 0.25 hectares of land overgrown with forest trees that has not been used for agricultural purposes for the last 20 years, where the forest trees can reach a height of at least 5 m and at least 75% canopy cover, and riparian forest corridors and windbreaks wider than one tree height of an adult tree and covering an area of at least 0.25 hectares.

The area of managed forest land, which equals the area of the "forest land remaining forest land" category under the UNFCCC and EU reporting, comprised 1,003,620 ha at the beginning of 2010 and increased to 1,116,239 ha by 2018. In the period 2000-2009, the forest area increased to 1,003,620 ha, which is why we used the same forest area for setting the BAU and modelling the future FRL. For the purpose of GHG reporting and accounting, the area of managed forest land is estimated by point sampling on a 1 km x 1 km grid through visual interpretation of digital orthophoto images of land use/cover, where differences between the actual land use map (ALUM) and previous estimation on the sampling grid are rechecked at approximately 5-year intervals. For more information on the methodological approach to land use and land-use change estimation, see Chapter 6.3 in the latest GHG inventory (NIR 2019). In accordance with IPCC guidelines, Slovenia uses a default transition period of 20 years after which areas of “land converted to forest land” are shifted to the “forest land remaining forest land” category.

For the purpose of defining SFM practices and management intensity, the area of managed forest land was stratified into eight homogenous groups or strata, which include different forest types with similar forest management practices (Table 7). Data sources used to perform the stratification are from forest management planning for the period 2000-2009 provided by the Slovenia Forest Service. Stratification is based on a hierarchical typology of forest sites based on the ecological and floristic similarity of forest plant communities (Kutnar et al., 2012). This system of forest types was developed for guiding the planning of all of the forests. Forest types are also the basis for the definition of the forest management classes at the level of forest management units and regional forest management units.

Table 7: Stratification of forests according to national forest type typology

Forest management practice (FMP)		Forest categories (Kutnar et al., 2012)	Area* (% of MFL)
FMP1	Riparian forest and fluvial forest	1, 2	1.5
FMP2	Sessile oak – hornbeam forests	3, 4	6.3
FMP3	Central European sub-montane beech forest	6, 8, 13	26.8
FMP4	Illyrian beech forest	5, 7, 10	27,2
FMP5	Illyrian fir beech forest	9	13.8
FMP6	Other thermophilus deciduous forests	11, 12, 14	11.4
FMP7	Spruce and fir forest	15, 16	4.4
FMP8	Protective forest and forest reserves	chiefly 17, 18, 19	8.6

*Data sources used for stratification are from forest management plans for the period 2000-2009 provided by the Slovenia Forest Service; forest area used is 1,003,620 ha.

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

In Slovenia, close-to-nature forestry has been formally used for over 50 years and fully complies with the provisions of the ecosystem approach. Close-to-nature forestry uses forest management methods that promote the conservation of nature and forests, as its most complex creation, while deriving tangible and intangible benefits from the forest such that it is preserved as a natural ecosystem of all its diverse life forms and the relations between them. Close-to-nature forestry is based on forest management plans adapted to individual site and stand conditions as well as forest functions and considers natural processes and structures specific to natural forest ecosystems (Table 8). Natural processes are altered as little as possible, while the financial profitability and social sustainability of forest management are maintained. Like natural processes, close-to-nature forestry also contains inbuilt mechanisms for continual internal checks (controls) providing a timely response to modify measures adapted in accordance with the developmental characteristics of single forest stands and the forest as a whole.

Table 8: Short description of the FMPs

Forest management practice (FMP)	Short description of FMP
FMP1: Riparian forest and fluvial forest	Shelter wood silvicultural system with a 60 y net rotation period and 10 y regeneration period is applied. The main tree species are alder, willow, poplar and other valuable hardwoods
FMP2: Sessile oak – hornbeam forests	Shelter wood silvicultural system with a 120-140 y net rotation period and 15 to 25 y regeneration period is applied. The main tree species are sessile oak, hornbeam, beech and other hardwoods.
FMP3: Central European sub-montane beech forest	Shelter wood silvicultural system with a 120 y net rotation period and 20 y regeneration period is applied. The main broadleaved tree species is beech and the predominant conifers are Scots pine and Norway spruce.
FMP4: Illyrian beech forest	Shelter wood and irregular shelter wood silvicultural system are applied with a 120-140 y net rotation period and 20-30 y regeneration period. The predominant tree species are beech, silver fir, ash and maple.
FMP5: Illyrian fir beech forest	Irregular shelter wood and selective silvicultural system are applied with a 140 y (on average) net rotation period and 20-35 y regeneration period. The predominant tree species are beech, silver fir and Norway spruce.
FMP6: Other thermophiles deciduous forests	Shelter wood and coppice silvicultural system are applied with 130 y and 30-50 y net rotation period, respectively.
FMP7: Spruce and fir forest	Irregular shelter wood and selective silvicultural system are applied with a net rotation period of 120-140 y for Norway spruce, 130-140 y for silver fir and up to 175 y for larch. Regeneration period alters with elevation and is on average 20-40 years. Conifers (Norway spruce and silver fir) predominate.
FMP8: Protective forest and forest reserves	The management in protective forests is limited to interventions for improving the protective function of forests. In forest reserves, no interventions are allowed, and forests are left to natural development.

Characteristics of close-to-nature forest management:

- Preservation of the natural environment and ecological balance of the landscape
- Sustainability of all forest functions
- Integrated approach to forest ecosystems
- Imitation of natural processes and forms
- Tree species suited to the site conditions
- Based on a cognitive approach - constant monitoring and learning
- Based on long-term economic efficiency
- Plans designed at a broader and more detailed level

Thus, silviculture practices supporting close-to-nature forest management foster continuous forest cover, boost mixed forest structure and tree species composition to improve soil quality, use forest structure and tree species composition adapted to the site conditions, promote natural regeneration with carefully selected tree species, avoid clear-cutting, encourage gap regeneration techniques, leave small branch, leaf, and bark litter to ensure site productivity, and use adapted management and harvesting technology to minimize soil degradation.

Table 9: Forest management intensity under business-as-usual (BAU) in the period 2000-2009

Forest management practice (FMP)		Commercial thinning (%) *			Regeneration cutting (%) *	
		DBH (cm): 10–19.9	DBH (cm): 20–29.9	DBH (cm): 30–39.9	DBH (cm): 40–49.9	DBH (cm): 50+
FMP1: Riparian forest and fluvial forest	con.	0.93	1.58	1.99	2.31	2.55
	broad.	0.77	1.09	2.09	2.27	2.89
	all	0.80	1.19	2.06	2.29	2.80
FMP2: Sessile oak – hornbeam forests	con.	1.40	2.54	4.59	5.76	8.13
	broad.	1.29	1.55	3.08	3.56	3.78
	all	1.33	1.90	3.82	4.62	5.62
FMP3: Central European sub-montane beech forest	con.	0.66	0.96	1.49	2.03	3.59
	broad.	0.69	0.75	1.51	1.68	3.92
	all	0.68	0.81	1.50	1.83	3.76
FMP4: Illyrian beech forest	con.	0.50	0.79	0.99	1.32	2.94
	broad.	0.41	0.53	1.07	1.06	2.20
	all	0.45	0.63	1.02	1.21	2.63
FMP5: Illyrian fir beech forest	con.	1.16	1.11	1.55	2.31	4.67
	broad.	1.26	1.11	1.84	1.97	6.56
	all	1.21	1.11	1.63	2.20	5.01
FMP6: Other thermophilus deciduous forests	con.	0.47	0.66	0.97	1.17	2.05
	broad.	0.42	0.28	0.73	0.87	1.67
	all	0.44	0.39	0.87	1.04	1.88
FMP7: Spruce and fir forest	con.	0.88	1.06	1.03	1.32	2.90
	broad.	1.06	0.88	1.34	1.23	4.19
	all	0.91	1.03	1.06	1.31	2.98
FMP8: Protective forest and forest reserves	con.	0.09	0.18	0.26	0.38	0.51
	broad.	0.14	0.20	0.49	0.66	2.52
	all	0.12	0.19	0.36	0.51	1.20
All forests	con.	0.66	0.91	1.21	1.72	3.57
	broad.	0.60	0.63	1.38	1.40	3.48
	all	0.62	0.74	1.27	1.58	3.54

*Commercial thinning and regeneration cut are presented as an average harvesting intensity in percentage (%) of the initial growing stock (2000).

For the purpose of modelling and estimating the forest reference level, the forest management intensity under business-as-usual (BAU) was elaborated as an average harvest ratio (in %) of the initial growing stock in the period 2000-2009 (Annex 2). The BAU ratios were composed for each FMP and all forests by five DBH classes and separately for conifers, broadleaves and all tree species together (Table 9). The average annual harvest from the NFI for the period 2007-2012 was used as the best available data in the reference period (see also Chapter 3.3) and combined with harvesting records structured by the five DBH classes, tree species and FMP of the Slovenia Forest Service for the period 2000-2009.

Taking the technical guidance (Forsell et al., 2018) into account, the projection of HWP inflows incorporates a fixed ratio between energy and other uses in the calculation. The average carbon inflow differentiated to HWP commodities in period 2000-2009 is subsequently multiplied by the ratio between the modelled harvest volumes in the projection and the average harvest documented in the period 2000-2009. This approach ensures that the provision stating that the ratio between energy use and wood processing in the projection is the same as in the period 2000-2009 ("a constant ratio between solid and energy use of forest biomass as documented in the period from 2000 to 2009 shall be assumed"). The C input quantities in the carbon pool of HWP are proportionate to the increase/reduction in harvest throughout the entire period of the projection in accordance with the EU Guidance (2018), section 2.5.6.

Table 10: HWP ratio for the period 2000-2009

Year	Harvest (1 000 t C)	HWP input (1 000 t C)				HWP %
		SW	WBP	Paper	Total HWP	
2000	925.7	143.8	32.2	26.7	202.6	22
2001	951.8	140.9	35.2	26.1	202.2	21
2002	978.3	143.3	37.7	27.0	208.0	21
2003	1,005.1	159.7	32.9	27.1	219.7	22
2004	1,032.3	167.0	34.1	27.4	228.5	22
2005	1,059.7	174.2	32.2	30.4	236.7	22
2006	1,087.5	193.3	34.6	17.4	245.3	23
2007	1,115.6	206.9	48.9	11.6	267.5	24
2008	1,144.1	187.2	47.2	11.3	245.8	21
2009	1,172.8	175.4	44.7	11.3	231.5	20
Average 2000-2009	1,047.3	169.2	38.0	21.6	228.8	22

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

Slovenia's methodological approach for determining the development of carbon pools based on the available data and national conditions follows the Commission's technical guidance (Forsell et al., 2018) and the provisions of Regulation (EU) No 2018/841, including the criteria and guidelines for the construction of the FRL. This approach includes carbon stock changes in above-ground biomass, below-ground biomass, dead wood and HWP, where the best available data were used.

The reference level does not include carbon stock changes in soil organic carbon or litter as there are currently no reliable data on the basis of which a projection for these two pools could be produced. As explained in Chapter 2.1, Slovenia is working on developing / gathering the data, and if upon becoming available, the data show changes over time, this will be included in the FRL and a technical correction made.

Modelling approach for living biomass

The modelling approach used in the estimation of reference level followed control method principles and the concept of normal forest (Gadow and Puumalainen, 2000; Bettinger et al., 2009). It simulates growing stock development in each of five DBH classes according to the main forest stand variables. Such a principle is regularly used in setting annual allowable cut at the forest management class level in forest management planning.

The data collected in the 2000, 2007, 2012 and 2018 NFI were used to set BAU in the period 2000-2009 (Chapter 3.2.2; Table 11) and project the development of growing stock in above-ground biomass for five extended diameter classes at the national level. The model includes variables such as growing stock, increment, ingrowth, harvest and mortality; the calculation of growing stock dynamics up to 2030 was obtained on their basis. The model takes into account BAU ratios for the period 2000-2009 (Chapter 3.2.2; Table 9). Although the NFI was launched in 2000, the control calculation of growing stock change when applying the stock-difference method and the gain-loss method for the period 2000-2007 showed that the data on harvest, mortality and increment for this period are biased due to changes in the field measurement method between the two consecutive measurements. Comparison between the 2000 and 2007 NFI resulted in a flawed calculation of harvest and increment for the period 2000-2007. Thus, the best available data on harvest and increment in the reference period are data from the 2007 and 2012 NFI.

Table 11: Input data for calculating the development of growing stock for the period 2010-2030

DBH class	10-19.9 cm	20-29.9 cm	30-39.9 cm	40-49.9 cm	50 cm +
Initial growing stock in 2010 (Mio m^3)	35.99	71.98	75.25	71.98	71.98
Ingrowth (m^3)	368,359				
Increment 2010 (% of GS)	1.77	2.21	2.43	3.53	1.88
Harvest – BAU 2000-2009 (% of GS)	0.62	0.74	1.27	1.58	3.54
Mortality 2010 (% of GS)	0.20	0.20	0.20	0.20	0.20

Data on increment, ingrowth, harvest and mortality are available only for the country as a whole, which is why the calculations obtained from this model have not been performed separately for strata but only for the country as a whole. The baseline year of the projection is 2010.

The model of normal forest used to simulate the development of above-ground living biomass is as follows:

$$GS(i) = GS1(i) + GS2(i) + GS3(i) + GS4(i) + GS5(i)$$

GS(i) – growing stock in year i (m3)
GS1(i) – growing stock of diameter class 1 in year i (m^3)
GS2(i) – growing stock of diameter class 2 in year i (m^3)
GS3(i) – growing stock of diameter class 3 in year i (m^3)
GS4(i) – growing stock of diameter class 4 in year i (m^3)
GS5(i) – growing stock of diameter class 5 in year i (m^3)
i – years of projection (2010-2030)

$$GS_{1(i)} = GS_{1(i-1)} + GS_{1(i-1)} \times In + Ingr - GS_{1(i-1)} \times Ha - GS_{1(i-1)} \times Mo - \frac{GS_{1(i-1)}}{T_1}$$
$$GS_{2(i)} = GS_{2(i-1)} + GS_{2(i-1)} \times In - GS_{2(i-1)} \times Ha - \frac{GS_{2(i-1)}}{T_2} - GS_{2(i-1)} \times Mo + \frac{GS_{1(i-1)}}{T_1}$$
$$GS_{3(i)} = GS_{3(i-1)} + GS_{3(i-1)} \times In - GS_{3(i-1)} \times Ha - \frac{GS_{3(i-1)}}{T_3} - GS_{3(i-1)} \times Mo + \frac{GS_{2(i-1)}}{T_2}$$
$$GS_{4(i)} = GS_{4(i-1)} + GS_{4(i-1)} \times In - GS_{4(i-1)} \times Ha - \frac{GS_{4(i-1)}}{T_4} - GS_{4(i-1)} \times Mo + \frac{GS_{3(i-1)}}{T_3}$$
$$GS_{5(i)} = GS_{5(i-1)} + GS_{5(i-1)} \times In - GS_{5(i-1)} \times Ha - GS_{4(i-1)} \times Mo + \frac{GS_{4(i-1)}}{T_4}$$

In – average annual increment (% of GS_{dbh}(i)); DBH = 1 … 5
Ingr – average annual ingrowth (m3)
Ha – average annual harvest (% of GS_{dbh}(i)); DBH = 1 … 5
Mo – average annual mortality (% of GS_{dbh}(i)); DBH = 1 … 5
T1 – transitional period of diameter class 1 (45 years)
T2 – transitional period of diameter class 2 (35 years)
T3 – transitional period of diameter class 3 (30 years)
T4 – transitional period of diameter class 4 (30 years)

Carbon stocks in above-ground biomass were calculated on the basis of the growing stock as calculated for 2010-2030 and parameters such as the biomass expansion factor (BEF), wood density (WD) and carbon fraction (CF) (Table 12). The emission factors for above-ground biomass were determined from the annual differences in the hectare values of carbon stocks. The annual carbon stock change in above-ground biomass was calculated as the product of the emission factors and the surface area of managed forests. For the calculation of CO_2 emissions, annual carbon stock change in above-ground biomass was multiplied by a factor of -44/12.

Table 12: Parameters of the main tree species used to convert biomass to carbon stock

Tree species	WD (t m^{-3})	BEF (dimensionless)	R (dimensionless)	CF (t C t^{-1} d.m.)
Spruce	0.400	1.15	0.20	0.47
Beech	0.584	1.15	0.24	0.47
Fir	0.394	1.15	0.20	0.47
Oak	0.580	1.15	0.30	0.47
Scots Pine	0.420	1.15	0.20	0.47
Maple	0.520	1.15	0.24	0.47
Hornbeam	0.630	1.15	0.24	0.47
Chestnut	0.480	1.15	0.24	0.47
Black Pine	0.420	1.15	0.20	0.47
Hop Hornbeam	0.630	1.15	0.24	0.47

The growing stock of below-ground biomass was calculated on the basis of the ratio between above-ground and below-ground biomass (R). The same coefficients as were used for reporting for the UNFCCC were used for this calculation (Table 12). Slovenia uses the default values from the IPCC

Guidelines of 2006, except for fir and beech, for which national factors (i.e. WD) are used. The annual carbon stock changes were calculated using the same procedure as for above-ground biomass.

The effect of climate change was not specifically taken into account in the methodological approach used. Climate change could have an effect on the future growth and composition of forest stands, but the impact is currently difficult to assess in quantitative terms. Thus, the assumption was made that climate conditions will not change in Slovenia in 2021-2030.

Natural disturbances were not directly incorporated into the model in the form of a separate module. Only past emissions from forest fires have been included in the reference level, i.e. as an average emissions value for 2000-2009. Despite the fact that forests have been subject to natural disturbances, such as the ice storm of 2014, the bark beetle gradations of 2015 and 2016 and the wind damage of 2017 and 2018, their effects were not taken into account when the projections were being drawn up.

Assumptions regarding carbon stock change in dead wood

The calculation of carbon stocks in dead wood is based on data from the NFI. At present, Slovenia only has reliable data on dead wood for 2007 and 2012. Despite the fact that dead wood was recorded in 2000, sampling at that time did not cover all the dead wood types recorded from 2007 onwards. In 2000 only fallen and standing dead trees were recorded, while in 2007 and 2012 the stock of stumps, snags and coarse woody debris were also estimated. These data were used to calculate the annual carbon stock changes for the period 2000-2009. The forest reference level includes the average value of carbon stock changes in dead wood for the period 2000-2009 based on the estimates reported in the latest GHG inventory under the EU and UNFCCC.

Assumptions regarding GHG emissions from biomass burning

All wildfires occurring on managed forest land have been recorded by the Slovenia Forest Service since 1993. There is no prescribed (managed) burning on managed forest land in Slovenia as this is not a common practice in forestry. The forest reference level includes the average value of all GHG emissions, including CO_2, CH_4 and N_2O, expressed in CO_2 equivalents for the period 2000-2009 and calculated on the basis of estimates reported in the latest GHG inventory under the EU and UNFCCC.

Estimation of carbon stock changes in HWP

HWP calculations follow the methodology set out in Chapters 2.3.5 and 2.5.6 of the Guidance on developing and reporting the Forest Reference Levels in accordance with Regulation (EU) 2018/841 (version 25 June 2018) and the IPCC Guidelines (2014). All other elements are the same as for the annual reporting and their methodology is described in Slovenia's National Inventory Report (NIR, 2018), specifically in the following chapters: PART 1: NATIONAL INVENTORY 1986-2016; 6.10. Harvested wood products, and PART 2: PART II: SUPPLEMENTARY INFORMATION UNDER ARTICLE 7, PARAGRAPH 1; 11 KP-LULUCF; 11.3.1.1.5 Harvested wood products.

HWP carbon stocks are based on detailed historical data from 1900 onwards according to the best available real production data for the selected HWP commodities (Sawnwood, WBP, Pulp production). The concept of using historical datasets supports efforts to improve the accuracy of HWP carbon stock dynamics estimation. Due to discrepancies and non-reliable statistical data (FAOSTAT) in the period

1991(1992)-1995, a simplified method for calculating HWP stocks based on average inflows for the selected period 1991(1992)-1995 would be significantly biased.

Inflows to HWP commodities originate from the domestic harvest of roundwood. Wood residuals and recovered paper are excluded from carbon inflows. All carbon inflows are uncontaminated with possible double counting issues and uncertainties related to recovered paper origin in order to ensure the integrity of carbon accounting (conservative approach).

Annual carbon outflows from the HWP pool are calculated using first order decay (FOD) and half-lives as defined in the LULUCF Regulation. Calculations of future emissions and removals originating from the HWP pool are consistent with GHG inventory reporting, thus ensuring methodological consistency between HWP contribution to FRL and GHG HWP reporting.

Projection of HWP inputs

The forest reference level for HWP is calculated from NFI data for all forests and multiplied by the area of managed forest land as reported in the latest GHGI (NIR, 2019). The average harvest in the period 2000-2009 was, using these assumptions, calculated at 4.5 Mio. m^3 y^{-1}. In accordance with the Guidance (2018) and the IPCC Guidelines (2014), the entire harvest derived from FM was used in calculations of the carbon pool of wood products. Wood from deforestation is taken into account on the basis of instantaneous oxidation and does not enter the HWP carbon pool. Data on deforestation and associated wood removals are derived from the SFS annual reports.

The average carbon inflow differentiated to HWP commodities in the period 2000-2009 is subsequently multiplied by the ratio between the modelled harvested volumes in use in the projection period and the average harvest documented in the period between 2000 and 2009.

Wood residues in HWP production are not included in carbon inflow figures as these commodities were accounted for based on instantaneous oxidation in line with the conservative approach in order to ensure integrity and consistency between domestic roundwood production and carbon inflows into the HWP pool.

Table 13: HWP production from domestic RW harvest (roundwood)

HWP inflow (kt C)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average 2000-2009
Sawnwood	143.8	140.9	143.3	159.7	167.0	174.2	193.3	206.9	187.2	175.4	169.2
WBP	32.2	35.2	37.7	32.9	34.1	32.2	34.6	48.9	47.2	44.7	38.0
Paper	26.7	26.1	27	27.1	27.4	30.4	17.4	11.6	11.3	11.3	21.6
Total	202.6	202.2	208	219.7	228.5	236.7	245.3	267.5	245.8	231.5	228.8

Projected HWP carbon inflow is calculated according to rates of change of the projected harvest as compared to the average of the historic harvest for the period 2000-2009.

4 FOREST REFERENCE LEVEL

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

The projection of growing stock, increment and drain according to the model used, assuming a continuation of the SFM practices from the reference period, shows a steady increase in these parameters in the period 2021-2030. The growing stock increases from 352 to 371 Mio m^3 in the commitment period, while the increment increases from 8 to 9 Mio m^3 (Table 14).

Table 14: Development of growing stock, increment and drain from 2021 to 2030

In 1,000 m^3	2021	2025	2030
Growing stock	352,488	361,170	371,588
Increment	8,581	8,793	9,045
Drain	6,861	7,148	7,499
Harvest	6,156	6,426	6,756
Mortality	705	722	743

The simulation of carbon stock changes in above-ground living biomass provides a net sink on managed forest land with average values of -2,119 kt CO_2 and -2,026 kt CO_2 in the periods 2021-2025 and 2026-2030, respectively (Fig. 4).

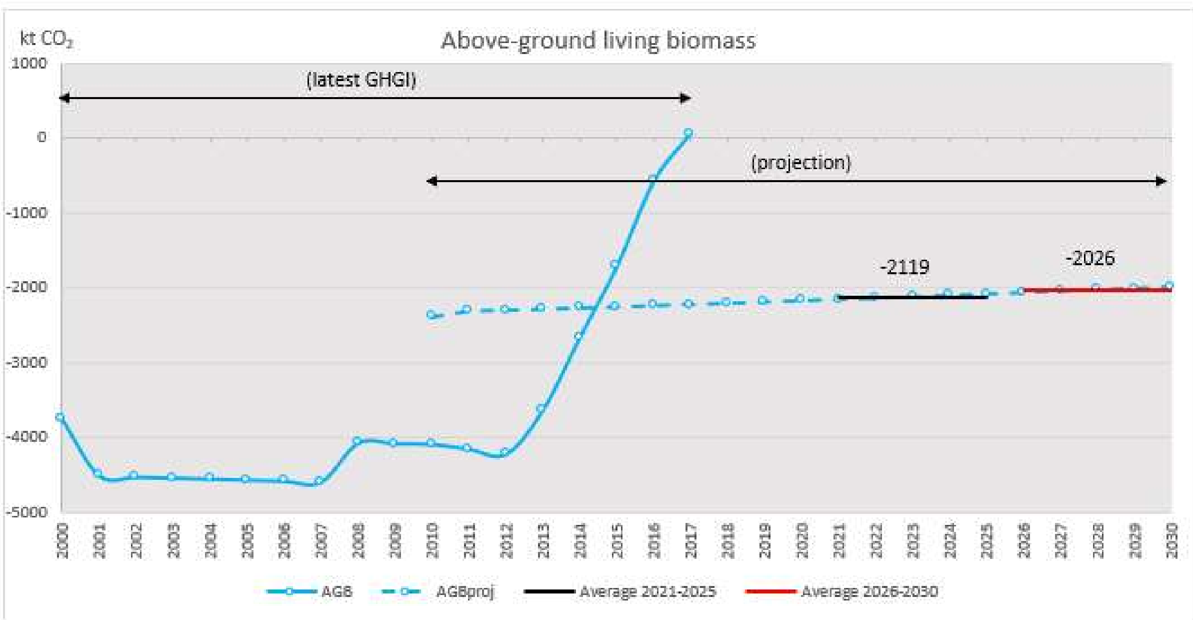

Figure 4: Net emissions in above-ground living biomass on managed forest land

The average removals due to below-ground biomass growth amounts to -486 kt CO_2 in the period 2021-2025 and -431 kt CO_2 in the period 2026-2030 (Fig. 5).

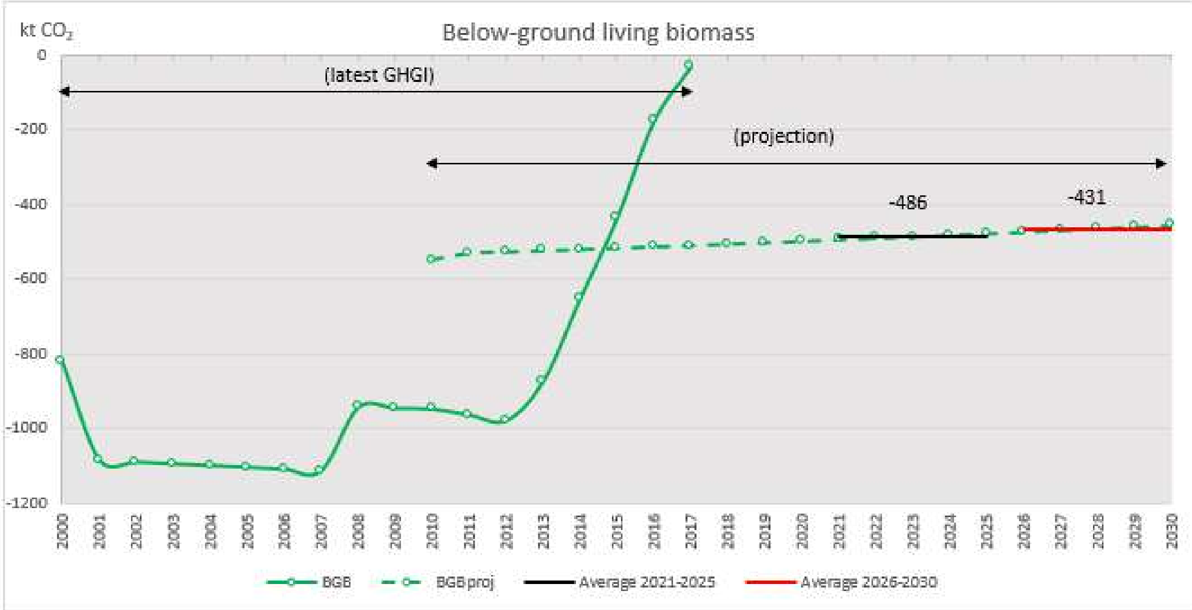

Figure 5: Net emissions in below-ground living biomass on managed forest land

In the period 2021-2030, the average net emissions as a result of carbon stock changes in dead wood are included in the FRL as the average value from the reference period and amount to -294 kt CO2 (Fig. 6). In recent years, the increased amount of dead wood, particularly in the form of standing dead trees, is the result of natural disturbances such as ice damage and bark beetle outbreaks that caused higher natural mortality.

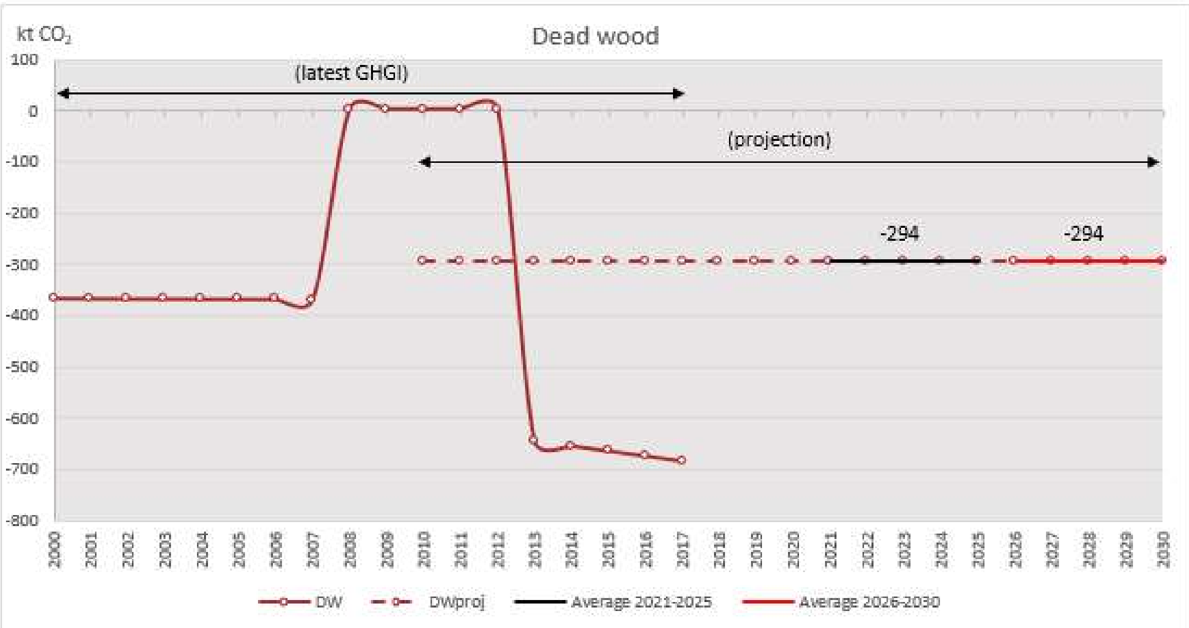

Figure 6: Net emissions from dead wood on managed forest land

Figure 7: Net emissions from HWP on managed forest land

Net emissions from harvested wood products show a slightly increasing trend over the commitment period (Fig. 7). The level of net emissions from HWP is relatively high for Slovenia, which is due to the application of the constant ratio of the products to harvested volume expected in the period 2021-2030.

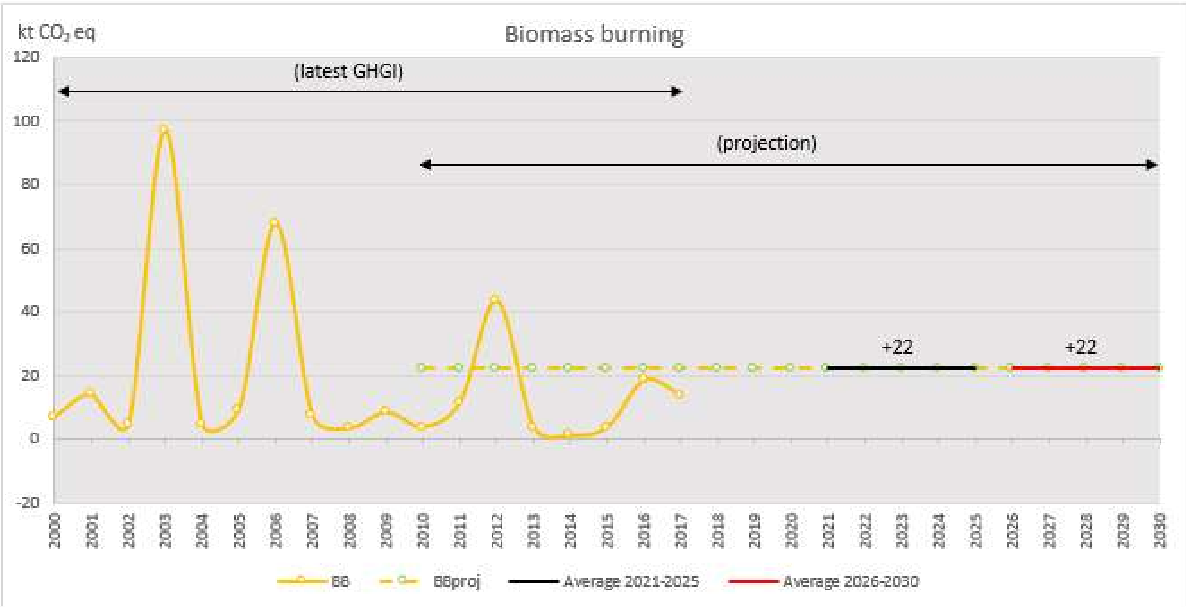

Figure 8: Net emissions from biomass burning due to wildfires on managed forest land

Emissions from biomass burning due to wildfires in forests, including CH_4 and N_2O, are projected as the average value of those emissions from the reference period (Fig. 8). During this period, the majority of forest fires occurred in the south-western part of Slovenia (Sežana region), with the largest forest fire event (Sela na Krasu in 2003) affecting an area of 1,593 ha.

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

The model used to construct the FRL was validated and compared to historical data that were reported under the national GHG inventory. The ability of the model to reproduce historical data in the period 2000-2018 is demonstrated in Figure 9. The comparison between the 2000, 2007 and 2012 NFI and the model used to construct the FRL shows high consistency between the measured and modelled values of growing stock for the period 2000-2012 (reference period). The Student's t-test showed no significant difference between those two data sets (P=0.75). After 2012, the modelled values differ from the NFI data for 2018. This is expected since the forest management policy changed. Annual harvest intensity increased (ReNFP, 2007) to 75% of the annual increment, and there were large policy interventions in the forestry sector (see Chapter 2.3.1.).

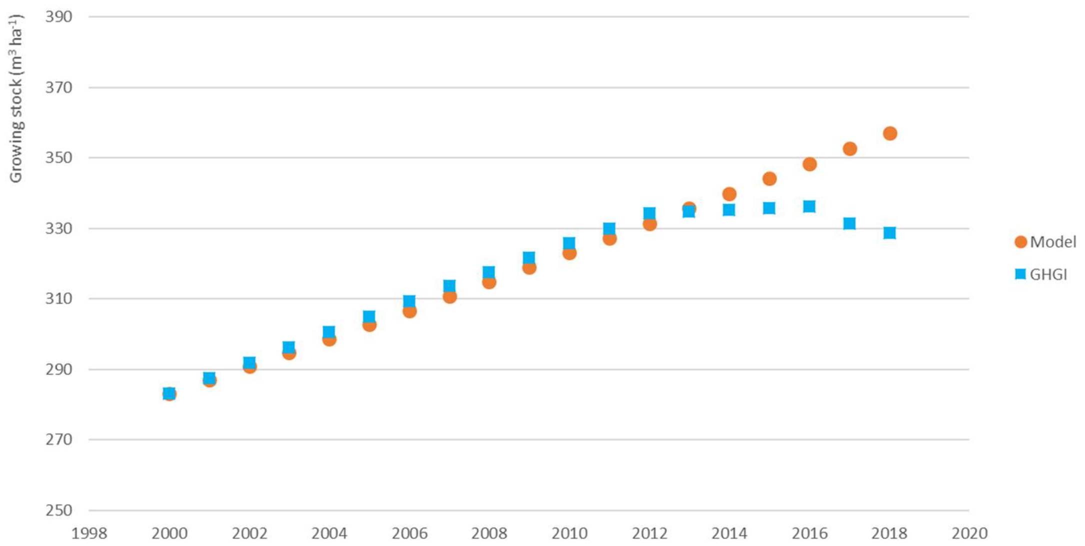

Figure 9: Comparison between modelled growing stock and growing stock used in the calculation in the latest GHG inventory

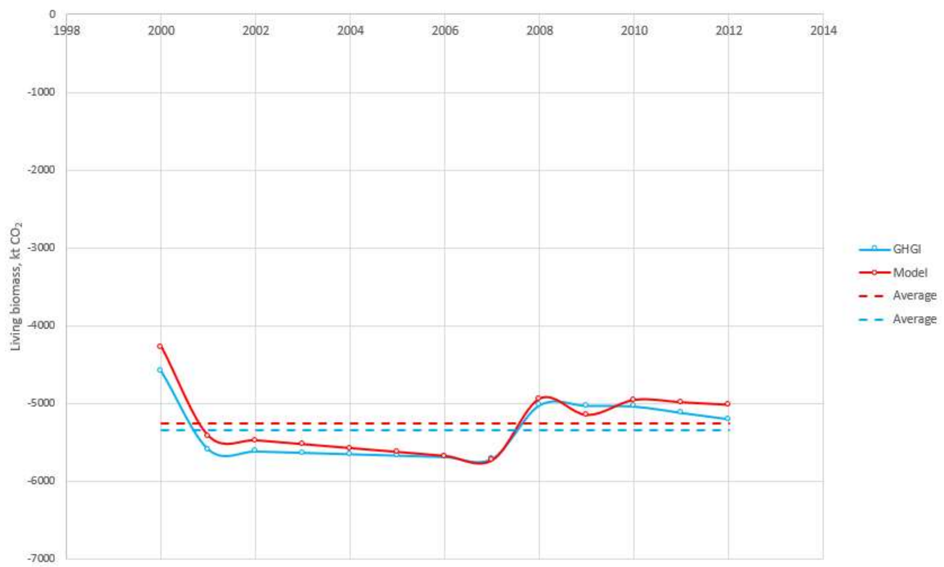

Figure 10: Consistency in the trend of net emissions between the model and historical data for the period 2000-2012

Furthermore, on the basis of the modelled growing stock, the carbon stock changes were calculated using the same factors that are used in the GHG inventory. The calculation indicates the ability of the model to reproduce the historical data from the national GHG inventory as shown (Fig. 10). The modelled values showed a consistent trend with the historical data over the period 2000-2012.

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

The forest reference level including harvested wood products for Slovenia in the period 2021-2025 is -3,270.2 kt CO_2. The forest reference level excluding the harvested wood products is -2,876.7 kt CO_2 (Table 15).

Table 15: Net emissions included in the forest reference level in the period 2021 to 2025

Carbon pool	2021	2022	2023	2024	2025	Mean
Above-ground biomass	-2,155.0	-2,137.4	-2,119.5	-2,101.3	-2,082.8	-2,119.2
Below-ground biomass	-494.1	-490.1	-486.0	-481.8	-477.6	-485.9
Dead wood	-293.9	-293.9	-293.9	-293.9	-293.9	-293.9
Harvested wood products (HWP)	-393.2	-392.4	-392.7	-393.8	-395.4	-393.5
Biomass burning	22.3	22.3	22.3	22.3	22.3	22.3
FRL (incl. HWP)	**-3,313.9**	**-3,291.5**	**-3,269.8**	**-3,248.5**	**-3,227.4**	**-3,270.2**
FRL (instantaneous oxidation)	**-2,920.7**	**-2,899.1**	**-2,877.0**	**-2,854.6**	**-2,831.9**	**-2,876.7**

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6 ANNEXES

Annex 1: Data on growing stock in 2000 and annual harvest in the period 2000-2009

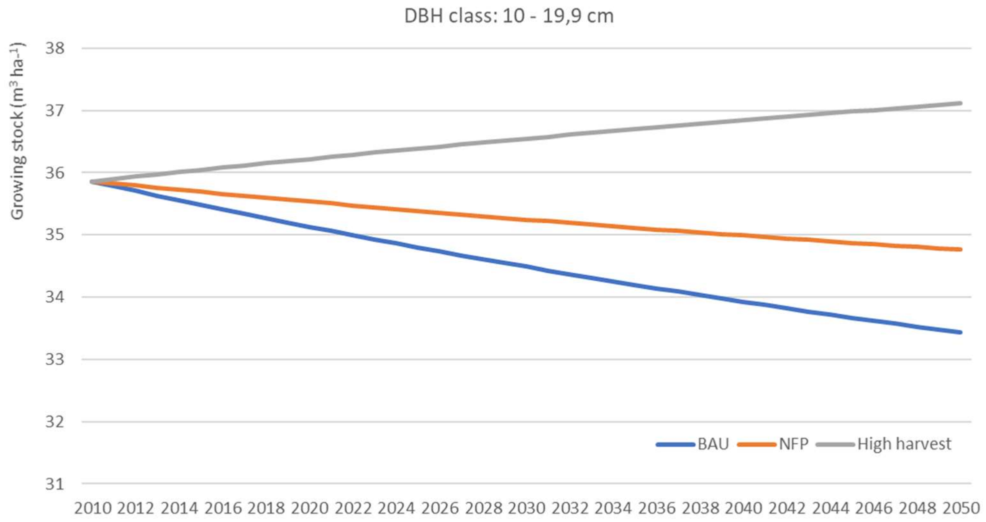
Growing stock (m³) in 2000

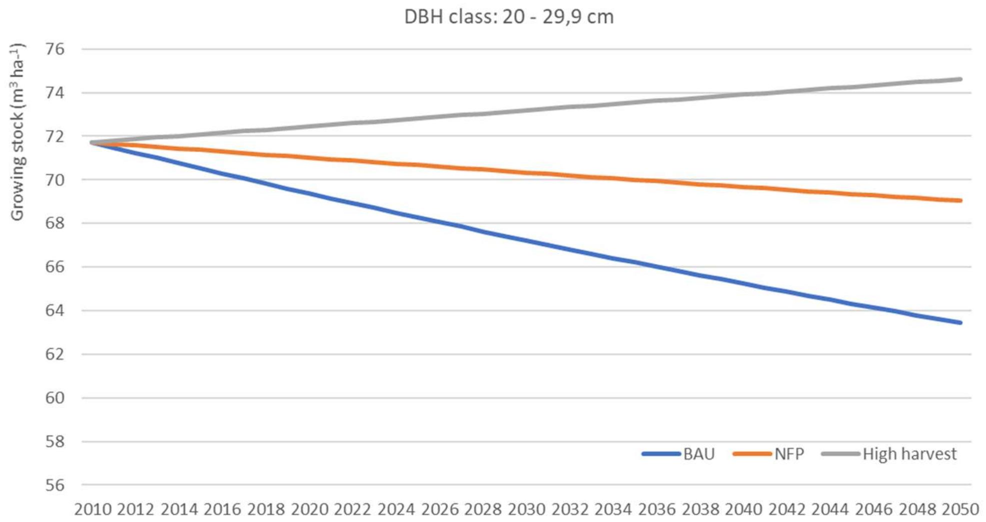
STRATUM	DS	10-19.9 cm	20-29.9 cm	30-39.9 cm	40-49.9 cm	50+ cm	Total
MFL 1	Conifers	106,475	223,037	276,504	226,142	137,785	969,944
MFL 1	Broadleaves	459,106	831,470	516,685	375,303	392,431	2,574,996
MFL 1	All	565,581	1,054,508	793,190	601,445	530,217	3,544,940
MFL 2	Conifers	510,446	924,513	912,797	697,562	415,782	3,461,100
MFL 2	Broadleaves	905,498	1,683,474	965,985	749,588	565,803	4,870,348
MFL 2	All	1,415,944	2,607,988	1,878,782	1,447,150	981,584	8,331,448
MFL 3	Conifers	3,105,076	6,474,818	8,050,625	6,330,818	3,953,904	27,915,242
MFL 3	Broadleaves	7,278,194	15,607,361	9,867,445	8,784,448	4,191,487	45,728,935
MFL 3	All	10,383,270	22,082,179	17,918,070	15,115,266	8,145,392	73,644,177
MFL 4	Conifers	4,984,990	10,433,843	16,229,726	13,170,480	5,762,913	50,581,951
MFL 4	Broadleaves	7,599,619	15,459,173	9,582,975	8,857,442	4,271,719	45,770,928
MFL 4	All	12,584,609	25,893,015	25,812,701	22,027,922	10,034,632	96,352,880
MFL 5	Conifers	2,141,553	4,664,176	6,769,099	7,275,093	7,643,731	28,493,653
MFL 5	Broadleaves	1,883,080	3,723,144	2,682,559	3,154,054	1,651,223	13,094,061
MFL 5	All	4,024,633	8,387,320	9,451,658	10,429,148	9,294,953	41,587,713
MFL 6	Conifers	1,829,840	2,881,652	2,809,678	1,809,350	699,120	10,029,642
MFL 6	Broadleaves	4,144,284	6,481,658	1,979,568	1,348,349	551,101	14,504,960
MFL 6	All	5,974,124	9,363,310	4,789,247	3,157,699	1,250,221	24,534,602
MFL 7	Conifers	1,189,205	2,494,164	4,911,360	5,183,480	3,434,957	17,213,166
MFL 7	Broadleaves	266,507	646,134	553,298	634,713	230,332	2,330,984
MFL 7	All	1,455,713	3,140,298	5,464,658	5,818,192	3,665,289	19,544,151
MLF8	Conifers	1,063,852	1,757,971	2,086,604	1,431,937	1,076,885	7,417,250
MLF8	Broadleaves	2,038,774	3,359,701	1,795,491	1,317,085	556,250	9,067,301
MLF8	All	3,102,626	5,117,672	3,882,095	2,749,022	1,633,135	16,484,550
SI	Conifers	14,892,797	29,892,817	42,671,215	35,500,042	23,125,078	146,081,948
SI	Broadleaves	24,103,610	48,263,566	26,929,968	26,235,022	12,410,346	137,942,512
SI	All	38,996,407	78,156,383	69,601,182	61,735,064	35,535,424	284,024,460

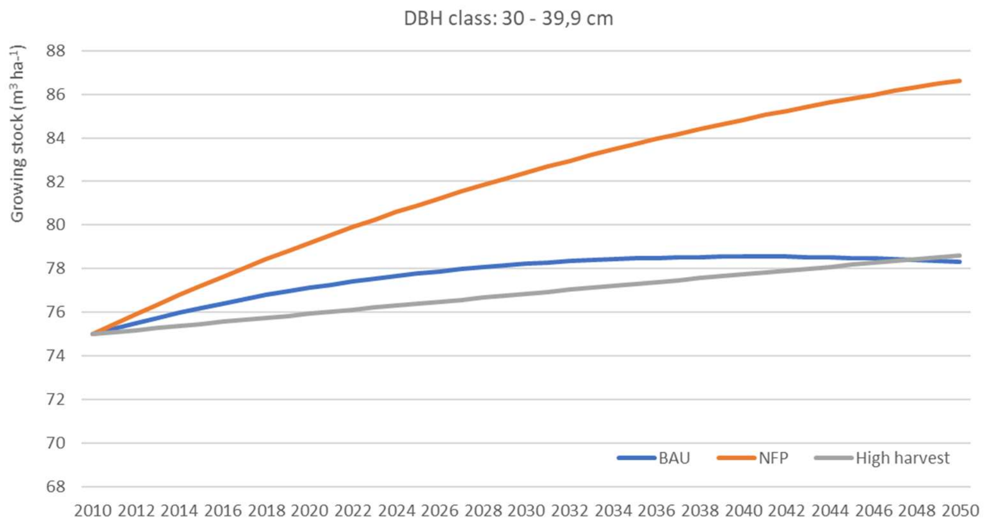
Harvest ($m^3\ y^{-1}$) in the period 2000-2009

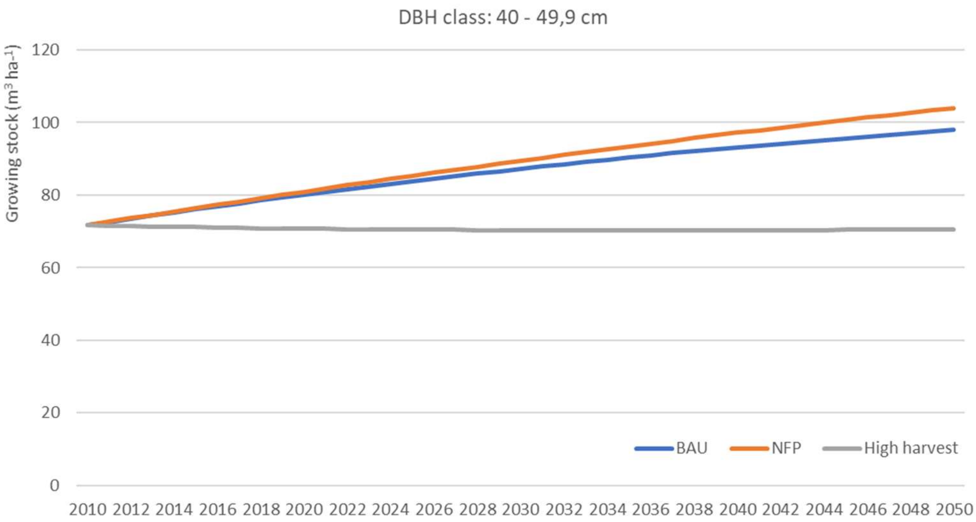
STRATUM	DS	10-19.9 cm	20-29.9 cm	30-39.9 cm	40-49.9 cm	50+ cm	Total
MFL 1	Conifers	988	3,529	5,503	5,220	3,512	18,752
MFL 1	Broadleaves	3,555	9,054	10,820	8,536	11,336	43,300
MFL 1	All	4,543	12,583	16,322	13,756	14,848	62,052
MFL 2	Conifers	7,125	23,455	41,918	40,209	33,805	146,512
MFL 2	Broadleaves	11,688	26,015	29,778	26,707	21,398	115,586
MFL 2	All	18,814	49,471	71,696	66,916	55,202	262,099
MFL 3	Conifers	20,610	62,373	120,110	128,552	141,877	473,522
MFL 3	Broadleaves	50,256	117,199	148,678	147,785	164,351	628,269
MFL 3	All	70,866	179,572	268,788	276,336	306,228	1,101,791
MFL 4	Conifers	25,081	82,055	159,896	173,337	169,241	609,610
MFL 4	Broadleaves	31,345	82,345	102,237	93,572	94,183	403,682
MFL 4	All	56,426	164,400	262,133	266,909	263,423	1,013,292
MFL 5	Conifers	24,846	51,782	105,051	167,778	357,013	706,469
MFL 5	Broadleaves	23,703	41,436	49,330	62,089	108,260	284,819
MFL 5	All	48,549	93,218	154,381	229,867	465,273	991,287
MFL 6	Conifers	8,666	18,904	27,211	21,087	14,325	90,192
MFL 6	Broadleaves	17,502	17,860	14,544	11,685	9,182	70,774
MFL 6	All	26,168	36,764	41,755	32,772	23,507	160,966
MFL 7	Conifers	10,454	26,538	50,636	68,481	99,719	255,829
MFL 7	Broadleaves	2,837	5,687	7,440	7,784	9,654	33,403
MFL 7	All	13,292	32,225	58,076	76,265	109,374	289,232
MLF8	Conifers	959	3,190	5,381	5,426	5,520	20,476
MLF8	Broadleaves	2,894	6,579	8,763	8,702	14,015	40,951
MLF8	All	3,853	9,769	14,143	14,128	19,535	61,428
SI	Conifers	98,729	271,826	515,705	610,090	825,012	2,321,362
SI	Broadleaves	143,780	306,176	371,589	366,860	432,378	1,620,783
SI	All	242,510	578,001	887,294	976,950	1,257,390	3,942,146

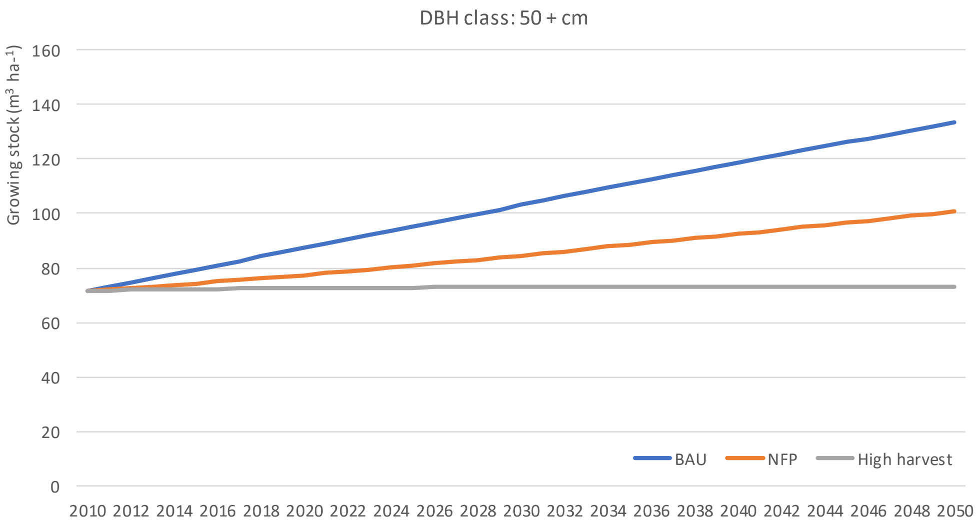
Annex 2: Development of age/diameter structure of the forest in the period 2010-2050 under different policy scenarios.








DBH class: 40 - 49,9 cm
Growing stock (m³ ha⁻¹)
0
20
40
60
80
100
120
BAU
NFP
High harvest
2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038 2040 2042 2044 2046 2048 2050


DBH class: 50 + cm
Growing stock (m³ ha⁻¹)
0
20
40
60
80
100
120
140
160
BAU
NFP
High harvest
2010 2012 2014 2016 2018 2020 2022 2024 2026 2028 2030 2032 2034 2036 2038 2040 2042 2044 2046 2048 2050

Annex 3: Data on historical and future HWP inflows and outflows

Year	SAWNWOOD Inflow (kt C)	WBP Inflow (kt C)	PAPER Inflow (kt C)	HWP TOTAL Inflow (kt C)	HWP TOTAL Outflow (kt C)	Stock change (kt C)
1986	222.8	41.8	37.1	301.7	183.0	118.7
1987	215.7	47.9	44.0	307.6	188.1	119.6
1988	210.3	48.0	42.8	301.0	193.0	108.0
1989	190.0	51.4	39.8	281.2	196.3	85.0
1990	152.0	31.9	27.1	211.0	196.0	15.0
1991	129.9	29.6	19.4	179.0	192.3	-13.3
1992	128.0	24.1	14.3	166.4	187.6	-21.2
1993	117.1	26.5	10.0	153.5	182.7	-29.2
1994	121.8	28.7	12.2	162.7	178.9	-16.2
1995	120.3	30.1	17.3	167.7	177.3	-9.7
1996	141.8	29.1	16.4	187.2	177.0	10.3
1997	118.3	28.3	22.2	168.9	177.5	-8.6
1998	138.5	34.1	23.1	195.7	178.8	16.9
1999	131.6	30.6	25.8	188.0	180.5	7.5
2000	143.8	32.2	26.7	202.6	182.2	20.4
2001	140.9	35.2	26.1	202.2	183.7	18.5
2002	143.3	37.7	27.0	208.0	185.0	23.0
2003	159.7	32.9	27.1	219.7	186.3	33.3
2004	167.0	34.1	27.4	228.5	187.7	40.8
2005	174.2	32.2	30.4	236.7	189.5	47.2
2006	193.3	34.6	17.4	245.3	189.7	55.6
2007	206.9	48.9	11.6	267.5	188.0	79.5
2008	187.2	47.2	11.3	245.8	186.5	59.3
2009	175.4	44.7	11.3	231.5	185.5	46.0
2010	161.8	39.5	12.9	214.3	185.0	29.3
2011	149.8	43.7	8.5	202.0	184.2	17.8
2012	145.1	45.6	8.2	199.0	183.1	15.9
2013	142.0	39.6	6.2	187.8	182.0	5.8
2014	147.8	49.1	16.1	212.9	182.6	30.3
2015	154.1	48.2	17.0	219.3	184.9	34.4
2016	154.3	42.1	18.1	214.5	187.0	27.5
2017	155.5	41.3	13.4	210.1	188.0	22.1
2018	223.9	50.3	28.6	302.8	191.4	111.4
2019	226.5	50.8	29.0	306.3	197.1	109.2
2020	229.1	51.4	29.3	309.8	201.9	107.9
2021	231.6	52.0	29.6	313.2	206.0	107.2
2022	234.2	52.6	29.9	316.7	209.7	107.0
2023	236.7	53.1	30.3	320.1	213.0	107.1
2024	239.3	53.7	30.6	323.6	216.2	107.4
2025	241.8	54.3	30.9	327.0	219.1	107.8
2026	244.3	54.8	31.2	330.4	222.0	108.4
2027	246.8	55.4	31.6	333.7	224.8	108.9
2028	249.3	55.9	31.9	337.1	227.6	109.6
2029	251.8	56.5	32.2	340.5	230.3	110.2
2030	254.2	57.1	32.5	343.8	233.0	110.8