Bundesministerium
Nachhaltigkeit und
Tourismus

# National Forestry Accounting Plan for Austria

Submission in accordance to the EU LULUCF Regulation
(Regulation (EU) 2018/841)

Vienna, 2018

# Content

# 1. General Introduction

## 1.1 General description of the forest reference level for Austria

The forest reference level proposed by Austria consists of the following mean values for the periods 2021-2025 and 2026-2030:

| C-pool | Mean 2021-2025 (Gg $CO_2$) | Mean 2026-2030 (Gg $CO_2$) |
|---|---|---|
| Above ground biomass | -3,217 | -2,115 |
| Below ground biomass | -171 | 87 |
| Deadwood | -207 | -237 |
| Litter + Soil C | 2,128 | 2,128 |
| HWP | -3,196 | -2,989 |
| **FRL (instantaneous oxidation)** | **-1,467** | **-137** |
| **FRL (incl. HWPs)** | **-4,663** | **-3,126** |

*Table 1: Mean values of $CO_2$ sinks (-) and $CO_2$ sources (+) for the projected periods 2021-2025 and 2026-2030 for the five carbon pools, the HWPs and the FRL*

Austria intends to make use of the provisions of Article 10 (Accounting for natural disturbances) of the LULUCF regulation[1], as applicable, and will provide information as requested under Article 10 (2) of the LULUCF regulation as soon as data for the period 2001 to 2020 is available.

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

Consideration of Annex IV A. Criteria and guidance for determining forest reference level

*(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*

[1] 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 Austrian FRL represents a sink in both periods, 2021 to 2025 and 2026 to 2030. In line with the LULUCF regulation, the Austrian FRL was derived by applying the concept of sustainable forest management for the reference period 2000 to 2009 in the respective accounting period. The management in the reference period ensured an overall sink of the considered pools of Managed Forest Land and Harvested Wood Products in Austria. Consequently, the Austrian Forest Reference Level defines a baseline which represents net sinks for Managed Forest Land and Harvested Wood Products for the commitment periods 2021 to 2025 and 2026 to 2030 (chapter 4.1).

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

The methodology for calculating the Austrian FRL is not based on an estimation of carbon stocks, but on carbon stock changes of the pools (chapters 3.1, 3.3, 4.1).

*(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 Austrian FRL is calculated in accordance with the methodologies laid down in the LULUCF regulation.

*(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 Austrian FRL includes the carbon pool of HWPs on basis of instantaneous oxidation and on basis of the first-order decay function and half-life values as defined in the LULUCF regulation (chapters 1.1, 3.3.3).

*(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 changes of the carbon pool of HWPs during the periods 2021 to 2025 and 2026 to 2030 of the Austrian FRL were estimated on basis of a constant ratio between solid and energy use of forest biomass as documented in the reference period from 2000 to 2009 (chapters 3.3.3).

*(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*

For more than 100 years sustainable management has been integrated in a well-established legal institutional and economic framework. A range of regulatory and economic instruments exists to safeguard a sustainable management, conservation and development of forest ecosystems. These are supported by manifold educational and informational measures.

The overall principles of the Forest Act (Federal Law Gazette I Nr. 1975/440, as amended), which are stipulated in § 1, are the preservation of forest area, the preservation of the productivity of forest sites and their functions, and the preservation of yields for future generations; i.e. sustainable management (chapter 2.3.1).

These principles guide any forest management activity undertaken in Austria, including during the reference period 2000 – 2009 and are an integral part of the calculation of the FRL, to appropriately represent a continuation of the long-standing Austrian tradition of managing forests in a sustainable way.

The FRL indicates a further increase of the standing stock in the Austrian forests in the FRL periods. The modeling simulated the replanting of the same species as being harvested. This ensures the sustainability of the existing tree species diversity in the Austrian forests. Single tree harvests were simulated to continue in the uneven aged forests, by that diverse forest structures are maintained. The FRL simulations suggest a further increase in the dead wood stock in the Austrian forests. All simulated management operations into account took the local situation at the NFI plots, e.g. adequate, reduced or no harvest in the various protected forest areas and appropriate management in protective forests at exposed terrain.

*(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 FRL is estimated on the same data (e.g. NFI, BEF,...) and tools which are also applied for the national projections of anthropogenic greenhouse gas emissions. Nevertheless, there are substantial differences in the framework conditions established in the LULUCF regulation, compared to those used for calculating projections, e.g. for estimating the changes in the HWP pool (constant ratio between solid and energy use) or in the calculation of the FRL (being based on the period 2000 to 2009)

The purpose of the projections is to integrate all potential influences on the forest management, particularly changes in the existing economic and political framework conditions for forest management, changes in wood demand and use, e.g. by an additional integration of an economic forest and wood market model.

Therefore, the tools applied and basic input data are the same in both, the FRL and the national projections, however the result differ.

*(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 Austrian FRL is fully consistent with the Austrian GHG inventory (chapters 2.1, 2.2, 4.2). The FRL is therefore complete (including all pools and areas, exactly as for the Austrian GHG inventory), consistent (using same input data, approaches and tools as for the GHG inventory) and thereby comparable to the results of the GHG inventory. The estimates were carried out with tools ensuring the highest possible accuracy and by applying QC steps similar to those for the Austrian GHG inventory. Technical corrections will be applied to match the GHG inventory estimates with the FRL approaches (chapter 4.2.1).

*Table 2: Equivalence table for the inclusion of the Annex IV B. elements in the Austrian NFAP report*x IV B.

| **Annex IV B. paragraph item** | **Elements of the national forestry accounting plan according to Annex IV B.** | **Chapter in the NFAP** |
|---|---|---|
| (a) | A general description of the determination of the forest reference level | 3 |
| (a) | Description of how the criteria in LULUCF Regulation were taken into account | 1.2 |
| (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 | NA |

| | | |
|---|---|---|
| (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 | 2.3.1, 3.2.1.2 |
| (c) | A description of adopted national policies | 3.2.1.2 |
| (d) | Information on how harvesting rates are expected to develop under different policy scenarios | 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 | 3.1 |
| (ii) | Emissions and removals from forests and harvested wood products as shown in greenhouse gas inventories and relevant historical data | 3, 0 |
| (iii) | Forest characteristics, including:<br>- dynamic age-related forest characteristics<br>- increments<br>- rotation length and<br>- other information on forest management activities under 'business as usual' | 3 |
| (iv) | Historical and future harvesting rates disaggregated between energy and non-energy uses | 4.1.5 |

# 2. Preamble for the forest reference level

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

The Austrian FRL includes all pools (aboveground and belowground biomass, dead wood, litter, soil, harvested wood products) and greenhouse gases, consistent with the Austrian GHG inventory. No carbon pool was omitted in the estimates of the FRL.

Carbon stock changes of the Austrian forests not in yield are neither yet estimated in the Austrian GHG inventory nor included in the FRL.

Any future reporting in the GHG inventory and inclusion in the Austrian FRL will be considered after finalization of the currently NFI-cycle (see chapter 4.2.1).

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

All carbon pools of the FRL are consistent to the ones in the Austrian GHG inventory. The applied methods are the same as for the Austrian GHG inventory or - in case of modeling vs. measured historic values – the models are based on and calibrated by the input data from the Austrian NFIs (since 1981) and are able to reconstruct historic results (see chapters 3.1, 4.2).

Two important deviations between FRL and values reported in the GHG inventory exist which will very likely require future technical corrections of the FRL (see chapter 4.2.1):

- The FRL is estimated for a constant forest area in yield and for the forest management at these areas as assessed by the last NFI 2007/09. This includes also the impacts from afforestation and deforestation. The FRL will need to be adjusted for these afforestation and deforestation impacts and the changing managed forest land area once the related parameters were measured for the first commitment period (after 2025).
- The litter and soil modeling of the FRL is based on a new YASSO model version while the historic values of the GHG inventory were estimated with the previous model version. Therefore, the historic time series in the GHG inventory needs to be recalculated with the new YASSO model version, and in case of changes in the historic results also a further modeling of the time series into the FRL periods will be implemented to ensure consistency of the FRL with the historic time series.

## 2.3 Description of the long-term forest strategy

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

Austria is one of the most densely forested countries in Europe with forests covering 48 % of the federal territory. Ever since the beginning of the Austrian Forest Inventory in 1961 a continuous increase in forest cover has been observed in Austria (by almost 300 000 hectares to date). Austrian forests have been a significant net carbon sink since the start of the NFIs in 1960 (Umweltbundesamt 2000, 2018), the standing stock has steadily increased (not only due to forest area increase but also on a per-ha basis) (BFW 2011). The Austrian forests have a high share of coniferous trees with more than 70 %, most of them spruce. Broadleaved wood covers about one quarter of forest area with increasing tendency. The share of mixed forests was increasing according to the last NFIs (improving resilience against climate change).

Typically for a Central European Alpine country, Austria has a high variety of climatic, site and growth conditions, and consequently a large number of forest communities and tree species. The forest ownership structure is also rather diverse, with a majority of the forests in private hands, some big forest enterprises, but about half of the forest area represents small scale ownerships which do not live by their forest. The varying conditions according to the Alpine landscape further diversify the management and harvest conditions in technical and economic sense. All these impacts lead to a combination of various practical forest management practices which cannot be described by strict management regimes but with probabilities of certain interventions in the forests due to the combination of framework conditions at the simulated plot and intervention probabilities as observed in the past. The Austrian FRL simulation and modeling fully reflects this broad range of forest management in Austria, specifically on basis of the observed results in the NFI period 2007/09. Consequently, there are no schemes of forest management of certain forest strata and conditions but a large variety of combinations depending on the growth conditions, species combination, stemwood dimensions and assortments, (economic) conditions for harvest and wood extraction, specific non-economic forest functions (e.g. protective and protected forests), ownership specifics among several other influences. Consequently, each simulated NFI plot and assessed tree for the FRL is treated individually following a hierarchic list of model components and decision trees as well as intervention probabilities as observed in the reference period 2000 to 2009 (the approach is described in detail in chapter 3). This implies that policies and measures are only indirectly effecting the simulation of the Austrian FRL, namely as far as they are reflected in the results and forest management as detected for the period 2000 to 2009. Of course, the results for this period as well as the FRL are impacted by and follow the regulatory framework conditions for forest management as laid down in the Austrian Forest Act.

Sustainable forest management has been a guiding principle of Austrian forest management policy for more than 100 years, balancing the relevant ecological, economic and social functions. Austrian forest management mainly focuses on the targets to maintain biodiversity, productivity, regeneration capacity and vitality of forests and to improve adaptation to changing – specifically climatic – conditions. A range of regulatory, financial and informational tools are being applied to safeguard a sustainable management, conservation and development of the forests. Principles of forest management in Austria and specific provisions are stipulated in the Forest Act (Federal Law Gazette I No. 1975/440, as amended), e.g. general bans on forest clearcuts/deforestation and on forest destruction, requirements for reforestation after fellings, sustaining forest (soil) productivity, specific protection and management measures against pests and other disturbances, restrictions on forest litter removal, provisions on harvest, haulage and forest protection. In order to balance the various interests in forest use and to assure the many benefits of the Austrian forest in the long term, the Federal Minister of Agriculture, Forestry, Environment and Water Management has adopted the Austrian Forest Program in 2005 and the Austrian Forest Strategy 2020+ in (2016). The strategy was jointly developed by 85 institutions involved in forest policy within the scope of the Austrian Forest Dialogue, its primary objective is to ensure and optimize all dimensions of sustainable forest management in a balanced way, paying special attention to the added value and the potential of the Austrian forestry and timber sectors. The strategy should help ensure the multifunctional services that forests render for present and future generations.

Both the Austrian Forest Strategy 2020+ and also the Austrian Climate and Energy Strategy, #mission 2030 (2018) emphasize the importance of a sustainable forest management strategy. The land use related policies and measures identified in the #mission 2030 should help to achieve the target for 2030 as defined in Article 4 of the LULUCF Regulation, in particular through

- continuously increasing tree growth and timber harvesting in Austrian forests on the basis of sustainable forest management, with the aim of increasing carbon storage in forests and harvested wood products in the long term and
- increasing the use of domestic timber in construction and utilizing the manifold opportunities of the bio-economy

The draft "Integrated National Energy and Climate Plan" for Austria which has been submitted end of 2018 to the European Commission is based on the policies and measures laid down in the #mission 2030 and other related domestic strategies.

The Austrian Program for Rural Development 2014-2020 also provides for support measures, e.g. for preventive action to protect forests from forest fires and natural disasters as well as to restore forest ecosystems after those events, and for increasing the resilience of forest ecosystems. The EU agricultural policy post-2020 should be developed with a view to support EUs environmental and climate policy.

Further details can be found in Austria’s Forest Report 2015 (BMLFUW 2015), Austria’s Seventh National Communication (2018) and in the Progress Report on LULUCF Actions Austria (BMLFUW 2016).

### 2.3.2 Description of future harvesting rates under different policy scenarios

Recently, a project was finalized which simulated the C stock changes in the Austrian forests and harvested wood products pools as well as the avoided emissions until 2100 due to the use of wood products instead of products based on substitute materials (Braun et al. 2016). Five scenarios were defined and estimated:

a. a reference scenario representing " business as usual",
b. a scenario simulating an increase of the demand of wood for energy by 20 % until 2100,
c. a scenario simulating an increase of the demand for solid wood use by 20 % until 2100,
d. a variant of scenario c above, with more optimistic wood import conditions and
e. a scenario simulating a moderate increase in standing stocks due to a further increase in protected areas.

All scenarios demonstrated the positive impact of wood products on the Austrian GHG balance, particularly by avoiding GHG emissions from products with a higher carbon footprint. The accumulated GHG savings of the reference scenario for a period of 90 years until 2100 equal 20 times the total annual GHG emissions of Austria. The results of the scenarios with increased wood demand showed slightly lower GHG benefits than the reference scenario. This is caused by an increase in harvest rates above the increments, which resulted in a decrease in forest biomass stocks (=a net-source). Despite the forests becoming a net-source, these scenarios also showed a very positive overall GHG saving benefits in the same order of magnitude than the reference scenario. The scenario simulating a moderate (half as high) carbon stock increase in forests (compared to historic years) due to a further increase in protected areas and a corresponding reduction in harvest rates, showed the highest overall results until 2100. These higher GHG benefits were only partly based on the carbon stock increases in the forests, but influenced by a rather constant wood extraction for sawnwood production, which allowed maintaining the GHG saving effects of wood products at a high level.

It should be noted that the better GHG result of scenario e requires a higher share of substitute products from other – mostly fossil based – materials to maintain the product service as indicated by the reference scenario.

The study shows the massive GHG benefits of the whole Austrian forest and wood chain, comprising the forest carbon stocks as well as the material and energy use, under different management scenarios. Each element of the wood chain (the forests, the HWP pool and the product substitution) contributes to the overall effect, with the product substitution (which influences the GHG balance of other sectors than LULUCF) providing by far the highest share.

# 3. Description of the modeling approach

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

The construction of the forest reference level is based on the following data sources and national modelling approaches:

- Field data from the Austrian National Forest Inventory (NFI, BFW 2011) including three full inventory cycles conducted in 1992/96, 2000/02 and 2007/09 covering the whole forest area of Austria.
- Results from projections for C-stock changes in biomass and deadwood for the two time periods 2021-2025 and 2026-2030 using the growth, harvest and mortality models implemented in the simulation program CALDIS-VB V0.1.
- Results from projections for C-stock changes in litter and soil for the two time periods 2021-2025 and 2026-2030 using the soil carbon model YASSO.
- Estimates for the HWP carbon pool changes as based on the future harvest for the two time periods 2021-2025 and 2026-2030 and the ratio of HWP production as documented for the reference period 2000 to 2009

Data from the Austrian National Forest Inventory (NFI) are available since the first inventory cycle conducted between 1961 and 1970. Further forest inventory cycles were carried out in the periods 1971–80, 1981–85, 1986–90, 1992–96, 2000–02 and 2007–09. The recent NFI started in 2016 and its assessment will be finished in 2021. The NFI of Austria is the main data provider for the greenhouse gas reporting of the forest land sector. Measured data for the forest area, stemwood volume increment and drain of the growing stock are the main basis for the fulfillment of the reporting obligations. The models used to construct the FRL are building upon the same data source for the reference period 2000-2009. The forest growth simulator CALDIS-VB V0.1 (LEDERMANN et al., 2017a) served as the basis for the calculation of the biomass increment, harvest and standing deadwood in accordance with the sustainable forest management practices as applied in the reference period 2000-2009. The model was set up on the most recent NFI data (2007/09) which covers results of the forest parameters (e.g. area, stock, increment, drain) for the observation period from NFI 2000/02 to NFI 2007/09 and consequently perfectly matches the reference period 2000 to 2009 for the FRL. Simulation runs were performed until 2030. Projected individual tree data were then aggregated to higher level information analogously to a NFI assessment. The projection of the FRL is based on the same climatic conditions as they had been observed in the reference period from 2000 to 2009. A more detailed description of the growth simulator CALDIS-VB V0.1 and its application can be found in chapter 6.2.3.

The litter and soil carbon stock changes were calculated with the YASSO model. The latest version that was available as an R script was used and was made available on request by the authors of the model (https://en.ilmatieteenlaitos.fi/yasso-description). The climate data for Yasso15 were extracted from the same data set as used in the forest growth model CALDIS-VB V0.1. The annual litterfall was calculated from the standing stock of stems by country and species specific biomass equations that have been used for the Austrian GHG inventory. The chemical quality of different types of the annual litterfall was derived from a database that is maintained by the user community of Yasso.

The area for managed forest land was kept constant at the level of 2009 and represents 3.366 Mio ha. This forest area represents solely the forests in yield because so far only for these forests carbon stock changes are reported in the Austrian GHG inventory. Carbon stock changes for the Austrian forests not in yield will be estimated after finalization of the recent NFI and reported in the GHG inventory and an adequate projection and adjustment for the FRL will be made then (chapter 4.2.1). Due to an implementation and simulation of exactly the same management practices of the reference period and revegetation measures with the same trees as harvested the area covered by deciduous trees increases from 27.7% (2010) to 29.2% (2030). Consequently the area of coniferous trees decreases from 72.3% (2010) auf 70.8% (2030). Please note: Although the revegetation is based on exactly the same trees as harvested throughout the simulation period a shift in the represented area of coniferous and deciduous occurs due to the differences in represented basal and crown cover areas between young and old trees (basal and crown cover areas represent the basis for estimating the area share of coniferous and deciduous trees).

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

#### 3.2.1.1 Documentation of stratification of the managed forest land

According to the most recent NFI in 2007/09 the area of managed forest land comprised 3.366 Mio ha. This area was kept constant during all simulation runs. For the renewal of a harvested forest stand, i.e. a NFI plot, exactly those tree species were considered which were present on the respective plot at beginning of the simulation runs. Due to the tree- and plot-level modeling approach, a stratification of the forest land according to forest type, fertility class, regions, soil types or climate zones is not adequate because each NFI-plot and tree is individually simulated and the individual-tree growth/harvest model CALDIS-VB V0.1 automatically considers the individual growth/yield and management circumstances at plot level and for each tree at the plot.

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

For the estimation of the forest reference level we developed a harvesting model based on the observed cuttings within the reference period 2000-2009. Representative data were available from the Austrian NFI 2000/02 and 2007/09. In order to consider the main management objectives in Austria, we developed two harvesting models, one for coppice forests and one for high forests. Each model consists of several sub-models (LOGIT-models) which have been developed in a hierarchical order. The LOGIT-models estimate a probability that a specific event – for example, a final cutting or the removal of a specific tree – will take place. The coefficients of the LOGIT-models were estimated via logistic regression from the data of the Austrian NFI. A graphical representation of the model concept is displayed in

Figure *1*. Predictor variables of the plot-level models are: mean and maximum diameter (dbh), mean and maximum tree height, stand basal area per hectare, percent share of conifers, ownership, logging distance (to the nearest forest road), slope and relief. Predictor variables of the tree-level models are: tree species, tree height, dbh and mean dbh, stand basal area per hectare, relief, ownership and logging distance. The harvesting model mimics the behavior of the forest owners and forest managers within the reference period from 2000 to 2009. It is well behaved and shows an excellent fit between the observed and predicted removals with regard to dbh-classes (see Figure 2), deciduous/conifers (see Figure 3) and thinning/final cutting (see Figure 4). Consistency between the modelled harvest and the harvest behavior in the reference period is demonstrated in that way.

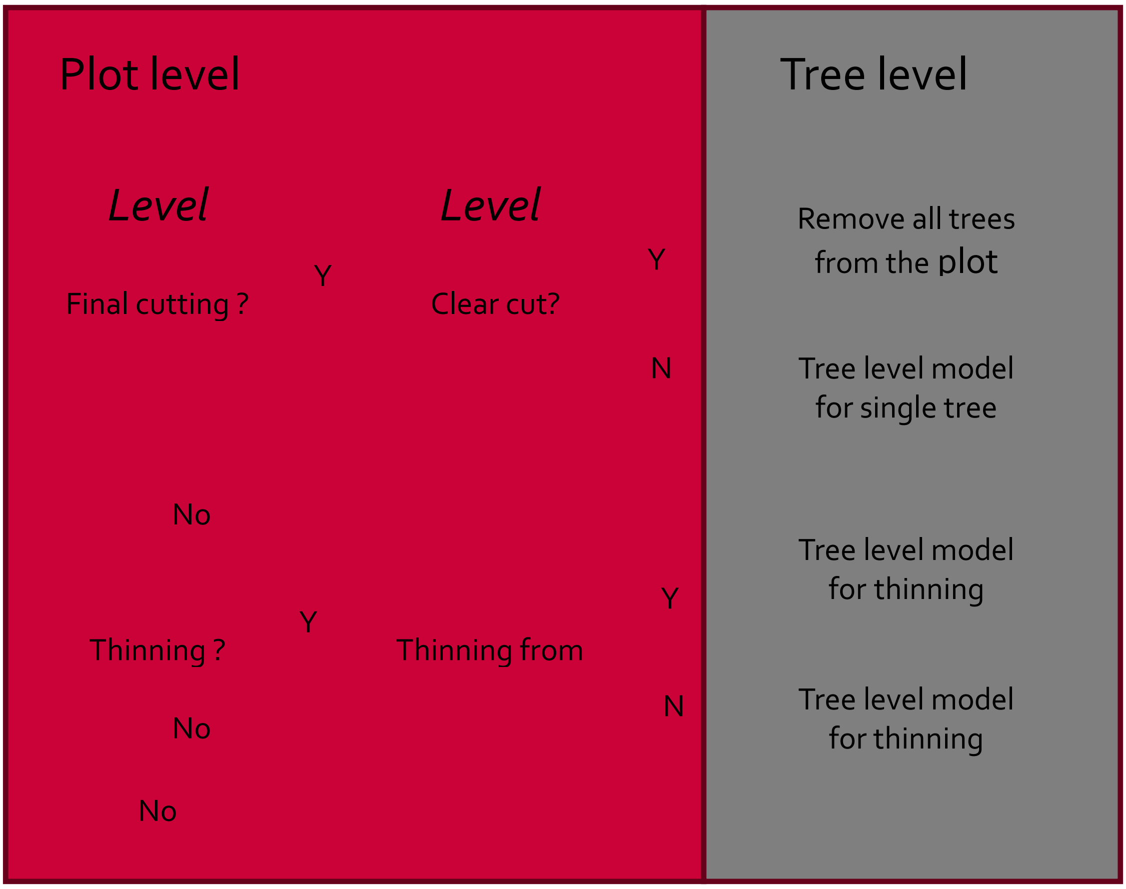


*Figure 1 : Flow chart for the application of the newly developed harvesting model*

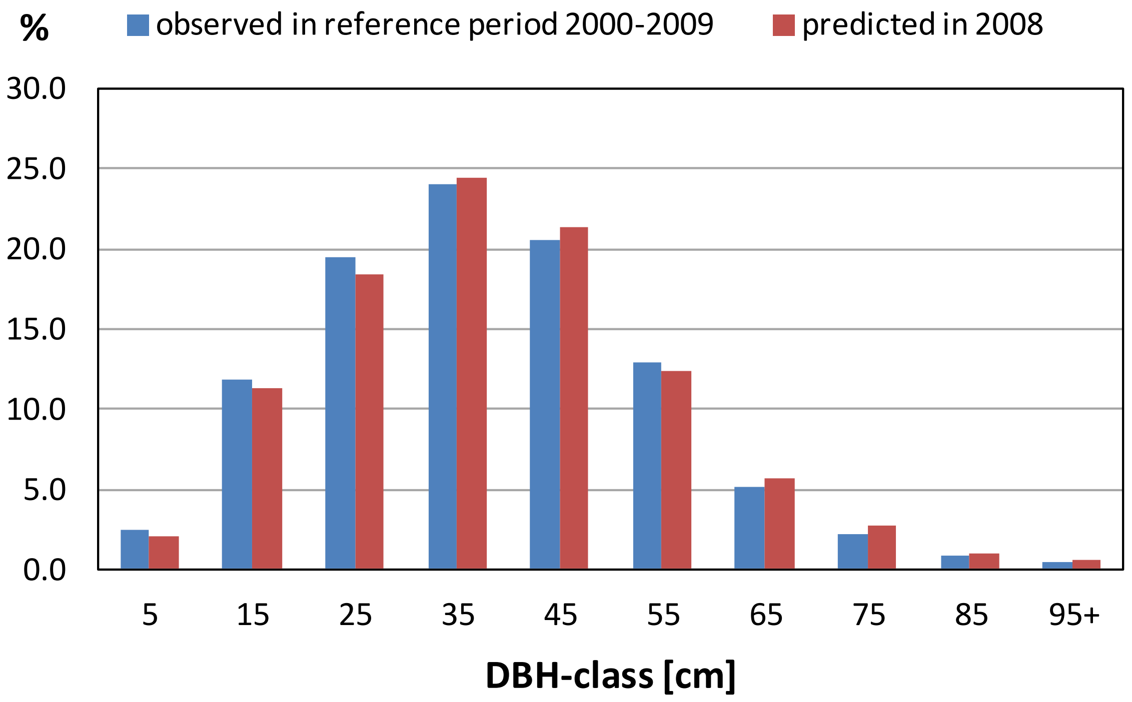


*Figure 2: Relative distribution of observed (within reference period 2000-2009 by NFI) and predicted (by model) removed tree volume*

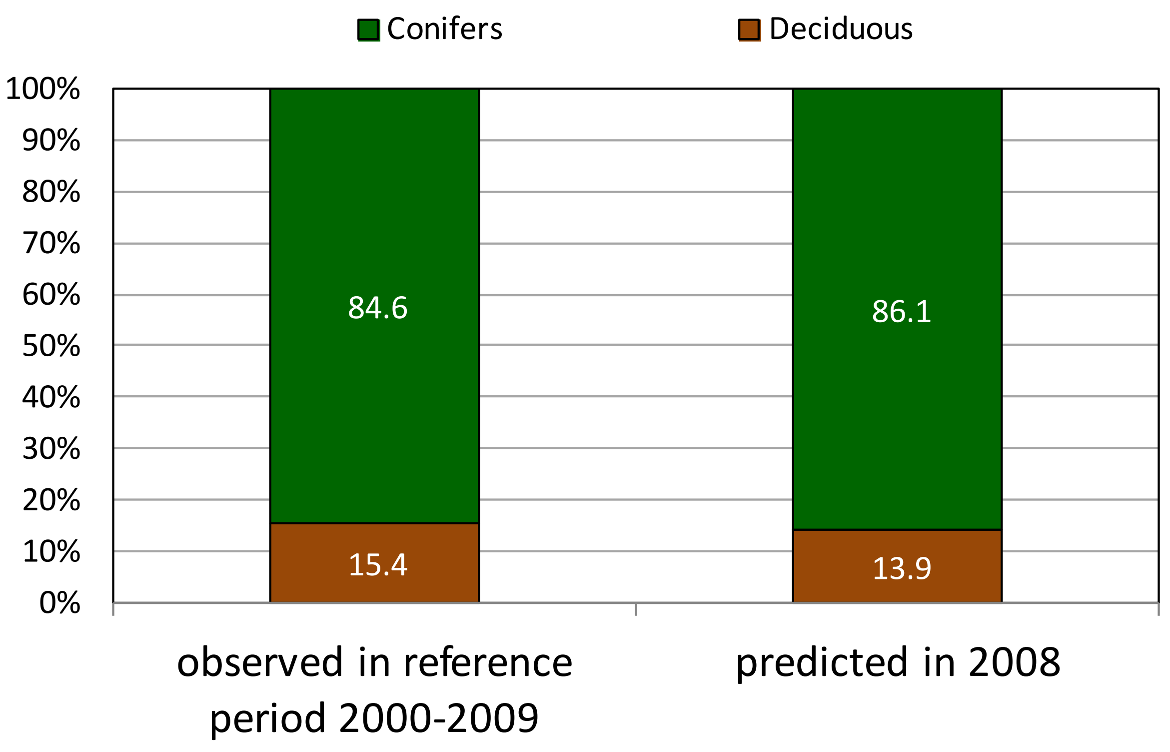


*Figure 3: Observed (within reference period 2000-2009 by NFI) and predicted (by model) percent share of conifers and deciduous trees of removed tree volume*

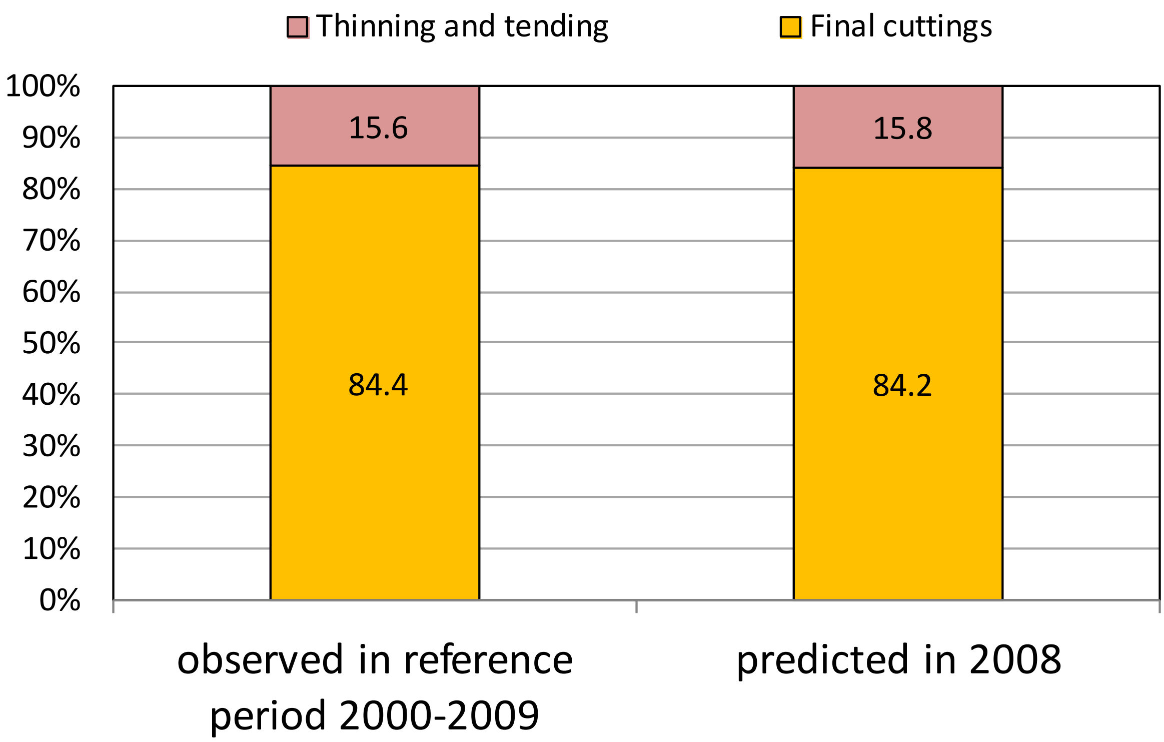


*Figure 4: Observed (within reference period 2000-2009by NFI) and predicted (by model) percent share of final cutting and thinning by of removed tree volume*

The decrease in total increment since the last two consecutive NFIs 2000/02 and 2007/09 correlates very well with the trend of the future increment simulations between 2020 and 2030 which also indicate a relatively gentle decrease from 29.7 Mio $m^3$ to 29.0 Mio $m^3$. This dynamic can be explained by a shift in the age-class distribution as a consequence of the continuation of the management practices as in the reference period. Figure 5 shows that the current annual increment observed within the reference period 2000-2009 is highest in age-classes 40-60 and 20-40. However, these are the two age-classes with the largest extent in the decrease of forest area (see Figure 6).

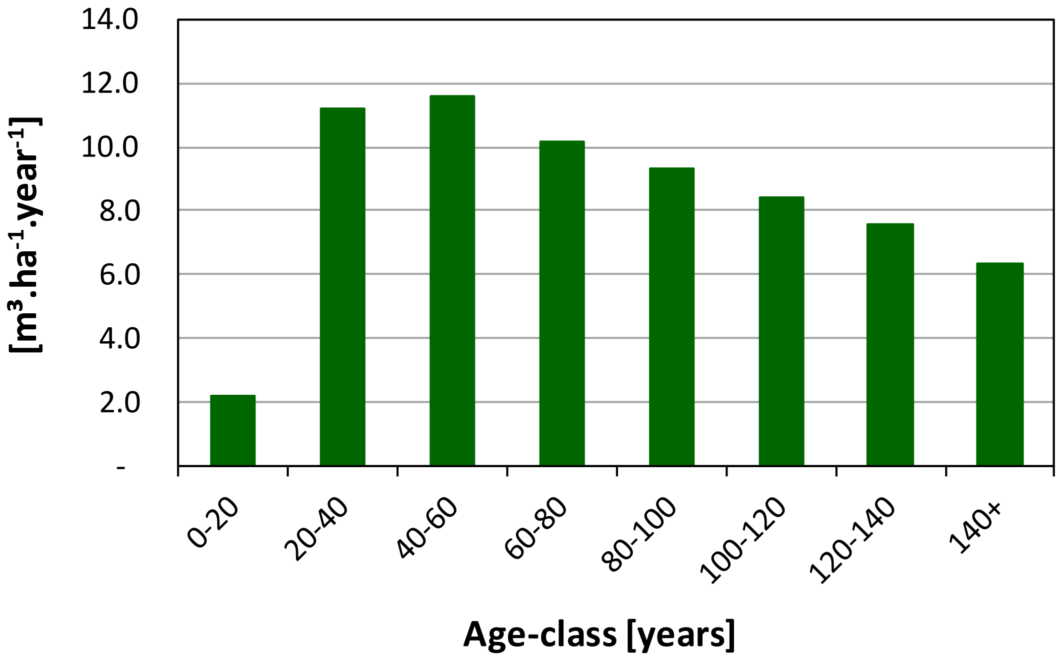


*Figure 5: Current annual increment by age-classes observed by NFI within the reference period 2000-2009.*

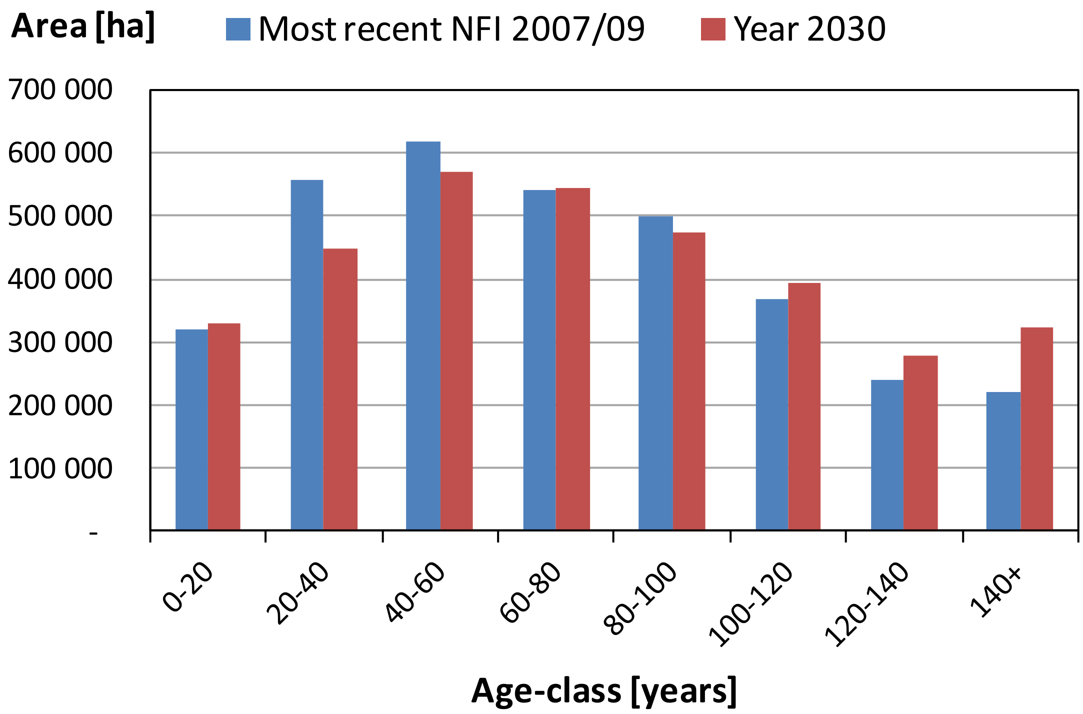


*Figure 6: Current annual increment by age-classes observed by NFI within the reference period 2000-2009 and modeled for the year 2030.*

Also the increase in harvest rates in the NFI period 2007/09 correlates very well with the trend of the future simulation results until 2030 as indicated by the model runs. It is important to emphasize that the figures of the simulated mean annual increment are always higher than the figures of the simulated mean annual harvest rates demonstrating the required assurance and continuation of the sustainable forest management from the reference period to the FRL period.

*Table 3: Total annual increment and drain (m3 stemwood) for the periods 2021/25 and 2026/30.*

| | **Mean 2021-2025 (Mio $m^3$)** | **Mean 2026-2030 (Mio $m^3$)** |
|---|---|---|
| Total annual increment | 29.7 | 29.0 |
| Total annual drain | 27.2 | 27.6 |

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

### 3.3.1 Modeling biomass growth and harvest and change of standing dead wood stocks

CALDIS-VB V0.1 is a climate-sensitive individual-tree based forest growth model (LEDERMANN et al., 2017a) that consists of the following sub-models: a basal area increment model (KINDERMANN 2010), a height increment model (GSCHWANTNER et al. 2010) , an ingrowth model (LEDERMANN, 2002), a harvest model (LEDERMANN et al., 2017b) and a model describing salvage cuts and tree mortality (LEDERMANN 2017). CALDIS-VB V0.1 is based on the same model concept and was parameterized from the same data set as PROGNAUS (PROGNosis for AUStria: Monserud and Sterba, 1996; Hasenauer, 2000; Ledermann, 2006). The only difference between CALDIS-VB V0.1 and PROGNAUS is that CALDIS-VB V0.1 uses climate variables in addition to the predictor variables of PROGNAUS. The basal area increment model, the height increment model and the mortality model of PROGNAUS have been validated several times (e.g. STERBA and MONSERUD, 1997; STERBA, 1999; MONSERUD and STERBA, 1999; STERBA et al., 2001; LEDERMANN, 2010). PROGNAUS was also used for the construction of the Austrian forest management reference level for the period 2013-2020. CALDIS-VB V0.1 uses a set of tree species-specific mathematical-statistical equations to project height and diameter growth as well as natural mortality of individual trees. The growth projections are based on climatic parameters (temperature and precipitation) and on tree, stand and site characteristics. The estimation of natural tree mortality is only based on tree, stand and site characteristics. A model for salvage cutting and incidental fellings is also integrated in CALDIS-VB V0.1. An ingrowth model estimates the renewal of forest stands. Both models resort to tree, stand and site characteristics. The model for salvage cutting requires climate and wind speed data, too. CALDIS-VB V0.1 was developed from Austrian NFI data covering the time period from 1981-2009. Because the NFI data are representative for the whole forest land in Austria, the model can be applied to all combinations of species composition, stand structure, stand treatment, and site conditions observed in the Austrian NFI. CALDIS-VB V0.1 was successfully applied in a study on green house gas dynamics in Austria (BRAUN et al. 2016).

The newly developed harvesting model (see chapter 3.2.1.2) was implemented in the forest growth simulator CALDIS-VB V0.1 in order to represent the same forest management practices as it was documented between the two consecutive NFI assessments 2000/02 and 2007/09. This extended version of CALDIS-VB V0.1 was set up on the most recent NFI assessment in 2007/09 and run until the year 2030. All implemented LOGIT-models, i.e. the harvesting model and the models for salvage cuts and natural mortality, estimate a probability that the respective event will occur. Therefore, we used uniformly distributed random numbers to decide whether the described event should occur.

For the projection of the FRL we have decided to use the same climatic conditions as they had been observed in the reference period from 2000 to 2009. For the implementation of this procedure we also used uniformly distributed random numbers. For a specific year within the projection period we randomly selected a year within the reference period (2000-2009) and used these climate data for the model projections. This selection procedure was repeated until the end of the projection period was reached. In order to cover the probabilistic nature of the model application, 100 simulation runs were carried out and the results used for FRL represent the mean values of these 100 repetitions.

The derivation of above and below ground biomass and related carbon stocks of the Austrian forest was calculated applying the same expansion and conversion ratios as for the annual national greenhouse gas reporting under UNFCCC for the period 2000 to 2009.

**Dead wood stocks** were modeled by means of the models that estimate salvage cuts and natural tree mortality. Both models had been developed from those trees of the Austrian National Forest Inventory (NFI) that changed their status from alive to dead within the periods of two consecutive NFI assessments. The salvage cut model estimates the dieback of trees due to storm events, dry spells, snow-breakage, and bark beetle attacks. A given percentage of these dead trees is assumed to remain as standing dead trees in the stand providing one source of influx to the dead wood stocks. On the other hand, the natural mortality model estimates the dieback of trees due to inter- and intra-specific competition. Also here, a given percentage of these dead trees is assumed to remain as standing dead trees in the stand while the other part is assumed to become down woody debris. The standing dead trees remaining in the stand estimated by the natural mortality model provide the other source of influx to the dead wood stocks. Note that only standing dead trees are considered for dead wood stocks while lying woody debris is considered as litter influx to the litter and soil modeling (this approach is consistent to the Austrian GHG inventory). The two sources of outflux from dead wood stocks are:  outflux due to harvesting, which is estimated via the newly developed harvest model, and outflux when a standing dead tree falls down and becomes part of the lying woody debris. The latter is estimated with a simple annual rate that was derived from the Austrian NFI data.

### 3.3.2 Modeling litter and soil C changes

For estimating **litter** and the **soil organic carbon** the Yasso15 model was used. It is an update of the original Yasso model that later evolved into Yasso07 and finally Yasso15 (LISKI et al. 2009, 2005; https://en.ilmatieteenlaitos.fi/yasso-description) was applied (BFW, 2015).

Yasso was introduced by Jari Liski (https://en.ilmatieteenlaitos.fi/cv-jari-liski). The acronym of the program is the Finnish term for 'soil'. A regularly updated description of the model and the source code are publicly available (description: https://en.ilmatieteenlaitos.fi/yasso-description; source code: https://github.com/JariLiski/Yasso15/blob/master/y15_subroutine.f90). Yasso15 is a decomposition model for organic matter. It is based on 18,500 data records from decomposition experiments that have been conducted worldwide (Repo et al. 2017).

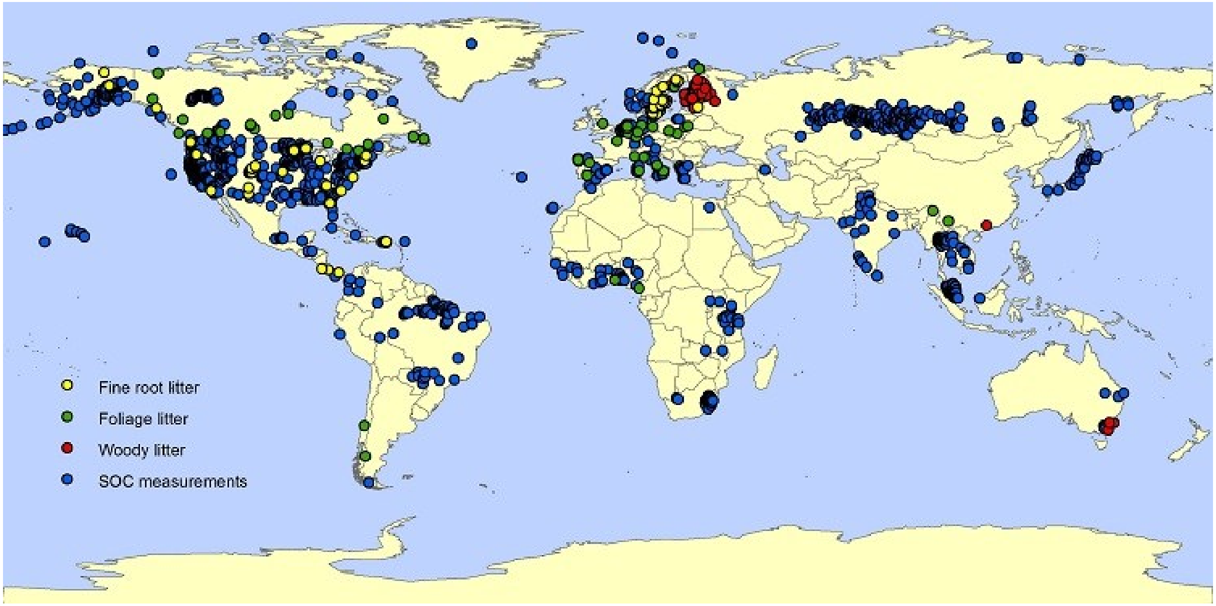


*Figure 7: The data for the decomposition model Yasso have been collected in different climatic zones and forest types (Figure from https://en.ilmatieteenlaitos.fi/yasso-description#Yasso15)*

It was the explicit intention of the author to provide a tool for national greenhouse gas inventories. The program is widely used in Europe (e.g. Finland, Estonia, Switzerland, Czech Republic, Norway, Romania, Austria, Spain) and references for the different applications are available:

- https://en.ilmatieteenlaitos.fi/yasso-publications;
- https://en.ilmatieteenlaitos.fi/yasso-publications#Presentations

Yasso was developed as an alternative for other more complex models that are requiring input data that are available on highly-instrumented experimental sites, but are rarely available for the majority of plots of a National Forest Inventory. Consequently, the concept of Yasso was

- To be globally applicable
- To require readily accessible input data
- To give a good estimate of changes in the soil carbon pool over time.

Organic matter is divided into 5 operationally defined classes, acid soluble, ethanol soluble, water soluble organic matter and humus. Each chemical class undergoes a specific pathway upon decomposition and releases $CO_2$ to the atmosphere. The decomposition pathway reflects the understanding of the decay of soil organic matter where microbial processes are transforming organic matter. The released $CO_2$ during decomposition can be understood as heterotrophic soil respiration (see

Figure *8*). The fractionation procedure is operationally defined and is described in Gholz et al. (2000) and Vavrova et al. (2009).

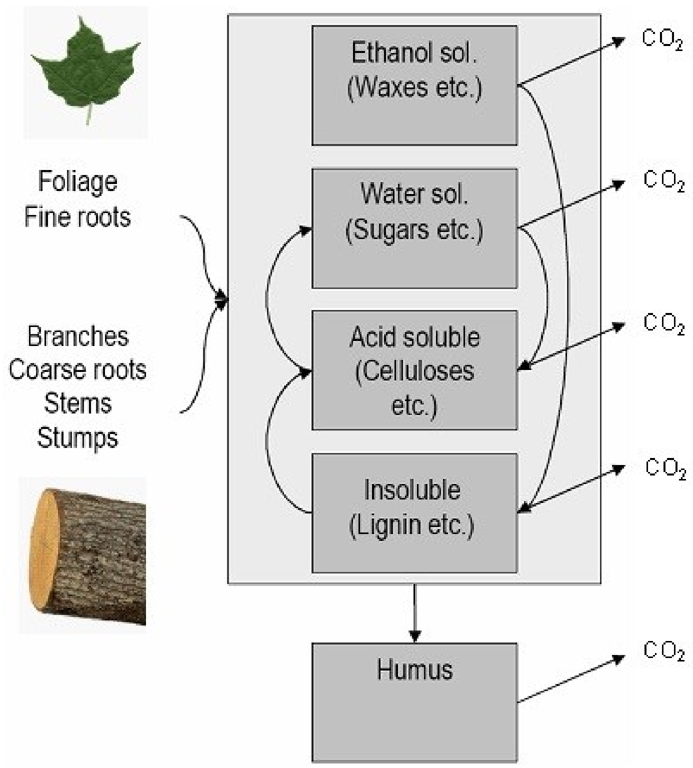


*Figure 8: Flowchart of Yasso15 based on a graphical representation on the webpage of Yasso (https://en.ilmatieteenlaitos.fi/yasso-description).*

Yasso15 uses an externally calculated input of organic matter to the soil. The carbon input is derived from the standing stock, harvest (residues) and dead wood input of the forest as captured by the results of the Austrian National Forest Inventory (for the reference period) and from the CALDIS simulation. Forest Inventory data and a specific forest management strategy have been incorporated in the simulation of the forest biomass (see chapter 4.2.3).

Moreover, the model requires the annual mean temperature, the temperature amplitude between warmest and coldest month and the total annual precipitation as climate data.

The external parameters were calculated in several steps:

- The climate data were derived from the same dataset as those that have been used for the climate parameters of CALDIS.
- The litter input to the soil was estimated from tree characteristics that are available in the output of CALDIS.
- Species- and compartment specific decomposition parameters were assigned to the litter

Stem volume was converted to stem mass by species dependent factors for wood density. The mass of the compartments needles/leaves, branches, fine roots and coarse roots was estimated by biomass functions that are used in the Austrian GHG reporting scheme.

The turnover of the compartments was taken from literature values and observations (Kögel-Knabner et al., 1988; Järvenpää et al., 2017). From these data the annual input of organic matter from the standing stock (aboveground and belowground sources) was calculated. In addition, carbon inputs from disturbances were considered. Tree mortality and wood extractions (harvests) were reflected by a consistent pattern that describes the fate of organic matter and quantifies the residues remaining in the forest. The data transformation from the simulated forest biomass to the input file for Yasso15 was done in R.

The climate data required for Yasso15 were derived from the same climate dataset as CALDIS-VB V0.1 .

The calculations were performed in annual time steps in an R implementation of Caldis15. In order to obtain a relevant starting point for the Yasso15 runs a spin-up process was performed. For each site a stand development was simulated with the forest growth model. The starting point was a zero-year old plantation that was allowed to grow for 100 years. The simulated growth was driven by climate data from the period 1960/90. It was checked and ensured that after 100 years the classes of soil organic matter (acid soluble, ethanol soluble, water soluble organic matter and humus; see above) reach equilibrium, indeed.

The basic fit of the YASSO model for the Austrian forest conditions is described in chapter 4.2.

### 3.3.3 Estimating the HWP stock changes

The related criteria of the LULUCF regulation were followed and the average ratio of solid to energetic wood use in the reference period 2000 to 2009 was calculated. For that purpose the carbon stocks of HWPs produced in each of the years 2000 to 2009 were related to the carbon stocks of harvested stemwood in each of these years (*Table* 4). A mean ratio was calculated for these years for each, sawnwood, panels and paper. The mean ratios were used to derive the produced carbon stocks of sawnwood, panels and paper for the years on basis of the modelled stemwood harvest carbon stocks for the FRL periods 2021 to 2025 and 2026 to 2030. Annual carbon inflow by HWPs and annual carbon outflow from the HWP pools due to the 1st order decay function and half-lifes defined in the LULUCF regulation result in the Carbon stock changes of the HWP pool in the FRL periods (chapter 4.1.5).

*Table 4: HWP production and stemwood drain in 2000 to 2009 in Gg carbon and %*

| **In Gg C** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sawn wood | 1251 | 1307 | 1421 | 1507 | 1458 | 1459 | 1437 | 1724 | 1667 | 1127 | |
| Wood panels | 363 | 489 | 601 | 628 | 572 | 581 | 678 | 716 | 729 | 540 | |
| Paper and paperboard | 737 | 786 | 848 | 953 | 899 | 931 | 991 | 1078 | 1117 | 868 | |
| Stemwood drain | 3539 | 3591 | 4224 | 4826 | 4677 | 4675 | 5422 | 6002 | 6151 | 5135 | |
| **In % of stemwood drain** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **Mean 2000-09** |
| Sawn wood | 35% | 36% | 34% | 31% | 31% | 31% | 27% | 29% | 27% | 22% | 30% |
| Wood panels | 10% | 14% | 14% | 13% | 12% | 12% | 13% | 12% | 12% | 11% | 12% |
| Paper and paperboard | 21% | 22% | 20% | 20% | 19% | 20% | 18% | 18% | 18% | 17% | 19% |
| Total share of solid wood use (sum) | 66% | 72% | 68% | 64% | 63% | 64% | 57% | 59% | 57% | 49% | 62% |

# 4. Forest Reference Level

The calculations of the Forest Reference Level consider all carbon pools of the annual national greenhouse gas inventory of Austria (Umweltbundesamt, 2018). The development of standing stock, increment and drain ($m^3$/ year) form the bases of the calculations for the carbon changes in the carbon pools (kt $CO_2$).

Therefore, the figures in this chapter include the results of the Austrian National Forest Inventory (NFI) from the periods 2000/02 and 2007/09 as used in the National Greenhouse Gas Inventory (GHGI) for the years 2000-2009 and the results of the simulations with CALDIS-VB V0.1 for the years 2009-2030.

The development of the standing stock underlines the sustainable forest management for the time period 2021-2030. Since the first NFI assessment in the early 1960ies the standing stock continuously increased in Austria and reached a value of 1,135 Mio $m^3$ at the NFI 2007/09. The simulation with CALDIS -VB V0.1 shows that the standing stock increases to 1,206 Mio $m^3$ in 2030 if the management practices and conditions from the reference period are considered. The development of standing stock shows a slight decrease for coniferous trees from 917 Mio $m^3$ (2010) to 910 Mio $m^3$ (2030) whereas for deciduous trees the standing stock increases from 228 Mio m3 to 295 Mio $m^3$ (see Figure 9).

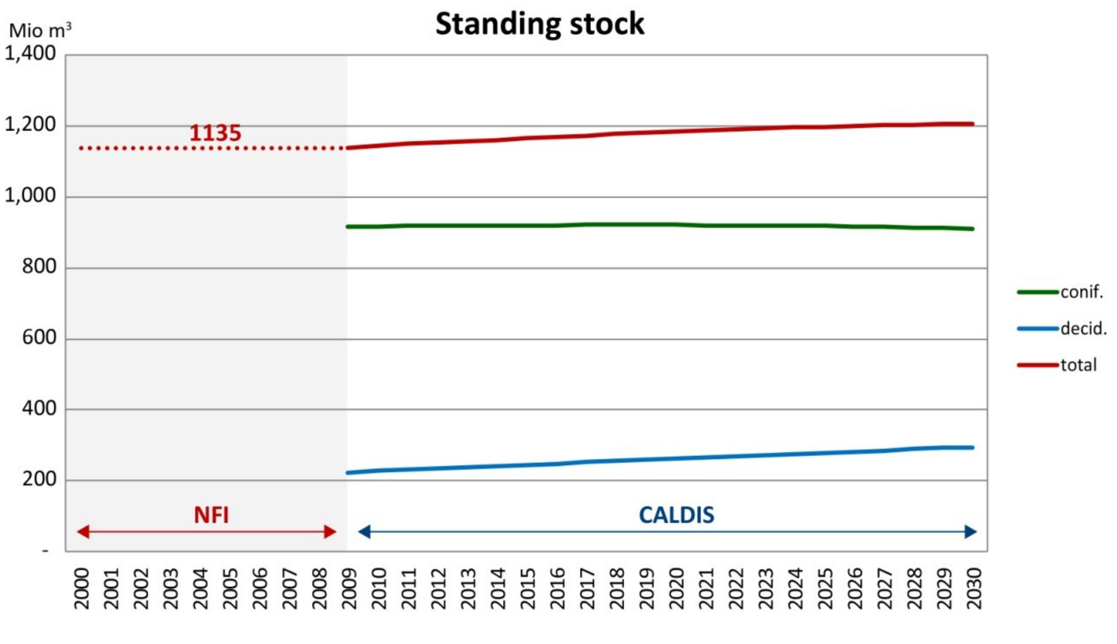


*Figure 9: NFI standing stock (2000-2009) and standing stock based on CALDIS simulation divided into coniferous and deciduous trees (2009-2030).*

The results of the CALDIS-VB V0.1 simulations show a total annual increment of 31.1 Mio $m^3$ for the year 2010 and therefore match well with the results of the NFI periods 2000/02 and 2007/09. The slight decrease of the total annual increment is explained in detail in chapter 3.2.1.2.

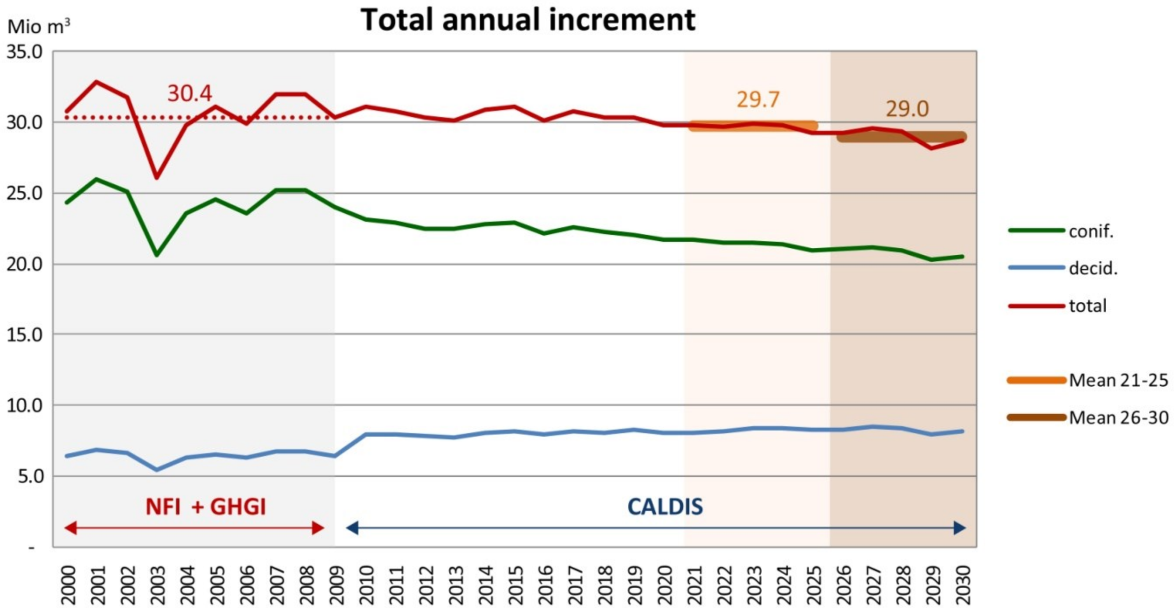


*Figure 10: Total annual increment (mio m$^3$) based on NFI data (2000-2009) and simulation runs with CALDIS (2009-2030); mean values for the two reporting periods 2021-2025 and 2026-2030*

The results of the CALDIS-VB V0.1 simulations show a total annual drain of 25.9 Mio m$^3$ for the year 2010 and therefore match exactly with the results of the NFI periods 2000/02 and 2007/09. For the reporting periods 2021-25 and 2026-30 the annual drain increases slightly to mean values of 27.2 and 27.6 Mio m$^3$ (see Figure 11).

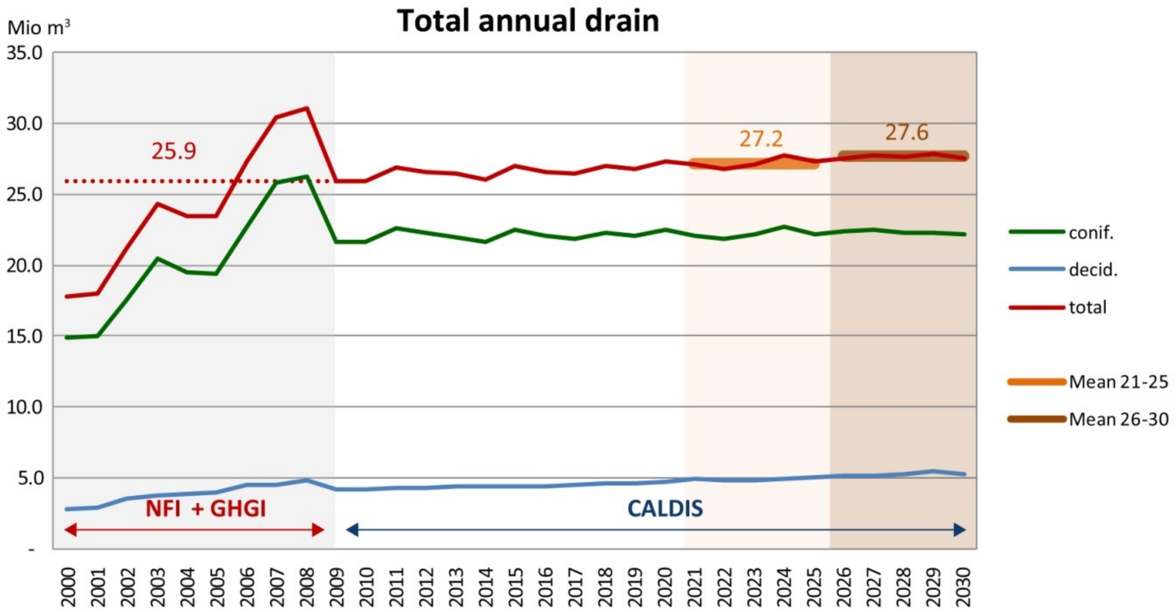


*Figure 11: Total annual drain (Mio m$^3$) based on NFI data (2000-2009) and simulation runs with CALDIS (2009-2030); mean values for the two reporting periods 2021-2025 and 2026-2030*

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

The data on annual increment and drain are the basis for the calculation of changes in above ground biomass, below ground biomass and dead wood. The methodology is described in detail in chapter 3.

### 4.1.1 Above ground biomass

Based on the results shown above the net changes in forest above ground biomass results in a carbon sink of -3,217 kt $CO_2$ for the reporting period 2021-2025 and -2,115 kt $CO_2$ for the reporting period 2026-2030 (see Figure 12).

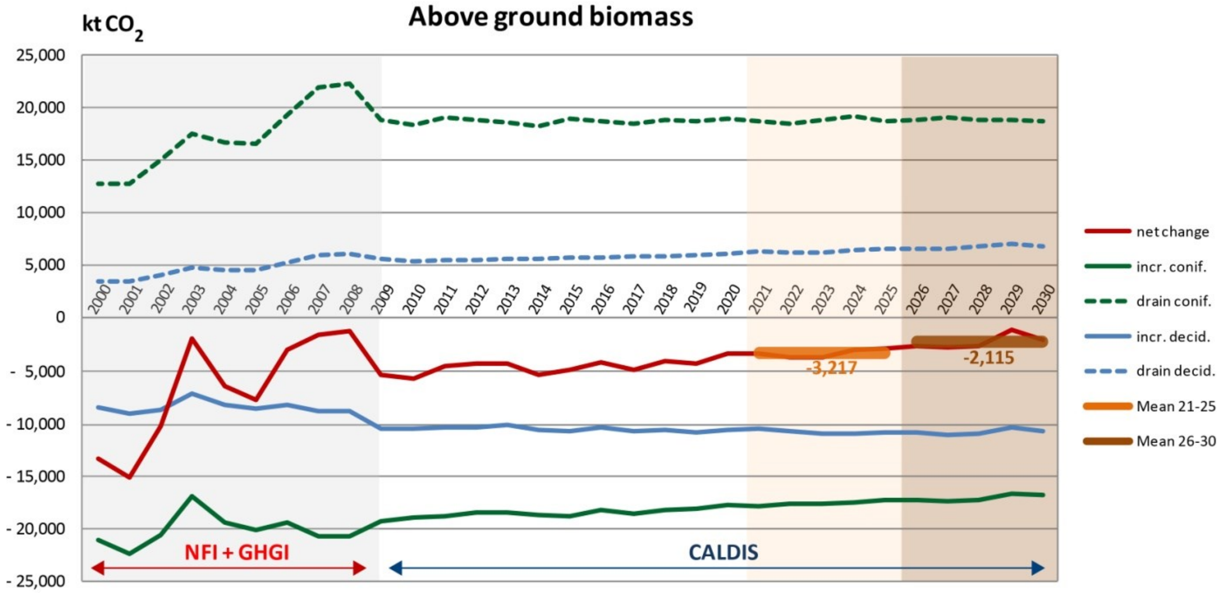


*Figure 12: Development of the aboveground biomass changes from 2000 to 2030*

### 4.1.2 Below ground biomass

Based on the results shown above the net changes in forest above ground biomass results in a carbon sink of -171 kt $CO_2$ for the reporting period 2021-2025 and a minor source of 87 kt $CO_2$ for the reporting period 2026-2030 (see Figure 13).

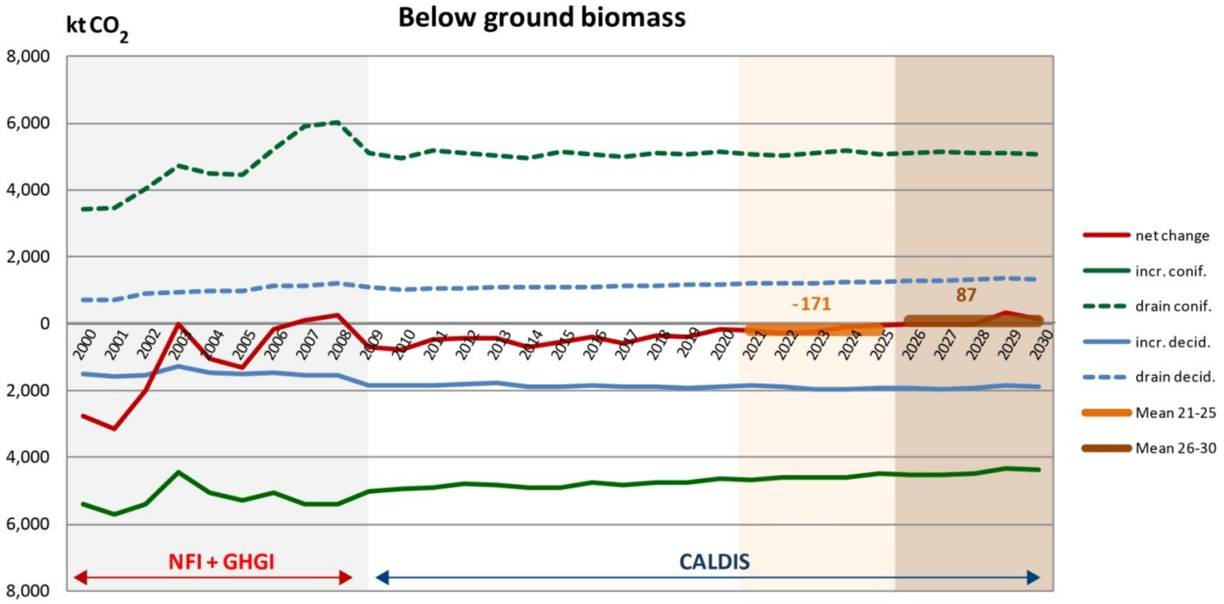


*Figure 13: Development of the belowground biomass changes from 2010 to 2030*

### 4.1.3 Deadwood

The estimates on C-stock changes in dead wood include only standing dead wood, because any falling dead tree (part) is accounted for as a C flux to the litter and soil in the modeling of litter and soil C stock changes.

Based on the data of the Austrian NFI the mean value of stock of standing deadwood is 6.1 $m^3$/ha for the period 2000/02 and 8.4 $m^3$/ha for the period 2007/09. This amounts to an increase of total standing deadwood stock of around 10 Mio $m^3$ between 2000 and 2009.

Based on the CALDIS-VB V0.1 simulation the deadwood stock increases to a total amount of 36 Mio $m^3$ until 2030. The mean values of the annual changes in the reference periods amount to 0.29 Mio $m^3$ (2021-2025) and 0.34 Mio $m^3$ (2026-2030) (see Figure 14). This represents an annual carbon sink of – 207.0 kt $CO_2$ for the reporting period 2021-2025 and -236.5 kt $CO_2$ for the reporting period 2026-2030.

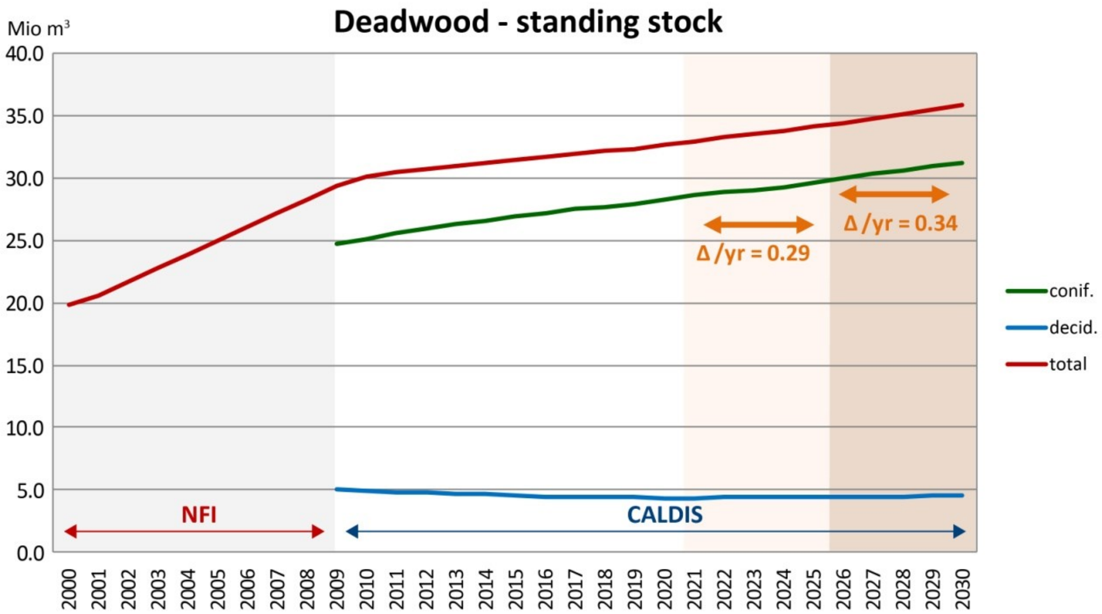


*Figure 14: Dead wood stock based on NFI data (2000-2009) and simulation runs with CALDIS (2009-2030); mean values of the annual deadwood stock changes (Mio $m^3$) are shown for the two reporting periods 2021-2025 and 2026-2030.*

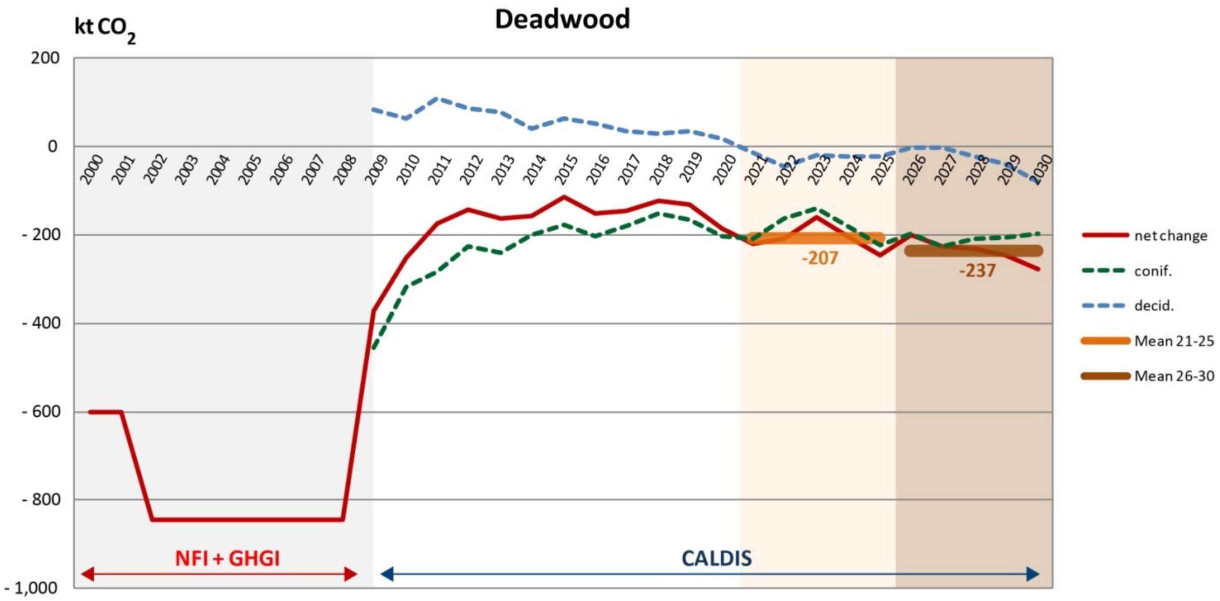


*Figure 15: Dead wood stock changes based on NFI data (2000-2009) and simulation runs with CALDIS (2009-2030); mean values of the annual stock changes (Mio $m^3$) is shown for the two reporting periods 2021-2025 and 2026-2030.*

### 4.1.4 Soil and Litter

During the simulation period 2008-2031 the litter plus soil carbon pool shows a slight decrease with a somewhat irregular pattern and varies between 114 and 109 t C per hectare. Irregularities are representing the harvesting pattern and disturbances that occasionally increase the soil C pool by the provision of coarse woody debris and belowground litterfall.

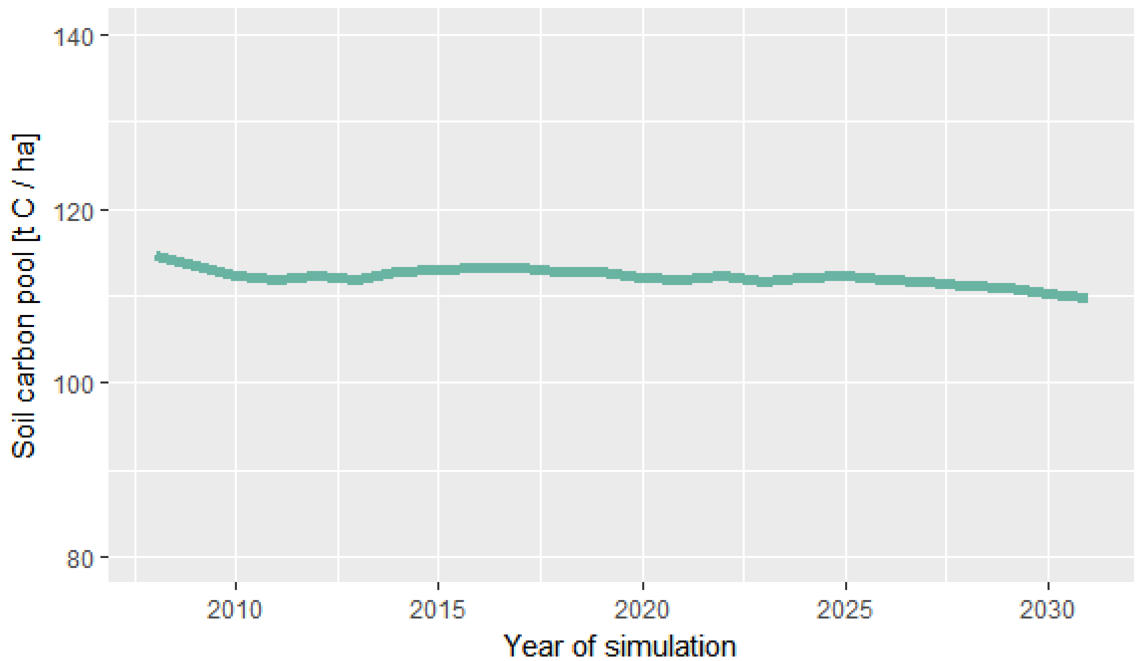


*Figure 16: Soil carbon pool in the simulation period of 2008 to 2031.*

Figure *17* shows the annual changes of the soil carbon pool. The pattern is mainly reflecting management effects. During the simulation period there are periods of carbon accumulation and depletion in the soil. The maximum annual carbon increase during the simulation period is 0.9 t C / ha, the highest annual decrease is 1.3 t C / ha. Overall, a slight decrease in the soil carbon pool is derived.

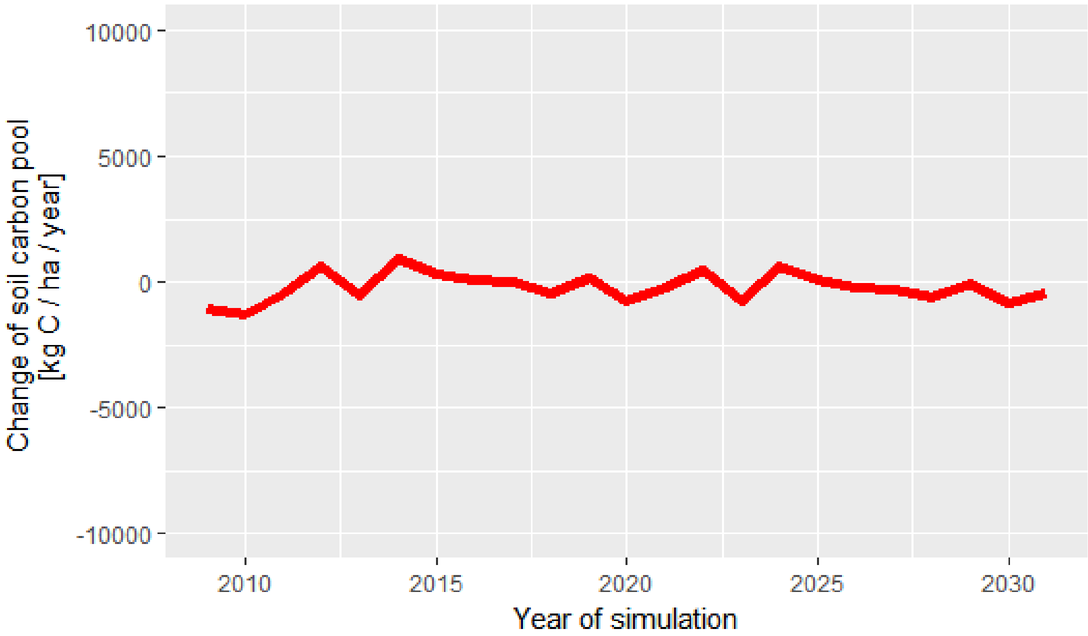


*Figure 17: Annual change of the soil carbon pool calculated as the difference between subsequent years.*

Annual changes of the soil carbon pool reflecting a composite of several thousand sites are difficult to interpret. Therefore, averaging the change over a longer time span gives a more reasonable picture and robust figures for the FRL period.

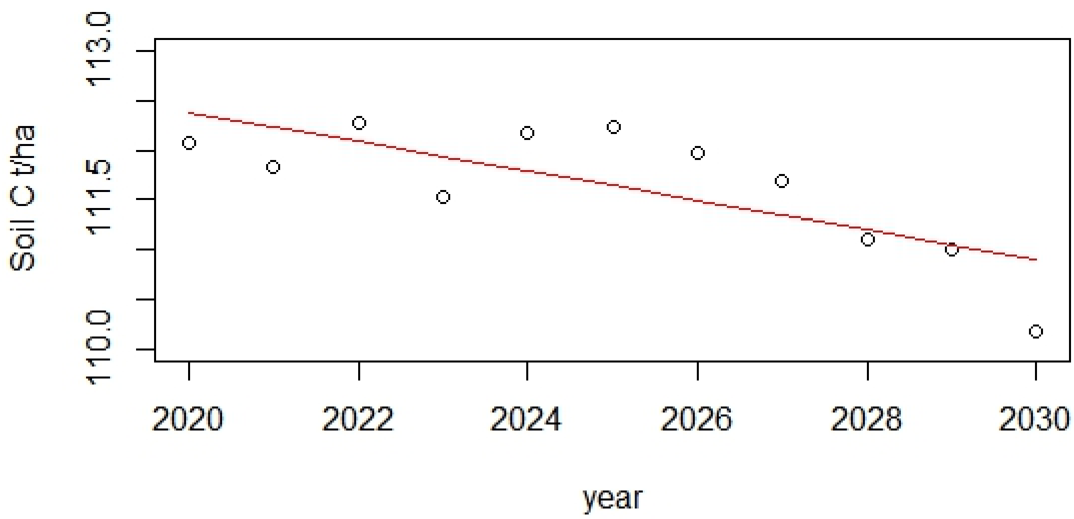


*Figure 18: Change of soil carbon during the relevant period of 2020 to 2030. The dots represent the annually assessed soil carbon pool, the red line shows the trend of a linear regression.*

The linear regression during the reference period of 2020 to 2030 has a slope of 0.15, suggesting a decrease of the soil carbon pool of 150 kg C / ha / year. The regression has an adjusted $R^2$ of 0.51 with a significance of 0.08%. The total annual carbon loss in litter and soil accounts therefore on average for 1,851 kt $CO_2$/year.

The model results on the average annual change in the soil C stock used for the current GHG reporting under UNFCCC show a carbon loss of 0.2 t C/ha/year for forest land remaining forest land.

This emission is completed by soil carbon stock losses due to increases in macadam or paved forest roads (these represent forest land in Austria. In order to be consistent with the reporting under UNFCCC and with the EU LULUCF regulation an annual increase in macadam or paved forest roads as for the reference period was also estimated for the two FRL projection periods resulting in an additional annual soil carbon loss which equals an annual emission of 277 kt $CO_2$/year. The method of estimate is the same as for the Austrian GHG inventory and described in the Austrian NIR (Umweltbundesamt 2018).

Consequently, the estimates for the total annual emissions due to litter and soil C losses amount to 2,128 kt $CO_2$ on average for both FRL periods.

### 4.1.5 Harvested Wood Products

The calculations according to chapter 3.3.3 lead to very similar, slightly lower net HWP carbon stock increases in the FRL periods compared to the reference period.

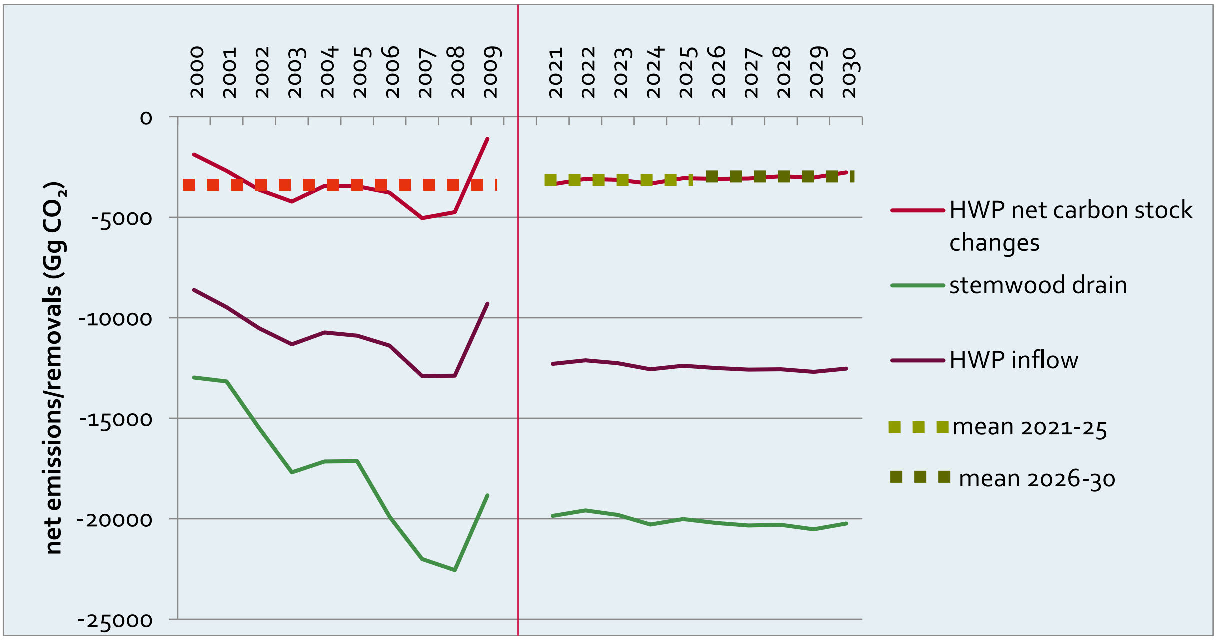


*Figure 19: HWP net carbon stock changes, HWP inflow and stemwood drain in the reference period and in the FRL periods.*

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

Both, the figures reported under the UNFCCC in forest land as well as the forest reference level are based on the results of the Austrian NFI. The emissions/removals reported under the UNFCCC category 4.A forest land are based on the results of increment and harvest according to the NFI periods 1986/90, 1992/96, 2000/02 and 2007/09.

The CALDIS-VB V0.1 model simulations for FRL are also based on the status (e.g. area, standing stock) of the Austrian forests as assessed by the NFI 2007/09. The area of managed forest land (forests in yield) represents 3.366 Mio ha and a standing stock of 1,134 Mio $m^3$ for 2008 (middle year of the last finished Austrian NFI, see also http://bfw.ac.at/rz/wi.home).

The models for estimating salvage cuts and natural mortality were developed from Austrian NFI data collected in the course of five assessment cycles: 1981/85, 1986/90, 1992/96, 2000/02 and 2007/09. In this regard it is important to note that the underlying data represent mean quantities for longer time periods (5-8 years). Hence, the models will never be able to estimate the amount of salvage cuts for a specific event, for example the storm event Kyrill. The best way for an evaluation of the model results is therefore to compare the model predictions to the observed quantities of the different NFI periods. The annual salvage cuts comprised 2.2 Mio. $m^3$ in the NFI 1986/90, 1.9 Mio. $m^3$ in the NFI 1992/96, 1.0 Mio. $m^3$ in the NFI 2000/02 and 3.1 Mio. $m^3$ in the NFI 2007/09. The model predictions for the period 2021-2030 vary between 1.7 Mio.$m^3$ and 2.2 Mio. $m^3$ per year with a mean of 2.1 Mio. $m^3$ per year, and are clearly within the range of the observed values of the NFI assessments. The same is true for the natural mortality model that predicts an annual amount of 1.7 Mio. $m^3$ for the period from 2021-2030 which is within the range of the NFI observations that range from 1.3 to 2.4 Mio. $m^3$ per year.

CALDIS-VB V0.1 is based on the same model concept and was parameterized from the same data set as PROGNAUS (PROGNosis for AUStria: Monserud and Sterba, 1996; Hasenauer, 2000; Ledermann, 2006). The only difference between CALDIS-VB V0.1 and PROGNAUS is that CALDIS-VB V0.1 uses climate variables in addition to the predictor variables of PROGNAUS. The basal area increment model, the height increment model and the mortality model of PROGNAUS have been validated several times (e.g. STERBA and MONSERUD, 1997; STERBA, 1999; MONSERUD and STERBA, 1999; STERBA et al., 2001; LEDERMANN, 2010). PROGNAUS was also used for the construction of the Austrian forest management reference level for the period 2013-2020.

The excellent fit between modeled and measured increment and drain is demonstrated in chapter 3.1.

The basic approach of running the soil carbon model Yasso is unchanged to the approach used for the Austrian GHG inventory. Climate data, site data, and forest inventory data are used as drivers of the soil carbon model. The model Yasso is specifically designed to utilize data of a National Forest Inventory for the estimation of the soil carbon stock. In order to estimate the carbon input to the soil several assumptions need to be made.

- The annual carbon input to the soil from needles and leaves can be estimated from the annually calculated needle/leaf biomass and a turnover rate (longevity) of the needles and leafs.
- The annual belowground carbon input to the soil can be estimated from the standing stock of the roots (as a fraction of the total tree biomass), a valid distinction between the

mass of fine roots and coarse roots, and a valid assumption of the longevity of fine roots and coarse roots.

- The harvesting pattern defines the input of coarse woody debris (stumps, roots, tree tops, harvesting residues) to the soil.
- The herbaceous vegetation and shrubs and the understory that are not assessed in the National Forest Inventory are not relevant for the annual soil carbon flow.

There have been several changes in the calculation of the soil carbon pool as compared to the latest Austria's National Inventory Report:

- The used model version of Yasso is different. Previously Yasso07 has been used, currently Yasso15 is used. The version Yasso15 uses an updated set of variables for the decomposition process of soil organic matter.
- The chemical characterization of the different fractions of soil organic matter is unchanged. The percentage of organic matter belonging to the AWENH fractions (acid-soluble, water soluble, ethanol soluble fraction, unsoluble organic matter and humic substance) is unchanged.
- The spin up procedure of Yasso was changed. Instead of calculating the average carbon input of the entire simulation period as starting value as steady state condition, an independent growth of the stand for approximately 100 years prior to the simulation period was used. The growth of the stand was initiated by a plantation of trees of age zero. The growth of the stand was simulated until the culmination of the average growth rate. When point in time is reached the timing of harvesting is ideal. Forest managers are ascertaining this point in time.
- Yasso15 introduced and uses a leaching factor that represents carbon losses from litterbags during the decomposition process. The leaching factor can be used to account for different types of carbon losses that are otherwise unaccounted in the model. The user manual describes cases where leaching factors between -0.000167 and -0.91717 have been used. For all sites of our calculations a uniform leaching factor of -0.07 has been used.
- The preparation of the input file for Yasso was ported from SAS to R.

The results of Yasso were tested against field measurements. For the period 1989 to 2006 a comparison of field data with simulation data was available. The field data were derived from a repetition of the more than 500 plots of the Austrian Forest Soil Inventory to a repeated assessment on 136 plots in 2006 (Figure 5). Moreover, the results of Yasso have been confirmed against field data in a climate manipulation experiment for calcareous soils (Schindlbacher et al., 2009).

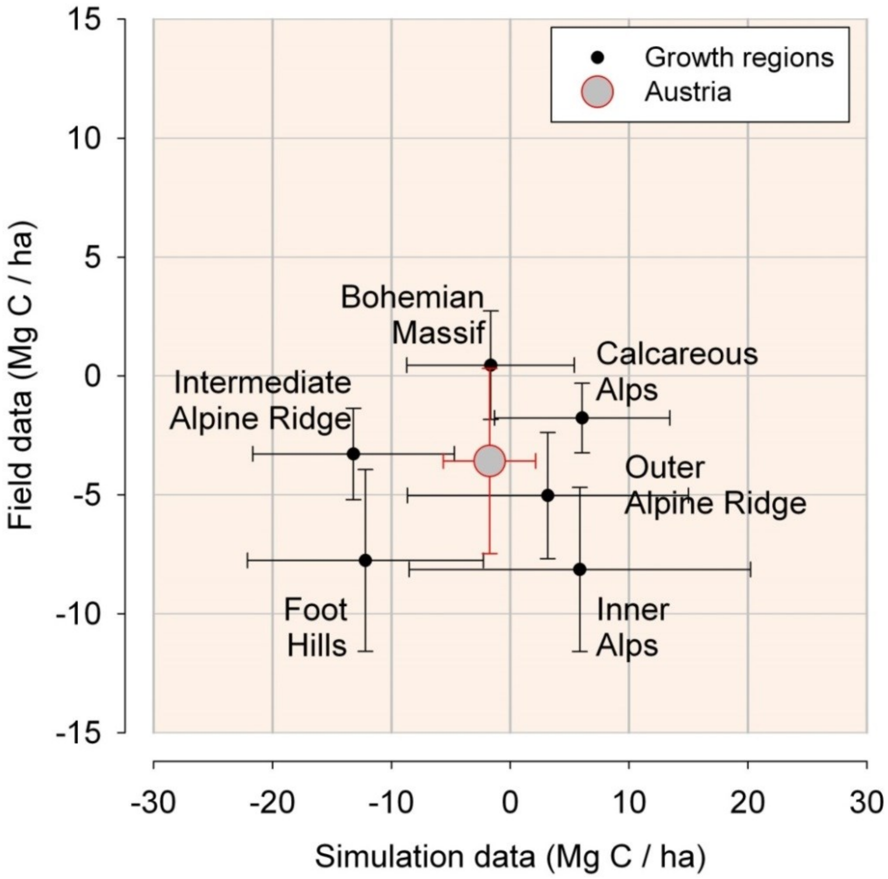


*Figure 20: Simulation and against field data. The soil carbon change of the Austrian Forest Soil Inventory (1989) versus Biosoil (2006) against simulated data with Yasso07 in the same time span. The results differ widely for Austrian regions. The result of the simulated values for Austria (grey bullet) is in close agreement with the simulation of the Forest Reference Level.*

A major difference in the approach of calculating the forest reference level to the GHG reporting for UNFCCC is the selection of sites. In the Austrian Forest Inventory each assessment unit comprises a tract of 4 plots where tree characteristics are monitored. At one plot of each tract (denoted as 0/0) soil characteristics are recorded in the Austrian Forest Soil Inventory System. The simulation of the soil carbon pool for the Austrian National Inventory Report was based on plot information (plot 0/0) and the standing stock, the harvesting pattern, and tree mortality were reported on a plot basis, based on measurements on the plot of the National Forest Inventory.

For the calculations of the forest reference level no field measurements were available. Instead, the calculations were based on the output of a simulation model (CALDIS-VB V0.1 ). The CALDIS-VB V0.1  model offers single-tree information (stem diameter, stem height, height of canopy, stem volume) and information on the fate of individual trees (dieback, harvest) on an annual basis. The fate of each tree according to the simulation can be tracked on an annual basis.

The latest National Forest Inventory in Austria is currently under way. Upon its completion the time series of the forest litter plus soil carbon pool changes will be re-calculated for the complete historic time series of the GHG inventory and until the FRL period by using the new YASSO model version and approach. This may lead to an adjustment of the forest litter and soil C changes in the Austrian GHG inventory and eventually to an additional technical correction in the FRL (see following chapter).

### 4.2.1 Future technical corrections of the Austrian FRL

The Austrian FRL will be steadily adjusted to ensure consistency between the GHG inventory and the FRL. This will be the case for any methodological change of the GHG inventory which has also an impact on the FRL estimate.

There are already known three such required technical corrections for the Austrian FRL in the future:

- The Austrian FRL is estimated on basis of a fixed area of the Austrian forests in yield as documented by the last available NFI 2007/09. This underlying area and the Austrian FRL integrate C stock changes also due to Afforestation and Deforestation. Consequently, the FRL will be technically corrected by subtracting the emissions/removals from Afforestation and Deforestation after finalization of the commitment period when the Afforestation and Deforestation figures for the commitment period will be available.
- The Austrian FRL does not yet include the carbon stock changes of forests not in yield. So far, only one (the last) NFI included an assessment of the biomass stocks of the Austrian forests not in yield. With a repetition of this assessment in the currently running NFI, Austria will be in a position to estimate the carbon stock changes of the forests not in yield in the GHG inventory and carry out projections to the commitment periods. This will allow and require a technical correction of the FRL.
- The litter and soil carbon stock changes of the Austrian FRL were estimated with a new version of the YASSO model starting from 2010 on, while the related figures of the GHG inventory are based on the previous model version. So, the complete historic time series of the GHG inventory will be also estimated with the new YASSO model version. This will likely lead to changes in the figures of the litter and soil C stock changes of Forest Land in the Austrian GHG inventory, but may also affect the FRL by eventually starting from a different litter and soil C stock level for the FRL projections from 2010 on compared to the YASSO model runs for the FRL estimates at hand. If this will be the case, the modeling runs will be carried out for the historic GHG inventory time series, but will also be continued and projected beyond, to the FRL periods 2021 to 2025 and 2026 to 2030. In

order to save resources, these YASSO estimates will be carried out once the new NFI results will become available.

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