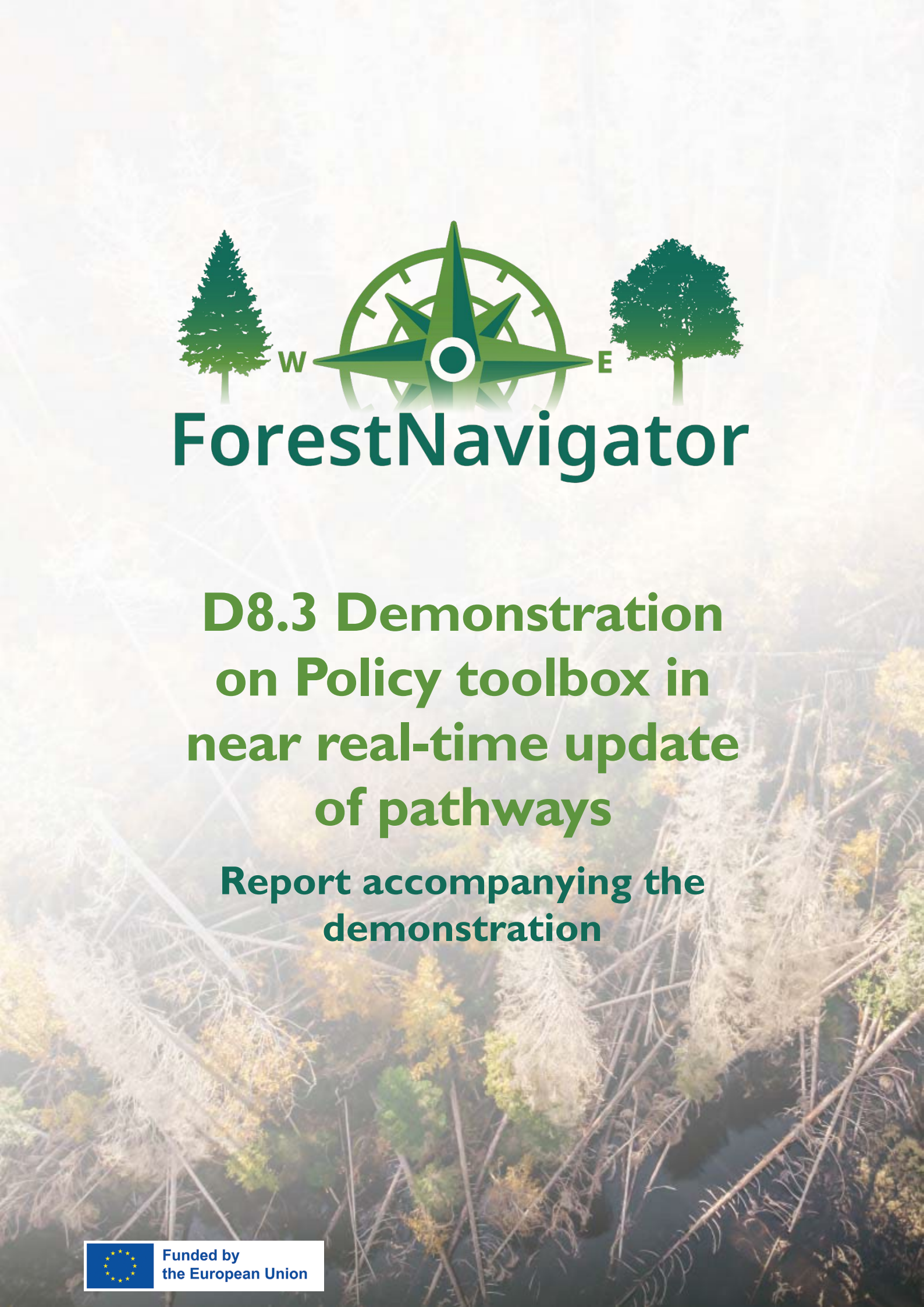



# D8.3 Demonstration on Policy toolbox in near real-time update of pathways

## Report accompanying the demonstration

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## Abstract

The ForestNavigator Emulator is the interactive scenario testing component of the ForestNavigator Policy Toolbox, which comprises the project's EU and national modelling infrastructure and its tools for accessing model results. Through a webbrowser, policy makers and analysts can explore how changing harvest assumptions affects the forest pathways calculated by the Global Forest Model (G4M), without preparing a new full model run. This makes the results accessible for rapid, consistent scenario screening: the recorded median calculation time for a 28-country projection was 0.015 seconds on the evaluation hardware, excluding web-interface overhead. The Emulator is available at https://fn-emulator.wkube.iiasa.ac.at/.

The Emulator was trained using 17 G4M trajectories covering 28 European countries, with annual data from 1990 and projections extending to 2100, where available. Evaluation on two complete harvest-sensitivity trajectories withheld from fitting gave coefficients of determination ($R^2$) above 0.995 for all six headline outputs. Weighted mean absolute percentage errors were below 0.5% for forest area and harvest, 1.96% for extracted logging residues, and approximately 4.5-5.0% for the living biomass and combined carbon balances. These results demonstrate close agreement with G4M within the tested scenarios.

The Toolbox and Emulator were demonstrated at the ForestNavigator MarketPlace in Brussels on 13 October 2026, alongside national applications for Ireland, Italy and the Czech Republic. The national statistical emulators estimated living biomass carbon balances from country specific CBM-CFS3 simulations. Following the demonstration, the national teams and task leader agreed to withdraw these regressions from the released interface because their limited carbon pool coverage could lead to misleading interpretations of the whole forest balance. The interface described in this report therefore retains the G4M emulator, while the national analyses and lessons learned are documented separately.

This report describes the Toolbox, the G4M emulator and its evaluation, the interface demonstrated in Brussels, and the national case studies. It sets out the scientific and practical limits that users need to consider when interpreting scenario results.



## Keywords

Policy Toolbox, emulator, surrogate model, neural network, G4M, forest carbon balance, harvest, near real-time update, EU forest policy pathways, LULUCF


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# Abbreviations

| | |
|---|---|
| **AI** | Artificial intelligence |
| **AIC** | Akaike information criterion |
| **CBM-CFS3** | Carbon Budget Model of the Canadian Forest Sector, version 3 |
| **$CO_2$** | Carbon dioxide |
| **CzSO** | Czech Statistical Office |
| **DOM** | Dead organic matter (dead wood and litter) |
| **EO** | Earth observation |
| **EU** | European Union |
| **EU-27** | The 27 Member States of the European Union |
| **FAWS** | Forest available for wood supply |
| **FERS** | Forest Environmental Research and Services Ltd |
| **FINTGAI** | Ratio of harvest to gross annual increment (Czech emulator) |
| **Fr** | Fellings intensity, fellings divided by net annual increment (Italian emulator) |
| **G4M** | Global Forest Model (IIASA) |
| **GA** | Grant Agreement |
| **GAI** | Gross annual increment |
| **GHGI** | Greenhouse gas inventory |
| **GUI** | Graphical user interface |
| **HR** | Harvest ratio, harvest divided by increment (Irish emulator) |
| **HWP** | Harvested wood products |
| **IEEP** | Institute for European Environmental Policy |
| **IFER** | Institute of Forest Ecosystem Research |
| **IIASA** | International Institute for Applied Systems Analysis |
| **LULUCF** | Land use, land-use change and forestry |
| **MLP** | Multilayer perceptron (feed forward neural network) |
| **NAI** | Net annual increment |
| **NFI** | National forest inventory |
| **NRMSE** | Normalised root mean square error |
| **NSE** | Nash Sutcliffe efficiency |
| **OLS** | Ordinary least squares |
| **$R^2$** | Coefficient of determination |
| **RCP** | Representative Concentration Pathway |
| **RMSE** | Root mean square error |
| **RS** | Remote sensing |
| **SSP** | Shared Socioeconomic Pathway |
| **UNFCCC** | United Nations Framework Convention on Climate Change |
| **WMAPE** | Weighted mean absolute percentage error |
| **WP** | Work package |

# 1. Introduction

The ForestNavigator project develops EU and national forest policy pathways using detailed models operated at National and EU scale as part of the EU and National Policy Modelling Toolbox, including G4M, GLOBIOM and national CBM-CFS3 applications. The projected pathways depend on the status and future forest growth, harvest, climate impacts, natural disturbance and policy assumptions used in each simulation in the models. Updating these assumptions requires the modelling teams to prepare, run and check a new set of simulations.

In the last decade we have observed events that have strongly modified the status of EU forests and their $CO_2$ removals/emissions. Among these events, natural disturbances can rapidly change the assumptions behind a forest policy pathway. For example, in the Czech Republic, during the bark-beetle outbreak harvest rose from about 16 million $m^3$ in 2015 to 32.6 million $m^3$ in 2019 as an effect of the increased salvaging of damaged wood (Czech Statistical Office, 2020). Such rapid changes can affect forest carbon stocks and $CO_2$ removals, modifying in the short- and medium-term achievable policy targets. Policy makers therefore need timely estimates of how changes in forest status and other modelling assumptions affect the potential pathways.

Task 8.3 aimed to demonstrate how projected forest carbon pathways could be updated to identify deviations from reference trajectories and inform timely adjustments to forest policies. The aim was to capture changes in key drivers of forest carbon dynamics, including forest increment, harvesting and natural disturbances, and assess how these changes could affect progress towards EU and national climate mitigation objectives. The initial plan of this task was to explore how new Earth Observation (EO) and statistical data could be assimilated into forest models to enable near-real time updates of projected forest carbon pathways, and this approach was motivated partly by the significant time lags associated with national forest inventory compete data cycles, which underpin many forest sector models. However, discussions among the modelling partners identified several methodological and practical challenges. First, the availability, timeliness and consistency of EO and statistical datasets vary considerably across countries. Although satellite observations may be acquired relatively frequently, the processing, interpretation and validation required to produce datasets suitable for forest carbon modelling can introduce substantial delays. Consequently, the availability of near real time observations does not necessarily translate into near real time information that can be directly incorporated into forest models. Second, the EU-level G4M model and the national CBM models differ in their structures, input requirements and representation of forest dynamics. This complicates the development of a common data assimilation approach that could be consistently applied across the different modelling frameworks. A further consideration was that the modelling teams had already incorporated the most recent suitable data available through earlier ForestNavigator activities, particularly Tasks 2.3 and 2.4 and the development of the reference projections under Task 8.1. Repeating this exercise within Task 8.3 would therefore offer limited additional insights. Given the challenges associated with the use of EO products for approximating in near real time forest harvest levels, as demonstrated in the testing of their integration in the CBM models under Task 2.4, the proposed demonstration also risked becoming a retrospective comparison of model outputs rather than a meaningful demonstration of near real time updating. In response to these challenges, the Task 8.3 partners collectively agreed to refocus the task on developing a simplified, model-based approach capable of reproducing how forest carbon sinks respond to changes in key drivers, for

imitating changes in forest conditions. The revised approach centred initially on establishing statistical relationships between harvesting levels and forest carbon outcomes, using outputs from the existing forest models. Harvesting was identified as a particularly relevant variable because it is an important driver of forest carbon dynamics and can be influenced by policy and management decisions. The intention was to develop a practical tool through which users could explore how changes in harvesting assumptions might affect projected forest carbon sinks, without requiring a new run of the underlying forest models for each harvest adjustment.

This approach also retained an important element of the original task: the ability to assess deviations from projected forest carbon pathways. In particular, the Task 8.1 reference projection was identified as the appropriate baseline against which alternative harvesting assumptions could be compared. The simplified relationships could be evaluated against existing model simulations to assess how reliably they reproduced the underlying models' responses. The partners also recognised that other factors, particularly large-scale natural disturbances and climate change, could affect these relationships and would need to be considered when interpreting the results and defining the tool's limitations. This revised direction ultimately led to the development of the proposed Emulator, this tool offers an accessible way to explore the sensitivity of modelled forest carbon outcomes to changes in selected assumptions. It therefore addresses the broader objective of Task 8.3 in supporting timely assessment of changes in forest carbon pathways and their implications for policy through a more feasible and transparent approach, while building directly on the modelling work undertaken elsewhere in ForestNavigator.

The ForestNavigator Emulator provides this interactive component of the Policy Toolbox. Users specify a change in harvest from a selected year and obtain estimates of realised harvest, forest area and the modelled carbon balance for individual countries or a European aggregate. Its main benefits are:

- **Speed:** rapid scenario calculations. The recorded median model inference time was 0.015 seconds on the evaluation hardware, excluding browser and network overhead.
- **Consistency:** a surrogate fitted to the G4M simulations used for the ForestNavigator pathways, with performance evaluated on withheld scenario trajectories.
- **Access:** a browser interface with documentation of its scope, evaluation and limitations.
- **Transparency:** comparison with a reference path and downloadable scenario results and evaluation statistics.

Chapter 2 explains the Policy Toolbox, the emulation approach, the G4M method and evaluation, the national regressions that were tested and withdrawn, and the interface and its limitations. Chapter 3 documents the Brussels demonstration and the lessons learned. Chapter 4 draws conclusions from that work.

# 2. The ForestNavigator Toolbox and Emulator

## 2.1. The ForestNavigator Policy Toolbox

The ForestNavigator Policy Toolbox comprises the project's modelling infrastructure and the interfaces through which its results are accessed and explored. The detailed models calculate the policy pathways, the Portal disseminates them, and the Emulator supports rapid tests of selected changes. These functions are complementary:

- The EU and National Policy modelling toolbox hosting the EU forest sector model GLOBIOM-G4M-X and the National Policy modelling toolbox hosting the National Policy Models (CBM-CZ, CBM-IE, CBM-IT, and HEUREKA)
- ForestNavigator Portal, with its Data Explorer and Pathways Explorer, which publishes the harmonised data and the pathways computed with the EU and National Policy modelling toolboxes in WP6-WP7- WP8, and
- ForestNavigator Emulator (this report), which estimates the G4M response in near real time when harvest deviates from the one included in the original fully modelled pathway, holding other pathway assumptions fixed.

The Portal provides access to the modelled pathways, while the Emulator allows users to investigate specified departures from their harvest assumptions. Both interfaces featured in the ForestNavigator Final Event programme reproduced in the Annexes.

## 2.2. Using emulated harvest responses for near real time updates

Updating harvest information and rerunning a full forest model requires new national statistics or remote sensing estimates to be harmonised with the model's inputs before a simulation can be run and checked. Suitable estimates are not always available in time for a rapid policy assessment, and differences in definitions and processing must first be resolved.

The emulator approximates the response to a changed harvest assumption using a statistical relationship fitted to G4M simulations. A new input path can therefore be evaluated rapidly while retaining the other assumptions represented in the source simulations. This is scenario updating through emulation. It estimates the parent model's response to a specified deviation and it does not assimilate new observations into model states or combine observational and model uncertainties. The distinction defines what the rapid calculation can support: screening the consequences of a changed assumption before a more detailed modelling assessment.

## 2.3. The G4M Emulator

Each model summarised in this report is documented in full, including its driving equations, on the emulator platform's own Documentation page (Annex).

### 2.3.1. The G4M model

G4M is a spatially explicit forest and land-use model developed at IIASA. Its land-use component compares economic returns from forestry and alternative uses, including carbon price effects (Kindermann et al., 2006, 2008). Forest management is represented through stand age, stocking, productivity and rotation decisions, with management adjusted to country level harvest targets

(Gusti, 2010; Gusti and Kindermann, 2011). The full model generates forest area, harvest, biomass and carbon fluxes. The Emulator approximates selected country level outputs from these simulations. Its user-controlled harvest and climate inputs do not reproduce all of the parent model's land-use and policy decisions.

### 2.3.2. Training data

The dataset contains 17 G4M trajectories (Table 1): the no-additional-policy Baseline from D6.3, the Reference Policy Scenario and eight climate variants from D8.1, and seven harvest sensitivity trajectories supplied from the D7.1 modelling work. The D6.3 Baseline and D8.1 Reference are distinct pathways with different policy assumptions. The sensitivity simulations were reused from D7.1 and they were not new full model experiments generated for this deliverable.

The climate runs combined two climate models, two Shared Socioeconomic Pathways and the inclusion or exclusion of $CO_2$ fertilisation. The dataset covered the EU-27 and the United Kingdom and contained 51,996 country-year rows and 149 G4M output variables. The D6.3 Baseline covers 1990-2070 and the other trajectories extend to 2100.

In harvest experiments, afforestation and deforestation remained on their prescribed reference trajectories and they were not recalculated in response to harvest. Increment was not fixed as an output: G4M's management and stand development responses were represented indirectly in the fitted increment, rotation and carbon outputs. The 2020 growth indicators used to construct predictors remained initial condition features, rather than new user controls.

Lastly, the principal G4M experiment changed the harvest demand path once, from the selected year onward, retaining the calibrated annual pathway shape thereafter. It is a sustained departure rather than a one-year mortality pulse. A pulse requires a later reversal or an explicitly prescribed recovery sequence. Such multiple change paths were not part of the withheld-scenario evaluation and are diagnostic only.

*Table 1: G4M scenario trajectories used to train and test the Emulator*

| Source | Trajectories | Content | Role |
|---|---|---|---|
| ForestNavigator D6.3 | 1 | Baseline pathway, no climate change | Training |
| ForestNavigator D8.1 | 1 | Reference pathway, no climate change | Training |
| ForestNavigator D8.1 | 8 | Climate runs: GFDL-ESM4 and UKESM1-0-LL, SSP2-4.5 and SSP3-7.0, with and without $CO_2$ fertilisation | Training |
| ForestNavigator D7.1 harvest sensitivities | 3 | high2, high3, low3 | Training |
| ForestNavigator D7.1 harvest sensitivities | 2 | base1, low2 | Validation (checkpoint selection, early stopping) |
| ForestNavigator D7.1 harvest sensitivities | 2 | high1, low1 | Final test (never seen in training) |

### 2.3.3. Emulator design

Figure 1 summarises the design of ForestNavigator Emulator. Each country-year observation has 213 predictors: requested roundwood and logging residue demand; afforestation and deforestation inputs; country, year and climate descriptors; driver lags of 1, 2, 5, 10, 20, 30 and 50 years; moving averages and cumulative deviations; and physical stock and growth proxies. The

2020 initial state features comprise total, old and new forest area; aboveground biomass in managed and afforested forest; old and new forest dead wood and litter; current and net annual increment; and average rotation lengths. Rotation and growth indicators convey age related information, but the Emulator does not simulate an explicit stand age distribution.

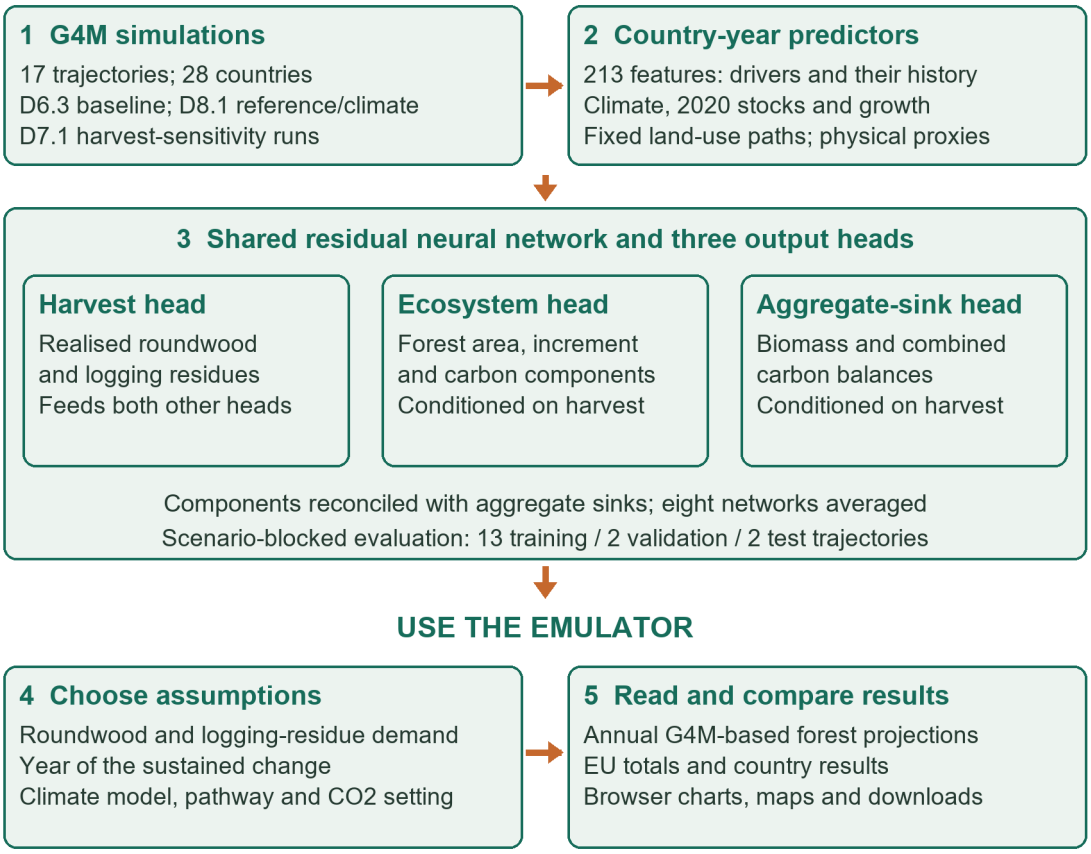



*Figure 1: Training flow and use of the ForestNavigator Emulator*

The neural network has a shared residual trunk and three prediction heads. The harvest head predicts realised roundwood and logging residue extraction. The ecosystem head predicts the remaining G4M variables using the shared features and predicted harvest. A third head uses the same inputs to predict aggregate living biomass and combined carbon balances directly. The component estimates are reconciled with those aggregate predictions (Table 2).

For selected outputs, the network predicts a deviation from a known baseline: realised harvest relative to requested demand, and total forest area relative to its 2020 value. Training estimates the mapping from predictors to these deviations. Forest area is therefore a predicted output, while the afforestation and deforestation inputs retain their prescribed paths. Small differences in predicted area should not be interpreted as a new land-use decision caused by a harvest experiment.

Non-negative bounds and country specific structural zeros constrain the outputs. For selected growth rate features, exceptionally low or sign reversed 2020 values are replaced by a median calculated from pre-2020 data. Saturating growth proxies limit the extrapolation of a constant initial growth rate. These constraints reduce implausible behaviour but do not establish accuracy beyond the evaluated scenarios. Training uses AdamW (Loshchilov and Hutter, 2019) and a weighted Huber loss (Huber, 1964), with additional terms for total harvest and aggregate carbon balances. Predictions are averaged across eight independently seeded networks.

*Table 2: Production configuration of the G4M Emulator*

| Characteristic | Production configuration |
|---|---|
| Spatial and temporal scope | 28 countries (EU-27 and United Kingdom). Annual data from 1990, with the WP6 reference ending in 2070 and the other trajectories ending in 2100. |
| Predictors | 213 country-year predictors; 149 G4M target variables |
| Core network | Shared residual multilayer perceptron (MLP) trunk, width 384, depth 5 |
| Output structure | Harvest, ecosystem and aggregate-sink heads; the latter two use predicted harvest. Head depth: 3. |
| Stabilisation | Linear skip paths, 2% dropout, robust feature scaling |
| Physical structure | Residual targets, structural zeros, hard non-negative bounds |
| Production ensemble | Eight independently seeded networks, averaged at inference |
| User controlled dimensions | Roundwood and logging residue demand, change year, climate model, pathway and $CO_2$ fertilisation |

### 2.3.4. Validation results

Complete scenario trajectories were separated before fitting: 13 were used for training, two for validation and the high1 and low1 harvest sensitivity trajectories for testing. No years from either test trajectory were included in fitting or checkpoint selection. The test trajectories nevertheless share historical conditions and modelling assumptions with the training simulations.

The reported test metrics cover the period 2020-2100, with 4,536 country-year values per output. All predefined acceptance checks were passed (Table 3). These tests assess agreement with G4M on two withheld harvest sensitivity pathways. They do not however, validate G4M against independent forest observations or establish the accuracy of new climate harvest combinations, repeated shocks or disturbances outside the training design.

After evaluation, the production ensemble was refitted on all 17 trajectories to use the available model information. The held-out scores describe the evaluation ensemble and should not be interpreted as an independent test of the final refitted production ensemble.

*Table 3: Emulator accuracy on the two held-out G4M trajectories*

| Output | $R^2$ | WMAPE | NRMSE | Gate metric and limit | Result |
|---|---|---|---|---|---|
| Total forest area | 0.99999 | 0.14% | 0.29% | WMAPE ≤ 2% | Pass |
| Roundwood harvest | 0.99996 | 0.42% | 0.94% | WMAPE ≤ 3% | Pass |
| Total wood harvest | 0.99989 | 0.47% | 1.62% | WMAPE ≤ 3% | Pass |
| Extracted logging residues | 0.99616 | 1.96% | 11.29% | WMAPE ≤ 5% | Pass |
| Living biomass sink | 0.99639 | 4.49% | 9.40% | NRMSE ≤ 18% | Pass |
| Total forest carbon sink | 0.99512 | 4.95% | 11.95% | NRMSE ≤ 18% | Pass |

Note: the coefficient of determination ($R^2$) describes the fraction of variation explained. Weighted mean absolute percentage error (WMAPE) is the sum of absolute errors divided by the sum of absolute G4M values. Normalised root mean square error (NRMSE) is the root mean square error (RMSE) divided by the G4M interquartile range. The high pooled $R^2$ values should be read alongside the error measures: the combined carbon balance has an NRMSE of 11.95%, and the errors for individual countries or years may differ from the pooled values.

Figure 2 compares G4M and Emulator totals for the 28 countries on the two test trajectories. Total wood harvest, including extracted logging residues, approaches about 780 million $m^3$/year on the higher path and 530 million $m^3$/year on the lower path. The Emulator follows the parent model harvest and carbon balance trajectories, including their change around 2030. Figure 3 shows the corresponding country-year comparisons.

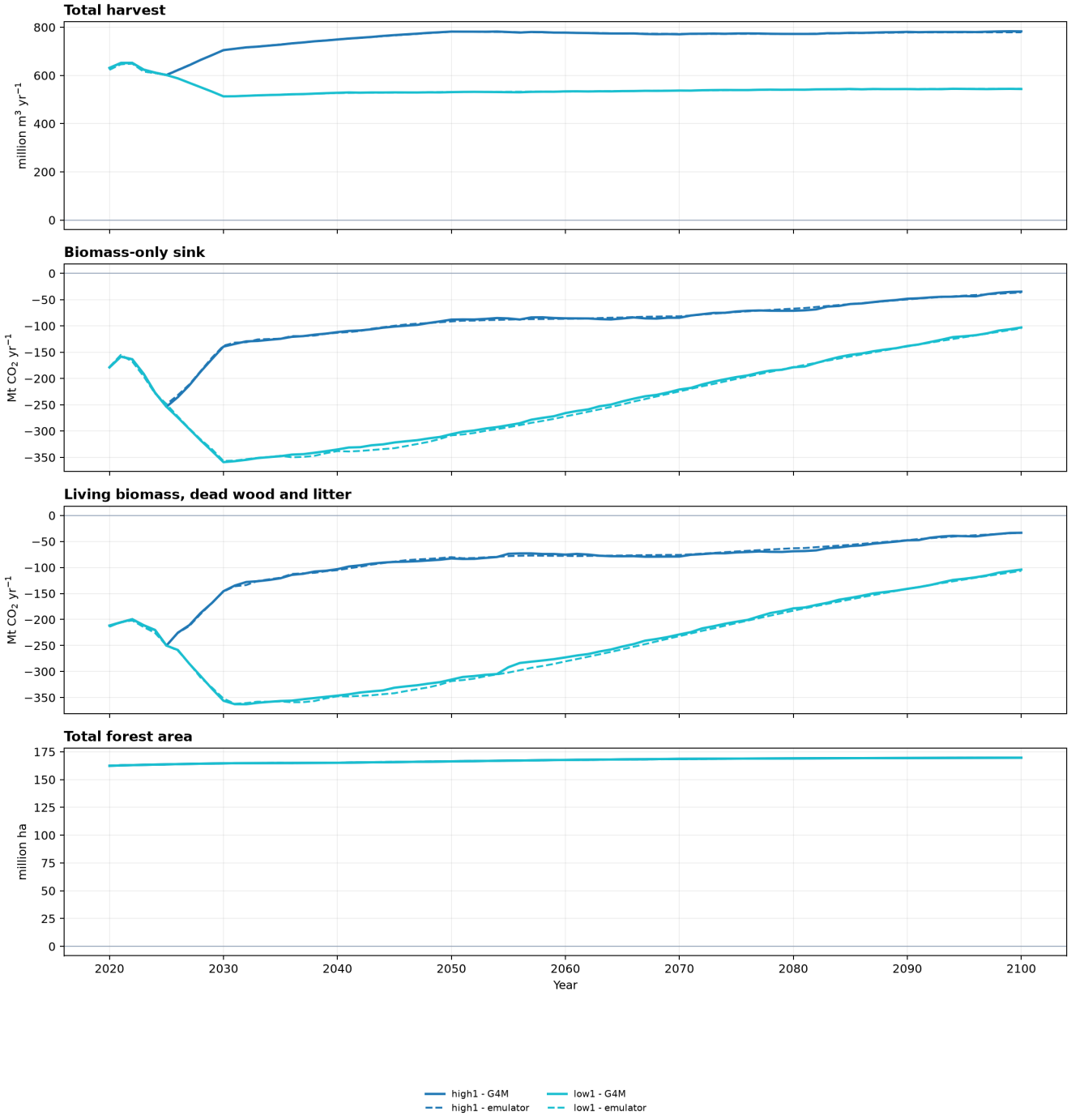



*Figure 2: Totals for 28 modelled countries: G4M (solid) and Emulator (dashed)*

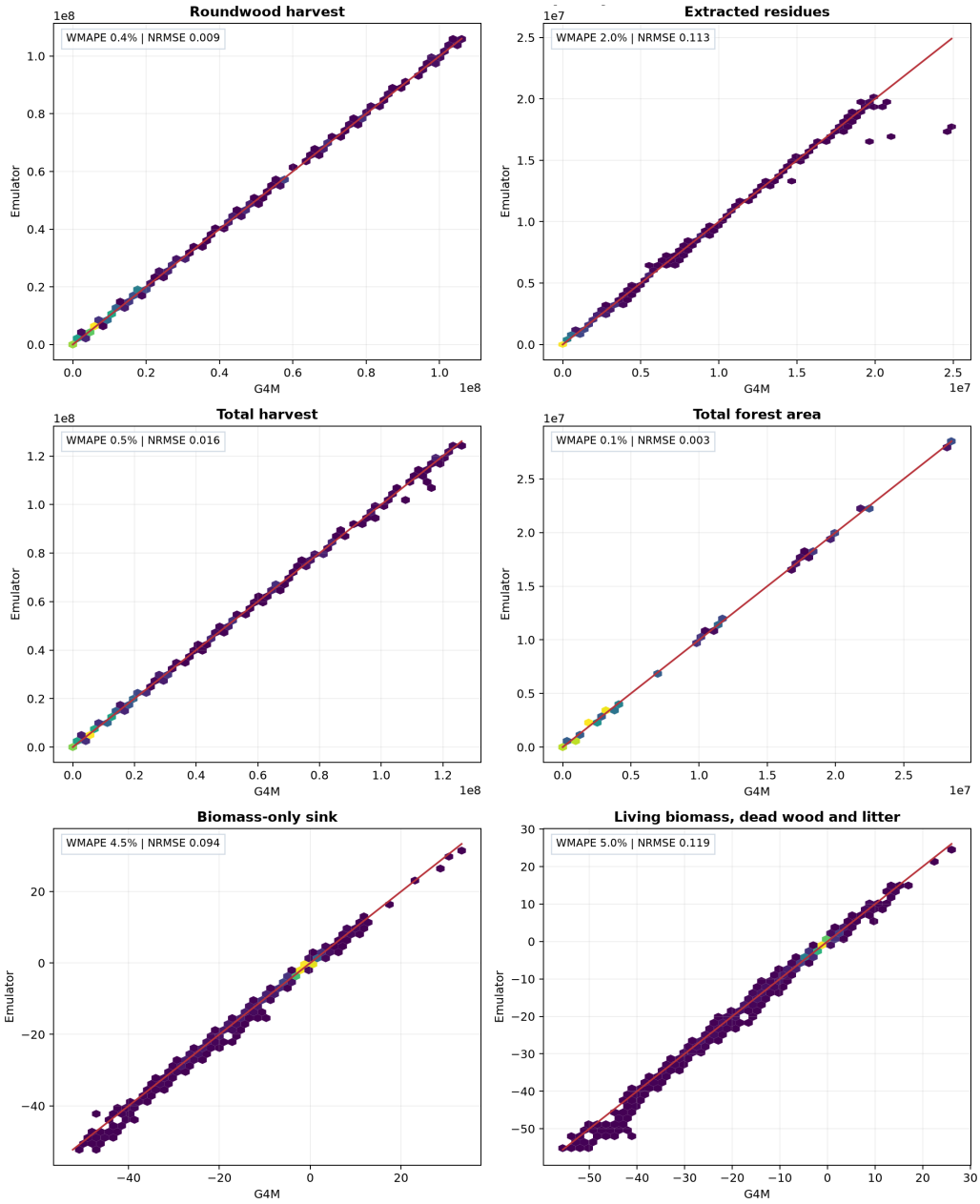



*Figure 3: Emulator against G4M, held-out trajectories*

Additional checks examine errors by scenario, country and period. Across the two withheld pathways, the largest scenario-level NRMSE was 9.0% for the combined carbon balance and 7.5% for living biomass and the largest scenario-level total harvest WMAPE was 0.47%. At the 90$^{th}$ percentile of country level errors, total harvest WMAPE was 1.05% and combined balance NRMSE was 7.75%. These results support rapid screening of the G4M response within the tested harvest scenarios, with greater caution for individual countries and longer horizons. The median calculation time was 0.015 seconds over five repetitions of a 3,108-row, 28-country projection, excluding browser and network overhead.

Relative carbon balance error increases over the projection horizon. For the combined balance, pooled country-year WMAPE is 2.75% in 2020-2030, 3.86% in 2031-2050, 5.39% in 2051-2070 and 7.44% in 2071-2100. Figure 4 shows annual errors for both test pathways and the period summary. Errors do not increase every successive year, and aggregation can offset country errors. The 2024-

2050 window illustrated in this report is therefore a cautious focus on mid-century screening, rather than a claim that the trained model has no later year outputs.

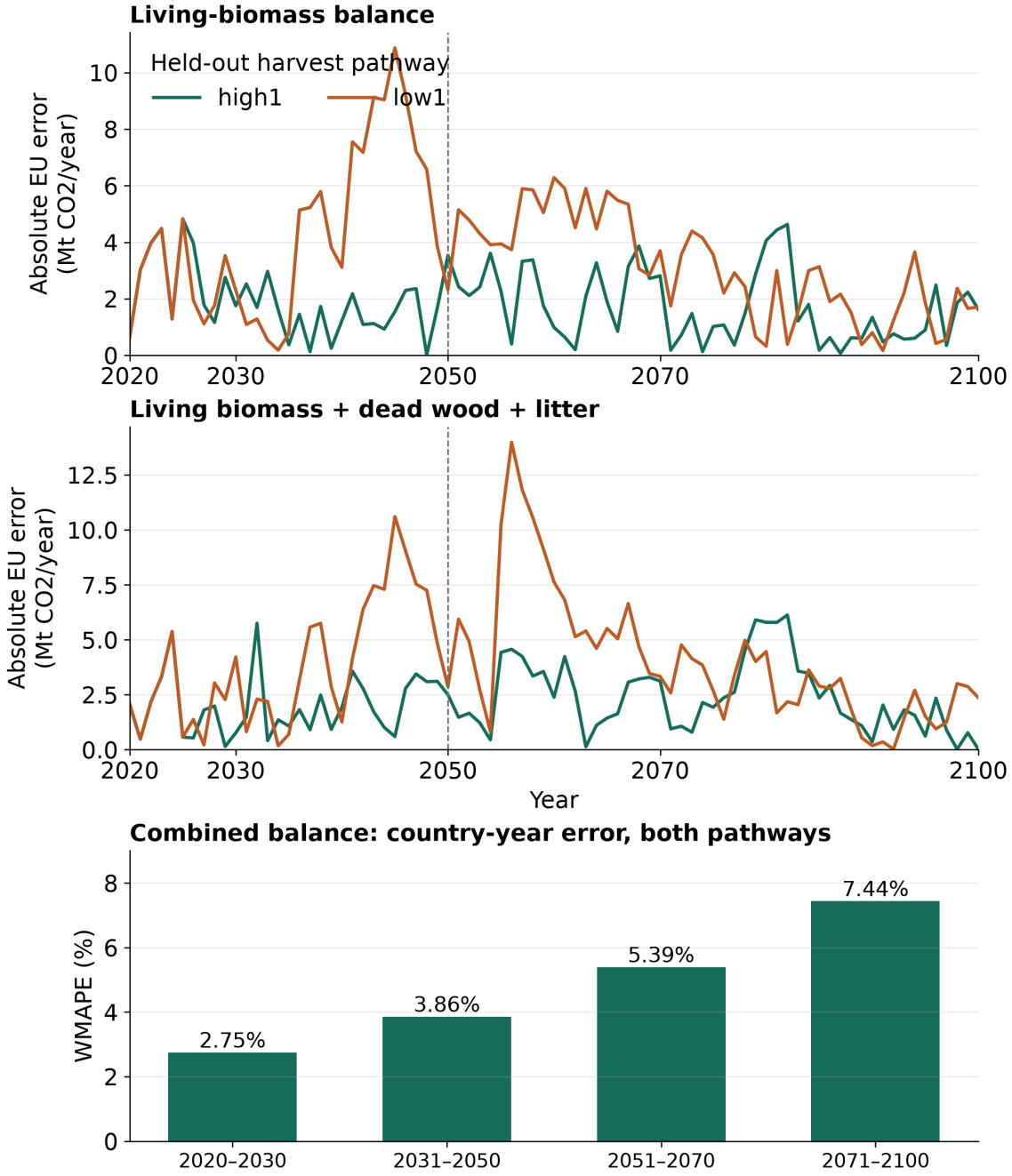



*Figure 4: Held-out carbon balance errors over the projection horizon*

Note: upper panels show absolute differences between the summed 28-country Emulator and G4M results for high1 and low1. The dashed line marks 2050. The lower panel reports weighted mean absolute percentage error across country-year values for both pathways. Country errors can offset when aggregated.

## 2.4. National CBM-CFS3 emulators: tested and withdrawn

The original intention was to develop emulators for G4M and the national CBM models. The national teams therefore fitted statistical approximations to their country-specific CBM-CFS3 simulations. CBM-CFS3 represents forest biomass, dead organic matter (DOM) and soil carbon dynamics (Kurz et al., 2009). The underlying national applications are described by Cienciala and

Melichar (2024) and Augustynczik et al. (2025) for the Czech Republic, Black et al. (2025) for Ireland, and Pilli et al. (2026) for Italy. The Italian study is a research application and is not identical to the official Italian greenhouse gas inventory method. Similarly, the Czech application reflects the ongoing research effort to fully incorporate the NFI-based information to the CBM-CFS3 model to be applied for the coming national GHG inventory submissions to EU and UNFCCC. Hence, the output may differ from the national GHG inventory reports released so far. As part of this work, country modellers fitted regressions to the national living biomass carbon balance using harvest intensity ratios and, where selected, other predictors (Table 4). The statistical emulators were integrated into the interface and used for the Emulator Demonstration in Brussels.

*Table 4: National CBM-CFS3 emulators tested in Task 8.3*

| | Czech Republic | Ireland | Italy |
|---|---|---|---|
| Team | IFER (Emil Cienciala) | FERS (Kevin Black) | Roberto Pilli |
| Predictor | FINTGAI: harvest divided by gross annual increment, with a linear year term for the all species model | HR: harvest / increment, by broadleaf and conifer, and conifer harvest volume | Fr: merchantable fellings divided by net annual increment on FAWS, with a quadratic time trend |
| Method | OLS on 2011 to 2024 | Stepwise regression using the Akaike information criterion (AIC), by species group | Two-phase OLS: harvest effect from 2005 to 2017, trend from 2024 to 2070 |
| Output | Living biomass carbon stock change | Living biomass carbon change | Living biomass sink (optional DOM ratio) |
| Validation | All species living biomass: out-of-sample $R^2$ 0.77 to 0.92 across the policy scenario and S1 to S4 | Validation NSE 0.83 (broadleaf) and 0.96 (conifer), 2025 to 2070 | Scenario comparisons included Fr 0.10 to 0.70. Recommended use: Fr 0.10 to 0.60. Errors -4% to +6% to 2040 within that range. |
| Not represented | DOM (tested, found unreliable), HWP | DOM, HWP | DOM as a fitted pool, stochastic disturbances, HWP |

Note: the Czech pilot NFI calibration is documented in Augustynczik et al. (2025, D6.2); the Irish and Italian applications are described by Black et al. (2025) and Pilli et al. (2026), respectively. These are model specific living biomass regressions, not complete national greenhouse gas inventories.

The national regressions estimate annual living biomass carbon change. Harvest or mortality can reduce that pool by transferring carbon to dead wood, litter, soil or harvested wood products, as well as by releasing carbon directly. Subsequent decomposition delays part of the atmospheric release (Kurz et al., 2009). A living biomass loss therefore cannot be treated entirely as an immediate emission. The Czech tests did not support a reliable DOM regression with the same predictors. The Italian tool offered an optional scenario-derived DOM ratio, which is a proxy rather than an independently fitted multi pool emulator.

After the demonstration, the national teams and task leader agreed to withdraw the CBM regressions from the released interface. Their living biomass outputs could be mistaken for whole forest emissions or removals, or could be compared with the broader G4M balance despite differing pool coverage and evaluation methods. Section 3.2 documents the national analyses and the lessons learned.

The retained G4M output combines living biomass, dead wood and litter for forest remaining forest and afforested land. It excludes soil carbon, harvested wood products and emissions from deforestation, and no statistical correction to greenhouse gas inventory levels is applied to the balance evaluated and reported here. In this G4M setup, forest management soil carbon changes are not explicitly represented; soil outputs associated with land-use conversion are outside the

reported aggregate. This defined forest category balance must therefore be distinguished from a complete inventory total.

## 2.5. Handbook for using the Emulator

The Emulator is accessed at https://fn-emulator.wkube.iiasa.ac.at/. The version illustrated in this handbook displays 2024-2050 and compares scenarios with a reference path. Figure 5 shows the Home page, which introduces the tool and provides an entry button. After entering G4M, the sidebar provides five pages: Dashboard, Create Scenario, Compare Scenarios, Documentation and Settings.

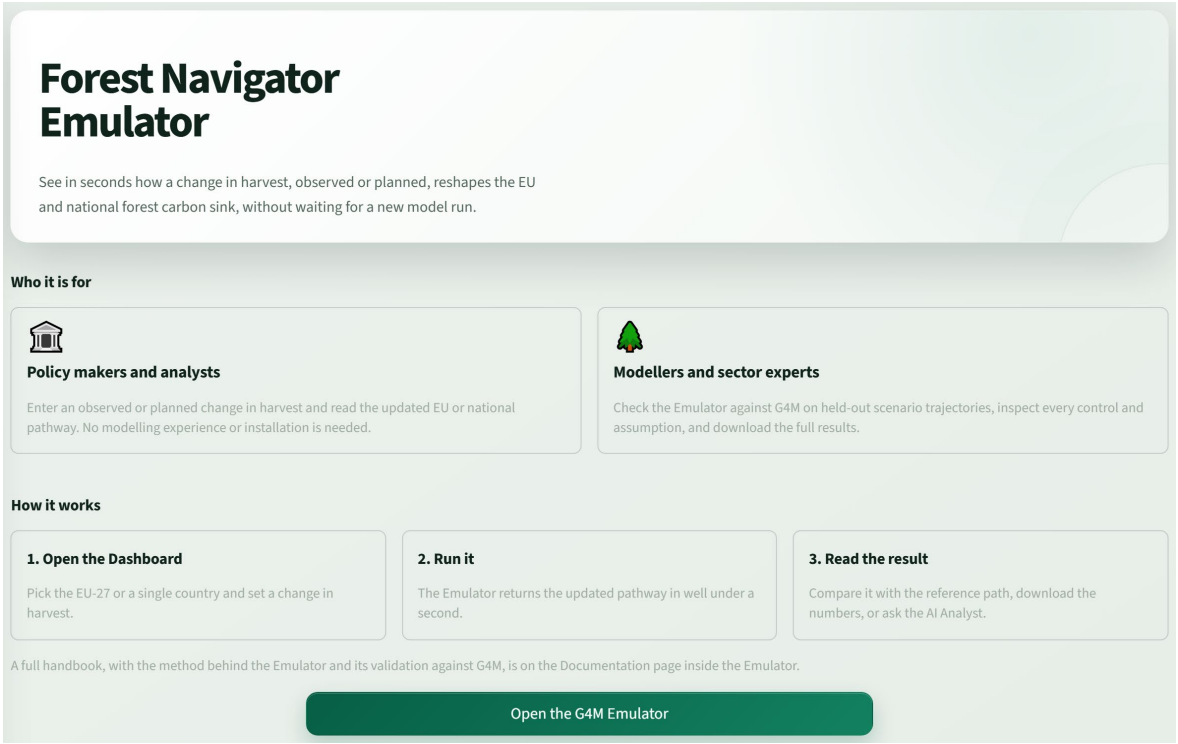



*Figure 5: Home page of the ForestNavigator Emulator*

### 2.5.1. Running a scenario on the Dashboard

The Dashboard provides a quick test of a sustained change in harvest demand. Figure 6 shows an EU-27 experiment in which roundwood demand moves to the upper end of the calibrated sensitivity range from 2030. The numbered controls correspond to the steps below.

1. **Geography (1).** Select the EU-27, the EU-27 and the United Kingdom, or a single country. For a single country, the change is applied to that country only.
2. Input type (2). Express the change as a normalized coordinate from -1.00 to +1.00, with 0 denoting the reference and the endpoints denoting the calibrated low and high paths. Absolute input is in million $m^3$/year at the selected geography and change year. The multiplier control is another interface representation of the same calibrated path coordinate; it should not be read as an exact multiplier of realised harvest in every year.
3. Change year (3). Set when the new harvest demand path starts, within the illustrated 2024-2050 window. Earlier years retain the reference path.
4. **Roundwood harvest (4) and extracted logging residues (5).** Set the change for each harvest component.

5. **Run Simulation (6).** The results appear within seconds.
6. **Read the results (7, 8).** Choose the harvest and sink variables and switch between absolute values and the change from the reference. The dashed line is the reference path.

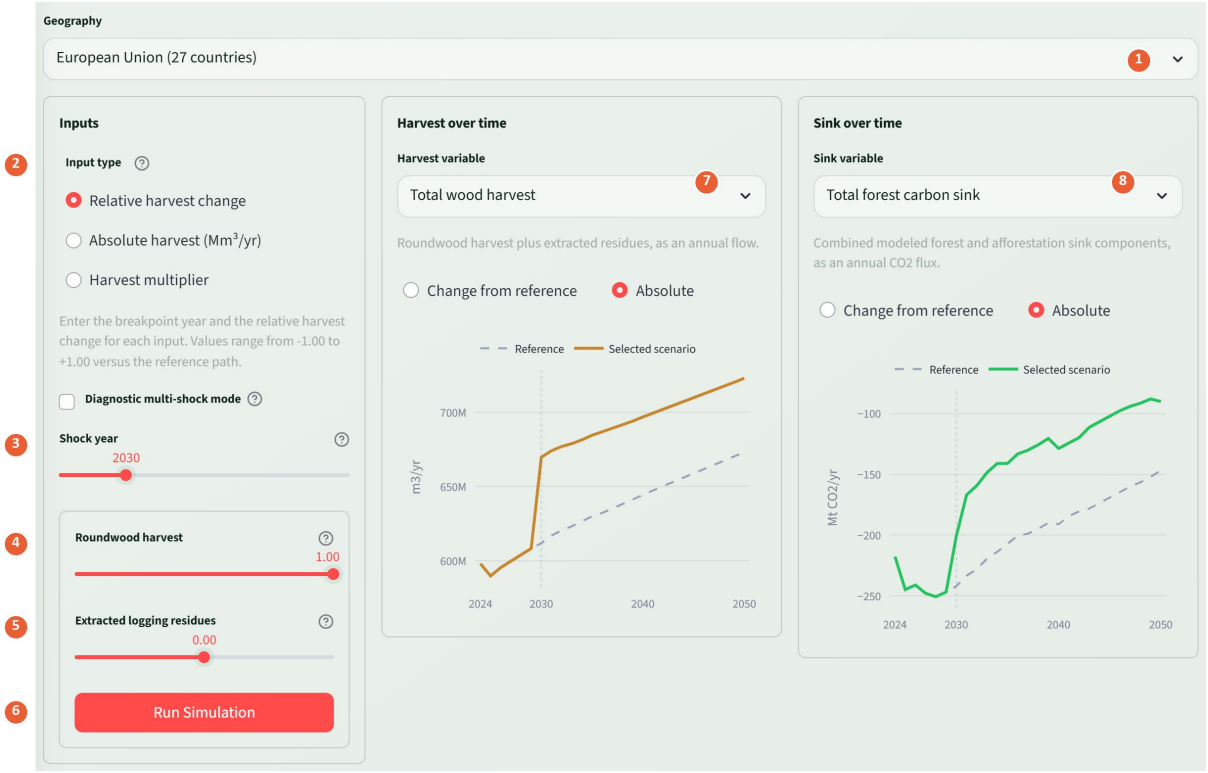



*Figure 6: Dashboard: EU-27 roundwood harvest +1.00 from 2030*

In the illustrated experiment, EU-27 harvest rises from 2030 and the modelled carbon sink weakens: the 2050 balance is about -90 Mt $CO_2$/year, compared with -147 Mt $CO_2$/year in the reference. Negative values denote removals and positive values emissions for the included pools. A map and country ranking show outputs for a selected year (Figure 7), and another chart plots two variables together. These values combine living biomass, dead wood and litter without an inventory level statistical correction; and they are not total forest land greenhouse gas inventory estimates.

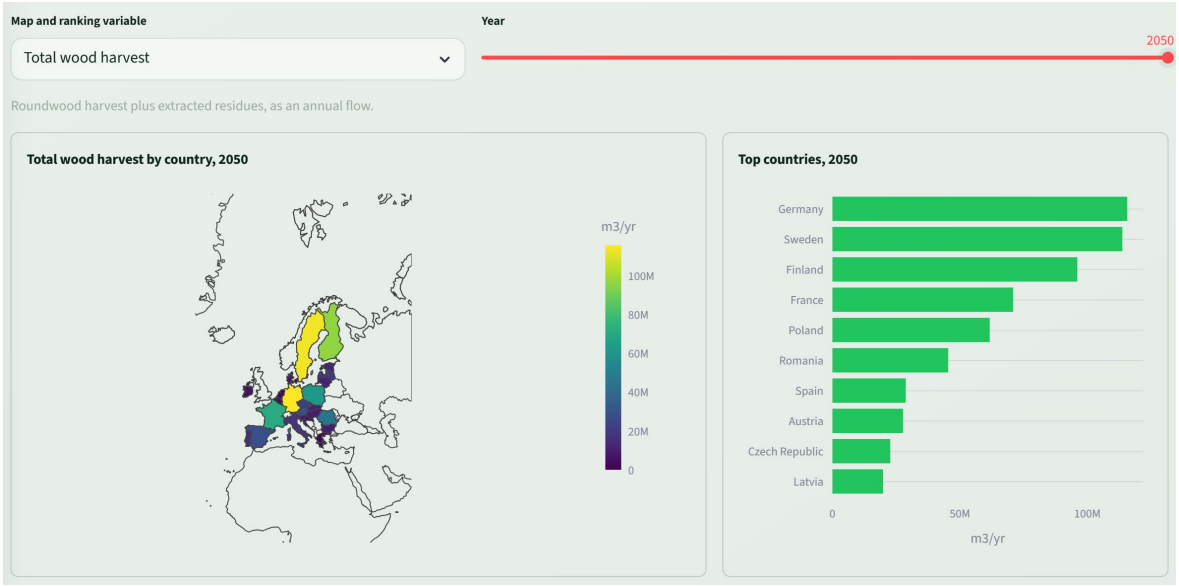



*Figure 7: Dashboard map and country ranking (total wood harvest in 2050)*

## 2.5.2. Climate assumptions: Create Scenario

Create Scenario adds climate assumptions (Figure 8): GFDL-ESM4, UKESM1-0-LL or no climate change; SSP2-4.5 or SSP3-7.0; and $CO_2$ fertilisation. The same-climate reference retains those settings and resets roundwood and extracted logging residue changes to zero. Comparing a scenario with that reference isolates the harvest change from the selected climate assumptions.

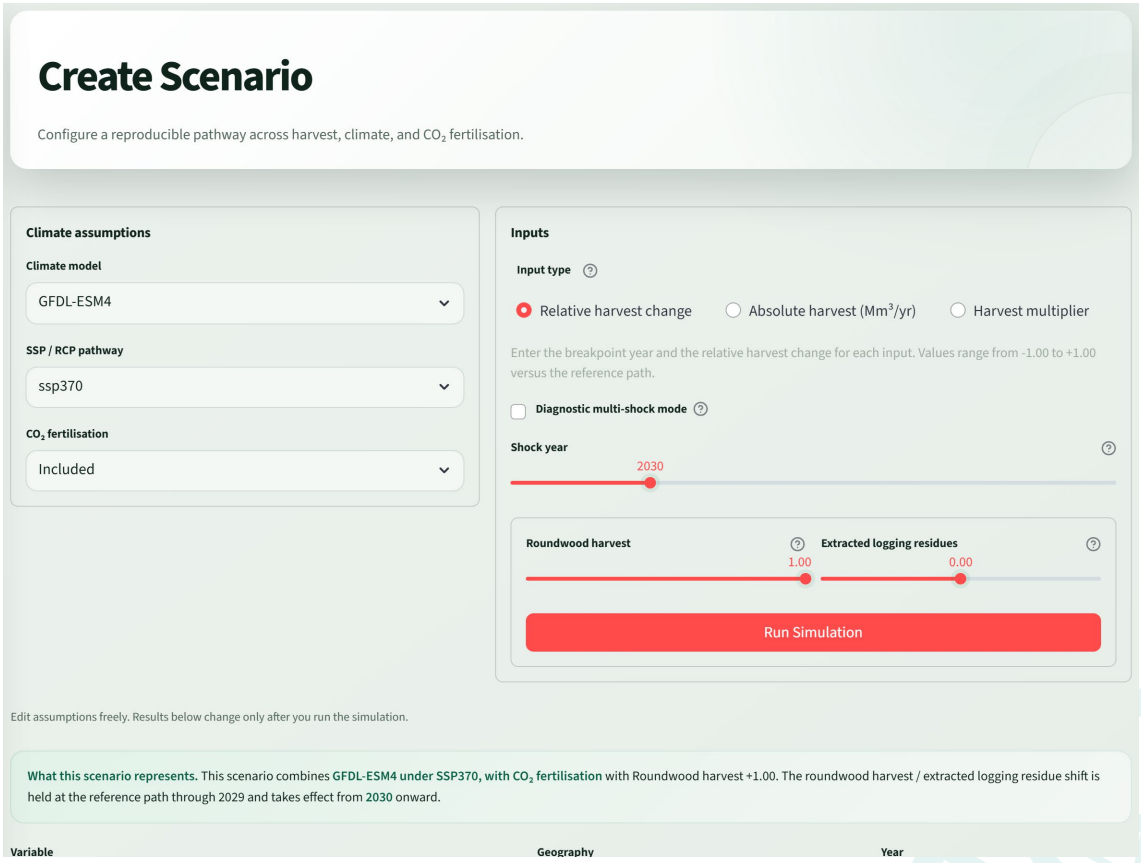



*Figure 8: Create Scenario: GFDL-ESM4, SSP3-7.0, roundwood harvest +1.00*

### 2.5.3. Comparing two pathways: Compare Scenarios

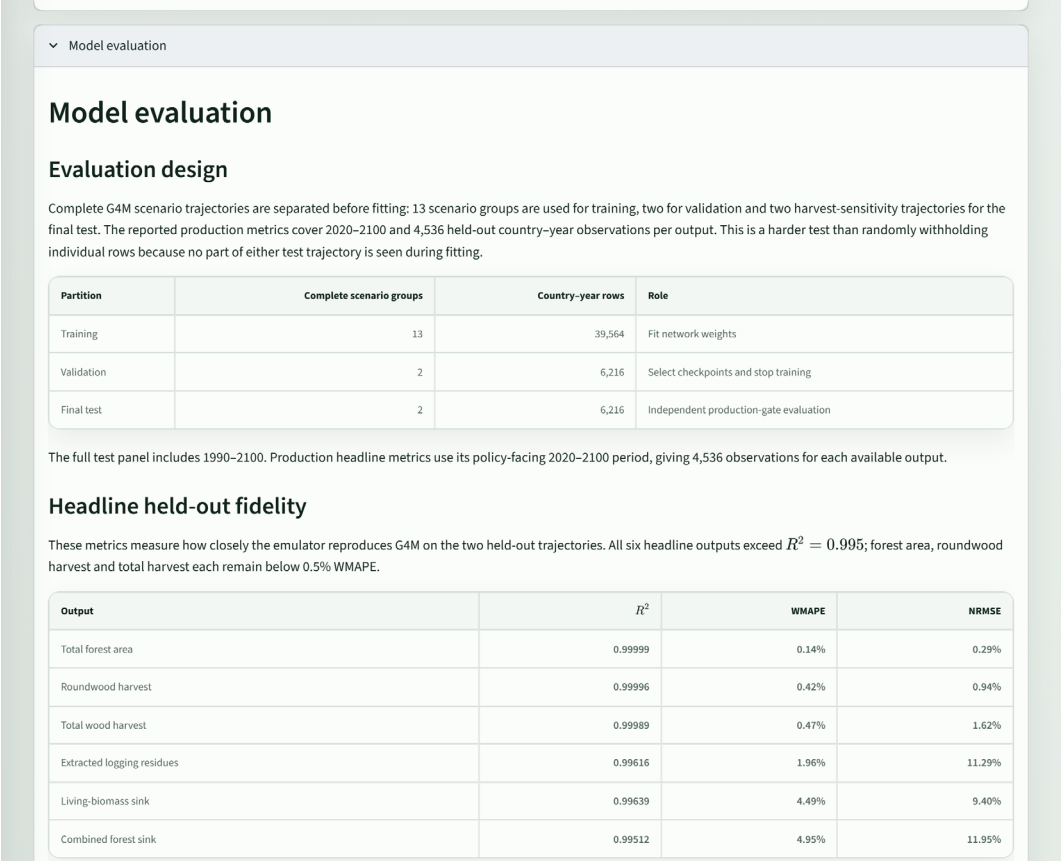
Compare Scenarios runs pathways A and B with separate climate and harvest assumptions and a shared or separate change year. Figure 9 compares upper (+1.00) and lower (−1.00) roundwood demand settings for the EU-27 from 2030, with no climate change and unchanged logging residue extraction settings. The combined living biomass, dead wood and litter balance in 2050 is about -90 $MtCO_2$/year in A and -328 $MtCO_2$/year in B. Both are G4M-based balances for the same included pools and neither is an inventory adjusted total.




*Figure 9: Compare Scenarios: EU-27 sink, harvest +1.00 (A) and -1.00 (B)*

### 2.5.4. Further functions

- **Diagnostic multi-shock mode** applies more than one change in harvest demand settings, for example an increase followed by a return toward the reference. These sequences were not used in the held-out validation and are exploratory calculations. They do not reproduce disturbance mortality, the transfer of unharvested dead trees or ecological recovery.
- **Save, load and download:** a scenario can be saved and reloaded, and all results can be downloaded as a table.
- **AI Analyst:** an optional assistant explains the interface and active results and can request another emulator scenario. Its instructions require numerical claims to use emulator outputs.
- **Documentation** (Figure 10) explains the scope, methods, evaluation, aggregation rules and limitations. Report an issue opens an email link for feedback.



Model evaluation

## Model evaluation

### Evaluation design

Complete G4M scenario trajectories are separated before fitting: 13 scenario groups are used for training, two for validation and two harvest-sensitivity trajectories for the final test. The reported production metrics cover 2020–2100 and 4,536 held-out country–year observations per output. This is a harder test than randomly withholding individual rows because no part of either test trajectory is seen during fitting.

| Partition | Complete scenario groups | Country–year rows | Role |
|---|---|---|---|
| Training | 13 | 39,564 | Fit network weights |
| Validation | 2 | 6,216 | Select checkpoints and stop training |
| Final test | 2 | 6,216 | Independent production-gate evaluation |

The full test panel includes 1990–2100. Production headline metrics use its policy-facing 2020–2100 period, giving 4,536 observations for each available output.

### Headline held-out fidelity

These metrics measure how closely the emulator reproduces G4M on the two held-out trajectories. All six headline outputs exceed $R^2 = 0.995$; forest area, roundwood harvest and total harvest each remain below 0.5% WMAPE.

| Output | $R^2$ | WMAPE | NRMSE |
|---|---|---|---|
| Total forest area | 0.99999 | 0.14% | 0.29% |
| Roundwood harvest | 0.99996 | 0.42% | 0.94% |
| Total wood harvest | 0.99989 | 0.47% | 1.62% |
| Extracted logging residues | 0.99616 | 1.96% | 11.29% |
| Living-biomass sink | 0.99639 | 4.49% | 9.40% |
| Combined forest sink | 0.99512 | 4.95% | 11.95% |

*Figure 10: Documentation page: evaluation design and held-out accuracy*

Table 5 lists the outputs available in the Emulator.

*Table 5: Outputs of the Emulator*

| Output | Unit | Definition |
|---|---|---|
| Total wood harvest | $m^3$/yr | Roundwood harvest plus extracted logging residues |
| Roundwood harvest | $m^3$/yr | Stemwood harvested from forests |
| Extracted logging residues | $m^3$/yr | Logging residues extracted from harvest sites |
| Forest area | Ha | Total forest area |
| Total forest carbon sink | Mt $CO_2$/yr | Living biomass, dead wood and litter in forest remaining forest and afforested land; no soil carbon, HWP, deforestation emissions or inventory-level correction |
| Living biomass sink only | Mt $CO_2$/yr | Living biomass of forest remaining forest and afforestation |
| Dead wood and litter sinks (diagnostic) | Mt $CO_2$/yr | Dead wood and litter, old and new forest |
| Afforestation, deforestation, net afforestation | ha/yr | Follow the reference path of the source scenario |
| Average rotation length | Years | G4M country-level average rotation length. The European display uses an unweighted country mean. |
| Harvest intensity | ratio | Total harvest divided by current annual increment in all forest or forest available for wood supply (FAWS), or by old forest net annual increment; diagnostic ratios |

### 2.5.5. HWP calculator

The emulator's net carbon balance can optionally include the harvested wood products (HWP) pool using a first-order decay function and applying the IPCC Production Approach. Historical product output, trade factors and carbon stocks are fixed to the ones of a source pathway through 2023 according to the historical semifinished products inflow reconstruction according to FOASTAT and wood trade calibrated in GLOBIOM (see D7.1, under quarantine). From 2024, product inflows are scaled by the ratio of the scenario's realised roundwood harvest to the same climate G4M reference, so only total throughput, not product mix, responds to the scenario. Each of the five product pools decays at a constant rate k = ln(2) / half-life, summed to a single country-level HWP stock and flux. Energy wood is excluded and assumed as immediate oxidation, for this reason it excludes also the carbon storage into BECCS (an option available in the original HWP calculator module).

Three resulting variables, HWP carbon stock, HWP emissions/removals and Forest + HWP balance, are available alongside the forest only outputs on the Scenario, Compare and Dashboard pages. Each is labelled '(experimental)': the coupling does not recalculate processing, trade or recycling and has not been independently validated against observed HWP statistics.

Half-life is the number of years for half of a product's stored carbon to leave the pool through use, decay or disposal. Carbon content converts each product's physical supply, in $m^3$ for the three wood volume products or tonnes for paper products and dissolving pulp, into carbon mass. All values are listed in Table 6 and shown as decay curves in Figure 11 below.

*Table 6: Reference half-life and carbon content by HWP product pool.*

| Product pool | Half-life (years) | Carbon content | Reference supply unit |
|---|---|---|---|
| Other wood biomass | 25 | 0.225 tC/m3 | 1,000 m3 |
| Sawnwood | 35 | 0.225 tC/m3 | 1,000 m3 |
| Wood panels | 25 | 0.30 tC/m3 | 1,000 m3 |
| Paper products | 2 | 0.45 tC/t | 1,000 t |
| Dissolving pulp | 10 | 0.50 tC/t | 1,000 t |

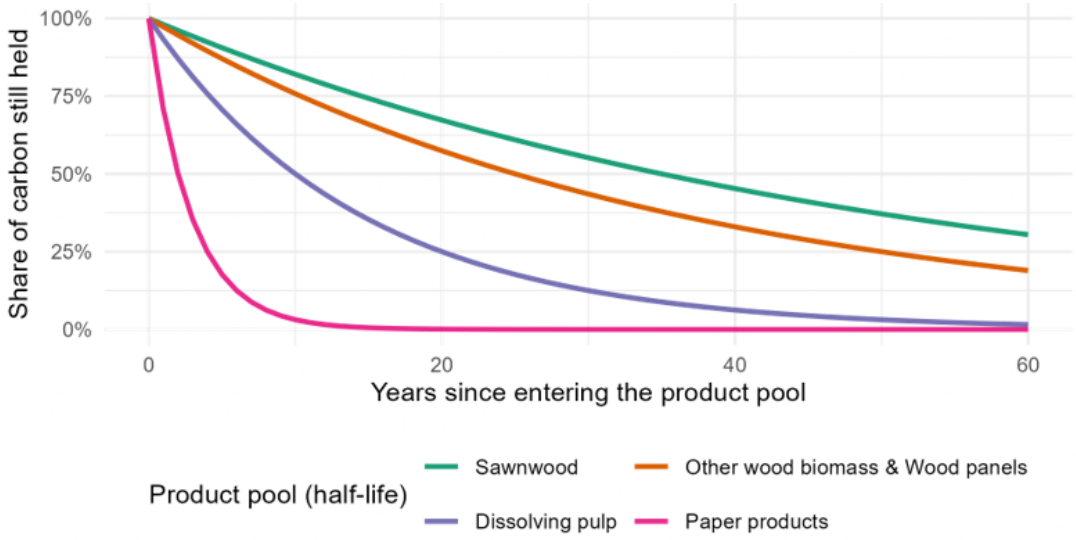



*Figure 11: Fraction of a single year's carbon inflow still held in each HWP product pool, by years since entering the pool.*

## 2.6. Limitations and important notes

The Emulator makes G4M harvest response experiments accessible within seconds, supporting rapid screening and comparison of assumptions. The following limits define how those results should be used:

- **An emulator of G4M, not a forecast.** The Emulator approximates the G4M response within the range of scenarios used to develop it. It inherits the assumptions of G4M and of the ForestNavigator scenarios, and it does not replace a full G4M run or a policy appraisal.
- **Controls.** Roundwood and logging residue demand, the year of change and climate settings are user inputs. Afforestation and deforestation retain the prescribed source paths. Annual increment and rotation length are predicted responses rather than independently controlled assumptions. Protection, restoration and explicit disturbance mortality interventions are outside these controls.
- **Tested paths.** The principal control selects a sustained change toward a calibrated low or high harvest path. Multiple changes, pulses or imposed recovery paths are exploratory: no separate full model tests establish their accuracy. Remaining within the annual volume bounds alone does not validate a new sequence of changes.
- **Carbon coverage and calibration.** "Total forest carbon sink" denotes living biomass, dead wood and litter for forest remaining forest and afforested land. Soil carbon, HWP and deforestation emissions are excluded from this aggregate. No greenhouse gas inventory statistical level shift is added. The D8.1 reporting workflow uses external HWP and statistical correction terms for its broader totals. Those totals must not be equated with this Emulator output. A fixed correction would align a level but would not supply a dynamic forest soil response to harvest.
- **Disturbances.** The interface has no separate mortality control. A harvest demand change represents altered timber removals. It does not reproduce all mortality, carbon transfers and delayed decomposition caused by a storm, drought or pest outbreak. The source G4M trajectories retain the historical conditions and prescribed disturbance assumptions used in their construction.
- **Accuracy.** Pooled held-out weighted mean absolute percentage errors are 4.49% for living biomass and 4.95% for the combined carbon balance, below 0.5% for forest area and harvest, and 1.96% for extracted logging residues. This is close agreement with G4M on the two tested pathways and supports scenario screening within that scope. Errors vary by country and horizon and the tests do not establish accuracy for every new harvest climate combination. Ensemble spread is not a calibrated confidence interval.
- **Time horizon.** The illustrated interface focuses on 2024-2050 for near and mid-century policy screening and to limit reliance on longer range approximations. Evaluation extends to 2100, but relative carbon balance error is larger at longer horizons (Figure 4): combined balance WMAPE rises from 2.75% in 2020-2030 to 3.86% in 2031-2050, 5.39% in 2051-2070 and 7.44% in 2071-2100. Annual errors are not monotonic, and passing the full horizon tests does not make all later year or user defined predictions equally reliable.

# 3. Demonstration of the Policy Toolbox and Emulator

The ForestNavigator Final Event took place in Brussels on 13 and 14 October 2026. The programme included a Toolbox demonstration on 13 October with applications for Ireland (Kevin Black, *FERS*), Italy (Roberto Pilli, *RP*) and the Czech Republic (Emil Cienciala, *IFER*), followed by an interactive Emulator session. The demonstration interface still included the national CBM regressions, which were subsequently withdrawn. This chapter records the prepared examples and their methodological lessons; the programme is reproduced in the Annex (ForestNavigator, 2026).

## 3.1. MarketPlace demonstration and case-study comparison

The WP8 demonstration plan assigned Julia Bognar (IEEP) the introduction and Andre Nakhavali (IIASA) the guided Emulator demonstration. Prepared examples explored temporary harvest pulses and sustained changes, using model specific inputs and charts. Table 7a records the calculations prepared for the demonstration; they are model experiments rather than observations of subsequent forest change.

Every example started in 2030. The two cumulative columns sum annual values from 2030 through 2050, inclusive, and subtract the row's comparison pathway from the experimental pathway. A positive carbon balance difference means less cumulative removal or more emission and a negative difference means more removal or less emission. Each row uses its own model and reference, so these differences are not a ranking of the models.

*Table 7: Demonstration examples, cumulative changes over 2030 to 2050*

| Example | Emulator | Carbon pools | Harvest assumptions | Δ harvest (million $m^3$) | Δ carbon balance (Mt $CO_2$) |
|---|---|---|---|---|---|
| 1A Czech Republic: one pulse | CBM-CZ | Living biomass | 2030 volume: 32.5 million $m^3$; comparison: 16.0. Three-year recovery profile. | +32.5 | +52.8 |
| 1B Czech Republic: three pulses | CBM-CZ | Living biomass | 2030, 2037, 2044: 32.5, 30.7, 27.9 million $m^3$, recovery after each pulse. | +84.6 | +129.3 |
| 2A Ireland: conifer pulse | CBM-IE | Living biomass | 2030 conifer harvest/increment ratio: 0.92, comparison: 0.70. Three-year recovery profile. | +2.5 | +3.5 |
| 2B Ireland: fixed ratios | CBM-IE | Living biomass | Broadleaf and conifer harvest/increment ratios held at their 2030 values through 2050. | −19.5 | −29.1 |
| 3A Italy: sustained intensity | CBM-IT | Living biomass | Fellings/NAI on FAWS: 0.40, comparison: 0.205 in 2030, rising to 0.245 in 2050. | +120.1 | +228.4 |
| 3B EU-27: high versus low | G4M | Living biomass, dead wood and litter | Roundwood path coordinate +1.00 versus -1.00, logging residue settings unchanged. | +3,973 | +4,755 |

The harvest assumptions column identifies volumes, intensity ratios or normalized path coordinates as appropriate. The national rows cover living biomass nd the G4M row also includes dead wood and litter. Pulse recovery shapes are imposed scenario assumptions. Consequently, compare an experiment with its own reference and retain its stated pool coverage and time period.

## 3.2. Lessons learned

Feedback collected by the developers during the Brussels demonstration identified three interface improvements:

- **Mobile use.** Participants asked for an interface better suited to smartphones.
- **An introductory page.** The opening page should explain the Emulator's purpose, its possible uses and its relevance to different users, with a link to a short tutorial.
- **Explanations within the interface.** Brief explanations beside variable names, chart titles and controls could help users interpret them.

The preparation and comparison of the national and European examples identified the following practical requirements:

- **Define harvest inputs and units.** G4M distinguishes roundwood from extracted logging residues. The Czech ratio uses gross annual increment, the Irish ratios use their national increment inputs, and the Italian ratio uses net annual increment on forest available for wood supply. These denominators must be stated when results are presented.
- **Keep comparisons within a consistent scope.** Show each experiment's difference from its own reference and state the model, carbon pools and harvest profile. A living biomass result from a national regression cannot be interpreted as the same quantity as G4M's combined biomass, dead wood and litter balance.
- **Explain the controls and limitations before use.** The demonstration planning identified a need for a short user guide. The handbook in this report provides the definitions needed to interpret the examples.
- **State how shocks evolve.** The archived Czech and Irish pulse examples impose a tapering harvest change over three years. These profiles are scenario assumptions and do not model the ecological legacy of a disturbance.
- **Identify the carbon pools.** A living biomass balance is a valid pool specific result, but it cannot by itself represent all relevant components of the forest carbon balance.

### 3.2.1. Czech perspective

The Czech emulator was built on the pilot CBM-CFS3 parametrisation using Czech National Forest Inventory data developed within ForestNavigator (Augustynczik et al., 2025, D6.2). It estimates annual living biomass carbon stock change from harvest intensity and year. The all-species equation achieved out-of-sample $R^2$ values of 0.77-0.92 across five tested CBM scenarios. This supports use under conditions represented by those tests.

The principal limitation for a potential public use is interpretation. A decline in living biomass transfers carbon to DOM and harvested wood products, as well as to direct emissions. Stumps and roots remain after conventional felling, and disturbances can leave standing dead trees that are salvaged later or decompose in place. Reading the entire biomass decline as an immediate

atmospheric emission would be misleading. A complete greenhouse gas balance must account consistently for the relevant carbon pools and transfers.

DOM decomposition is delayed and does not track living biomass change directly. The Czech regression tests did not support a reliable simplistic DOM extension using the same predictors, so they could not provide a complete ecosystem carbon balance. Process-based CBM-CFS3 calculations remain appropriate for examining those transfers. The retained G4M emulator includes living biomass, dead wood and litter, with its soil carbon, HWP, deforestation and calibration exclusions stated in Section 2.6.

### 3.2.2. Irish perspective

The Irish emulator retained separate equations for broadleaves and conifers. Validation over 2025-2070 gave Nash-Sutcliffe efficiencies of 0.827 and 0.962, respectively, against CBM outputs. These results support the tested living biomass approximation, but the regression omits the other pools required for a complete forest greenhouse gas balance. The underlying Irish CBM-CFS3 application was recalibrated with national forest inventory data and is described by Black et al. (2025).

### 3.2.3. Italian perspective

The Italian regression estimated its harvest coefficient using 2005 to 2017, excluding the Vaia storm and subsequent bark-beetle years. Its time trend was fitted to CBM projections for 2024 to 2070, so this component reproduces a modelled trend rather than independently forecasting it. The Task 8.3 analysis recommends fellings intensities from 0.10 to 0.60. An optional DOM proxy adds 41% to 48% of the living biomass sink, depending on intensity. These are ratios derived from the supplied CBM scenarios, not an independently fitted DOM model. They do not represent the delayed transfers caused by future stochastic disturbances. The underlying Italian CBM research application is described by Pilli et al. (2026).

### 3.2.4. Decision

The national teams and task leader agreed to retain the G4M emulator and withdraw the national regressions from the released interface. G4M provides the broader and consistently labelled balance of living biomass, dead wood and litter, with explicit exclusions. The national regressions remain documented as living biomass tools and their removal prevents those single pool outputs from being presented or compared as complete forest carbon balances.

# 4. Conclusion and next steps

Task 8.3 delivered an accessible browser-based emulator that allows policy makers and analysts to screen the G4M response to changed harvest assumptions within seconds. The held-out evaluation demonstrates close agreement with the parent model for the tested pathways. Together with comparisons, maps and downloadable results, this provides a practical way to identify changes that warrant a more detailed full model assessment. The performance evidence and its limits are set out in Section 2.3.4.

The national CBM regressions reproduced living biomass responses within their tested scenarios. They were withdrawn from the released interface because that pool specific result could be mistaken for a complete forest balance. The retained G4M output also has defined carbon pool and calibration exclusions, which must remain visible whenever the results are used.

The work identifies requirements for any future extension, rather than a commitment to additional project deliverables:

- Additional controls or updated pathways require corresponding full model simulations and a new evaluation before they can be presented as supported Emulator features.
- Any uncertainty interval intended for decision support requires independent assessment and calibration.
- A broader forest carbon balance requires compatible soil, HWP and deforestation data, with explicit land category definitions and consistent treatment of inventory alignment.
- Clear navigation between the Portal and Emulator would help users distinguish published full model pathways from new scenario experiments.
- Keeping model versions, full scenario settings and exported results together is necessary for reproducibility.

# 5. References


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# 6. Annexes

## 6.1. Emulator Platform Documentation

The following pages reproduce, as screenshots, the Documentation tab built into the emulator platform itself, the same description and governing equations shown in-app for each model, captured directly from the running interface. The CBM-CFS3 national emulators are included for completeness. Their interface tab is withdrawn (see Limitations and important notes) but the underlying documentation and code remain in the platform.

### 6.1.1. G4M model

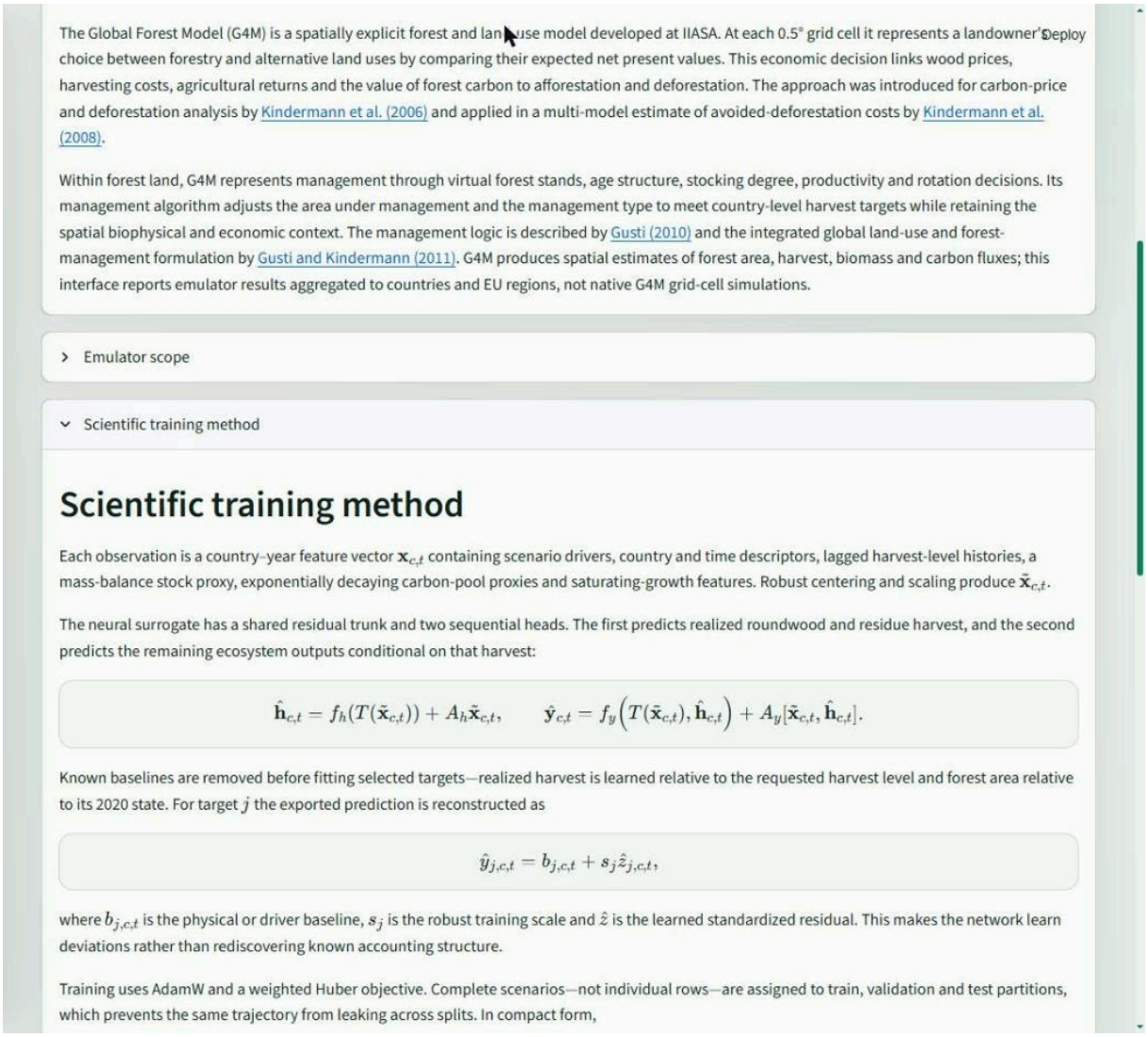
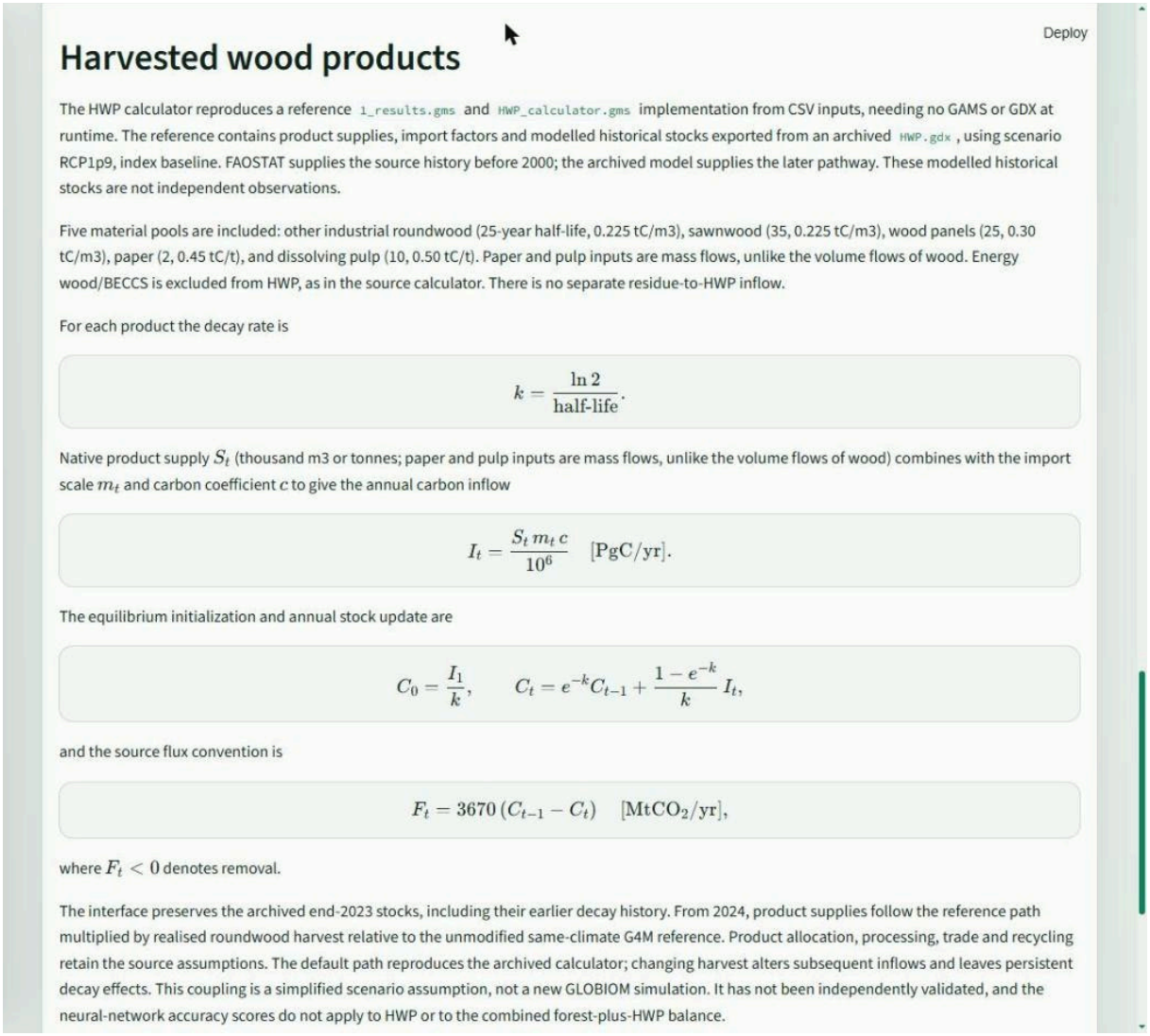



*Figure 12: G4M model description and training-method equations (platform Documentation page).*

## 6.1.2. Harvested wood products



Deploy

# Harvested wood products

The HWP calculator reproduces a reference `1_results.gms` and `HWP_calculator.gms` implementation from CSV inputs, needing no GAMS or GDX at runtime. The reference contains product supplies, import factors and modelled historical stocks exported from an archived `HWP.gdx` , using scenario RCP1p9, index baseline. FAOSTAT supplies the source history before 2000; the archived model supplies the later pathway. These modelled historical stocks are not independent observations.

Five material pools are included: other industrial roundwood (25-year half-life, 0.225 tC/m3), sawnwood (35, 0.225 tC/m3), wood panels (25, 0.30 tC/m3), paper (2, 0.45 tC/t), and dissolving pulp (10, 0.50 tC/t). Paper and pulp inputs are mass flows, unlike the volume flows of wood. Energy wood/BECCS is excluded from HWP, as in the source calculator. There is no separate residue-to-HWP inflow.

For each product the decay rate is

$$k = \frac{\ln 2}{\text{half-life}}.$$

Native product supply $S_t$ (thousand m3 or tonnes; paper and pulp inputs are mass flows, unlike the volume flows of wood) combines with the import scale $m_t$ and carbon coefficient $c$ to give the annual carbon inflow

$$I_t = \frac{S_t\, m_t\, c}{10^6} \quad [\mathrm{PgC/yr}].$$

The equilibrium initialization and annual stock update are

$$C_0 = \frac{I_1}{k}, \qquad C_t = e^{-k} C_{t-1} + \frac{1 - e^{-k}}{k}\, I_t,$$

and the source flux convention is

$$F_t = 3670\,(C_{t-1} - C_t) \quad [\mathrm{MtCO_2/yr}],$$

where $F_t < 0$ denotes removal.

The interface preserves the archived end-2023 stocks, including their earlier decay history. From 2024, product supplies follow the reference path multiplied by realised roundwood harvest relative to the unmodified same-climate G4M reference. Product allocation, processing, trade and recycling retain the source assumptions. The default path reproduces the archived calculator; changing harvest alters subsequent inflows and leaves persistent decay effects. This coupling is a simplified scenario assumption, not a new GLOBIOM simulation. It has not been independently validated, and the neural-network accuracy scores do not apply to HWP or to the combined forest-plus-HWP balance.

*Figure 13: Harvested wood products calculator description and decay equations (platform Documentation page).*

### 6.1.3. CBM-CFS3 national emulators – overview

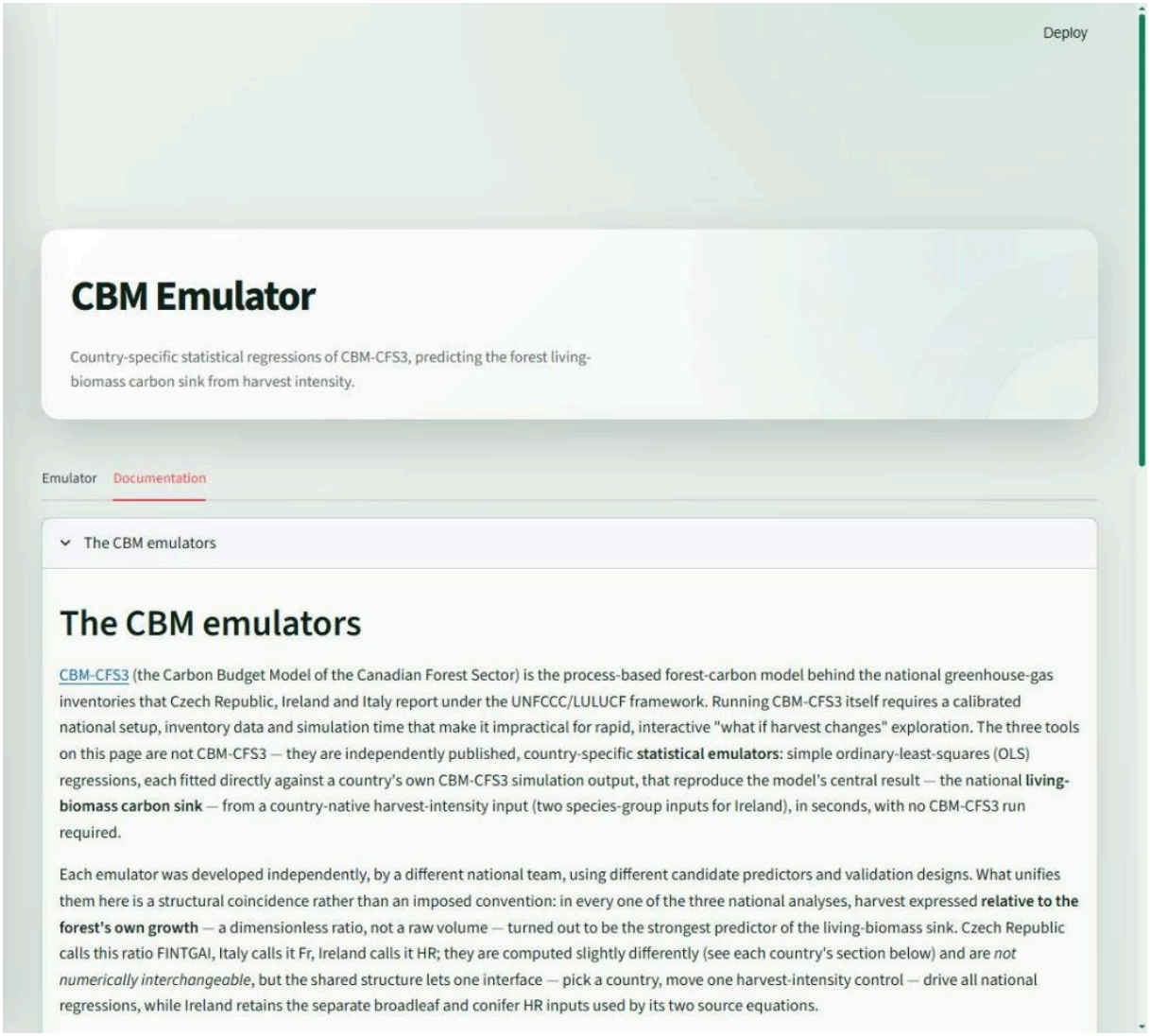



*Figure 14: CBM-CFS3 national emulators: overview (platform Documentation page, withdrawn interface tab).*

### 6.1.4. CBM-CFS3 – Czech Republic

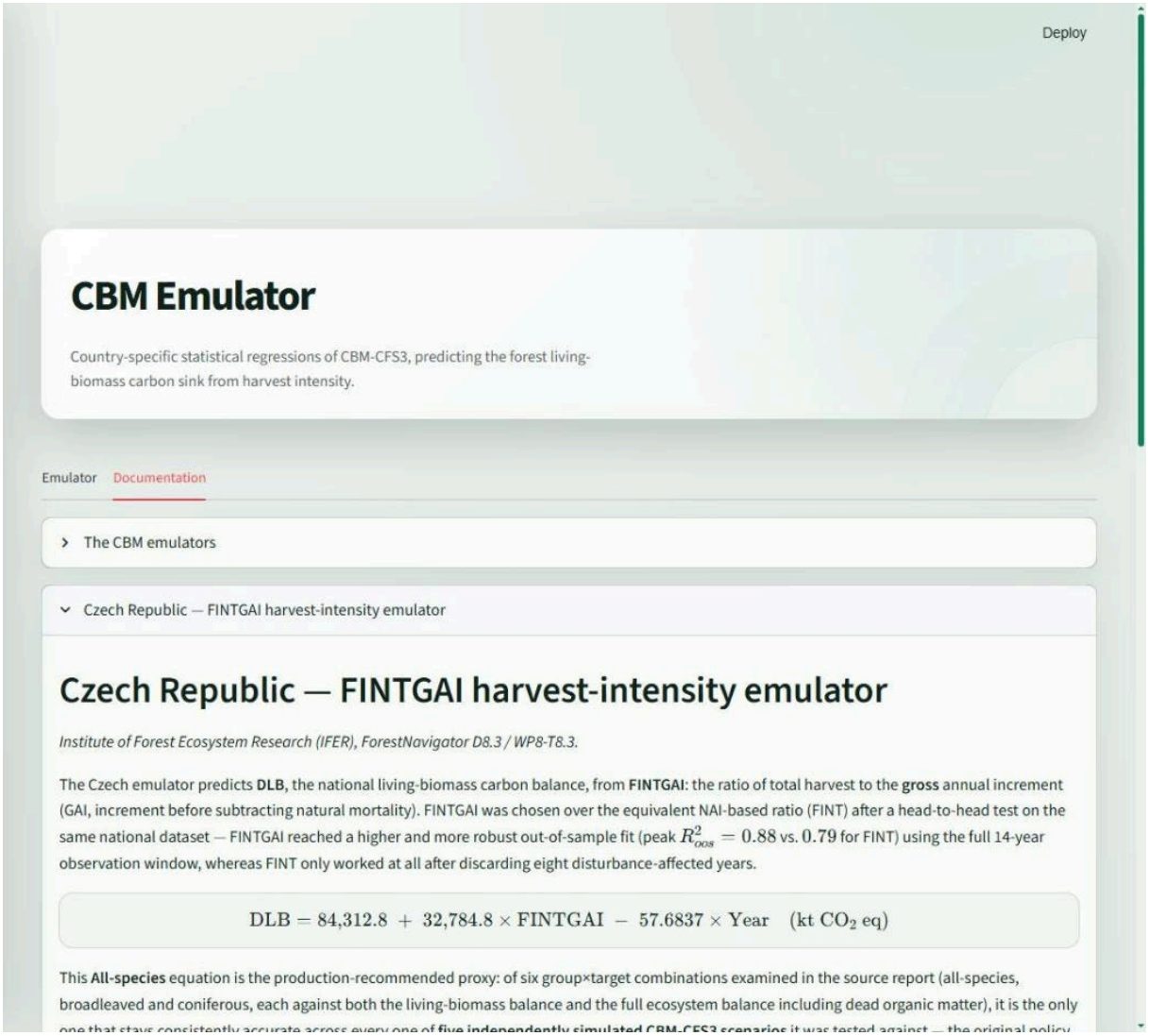



*Figure 15: Czech Republic FINTGAI harvest-intensity emulator (platform Documentation page, withdrawn interface tab).*

### 6.1.5. CBM-CFS3 – Ireland

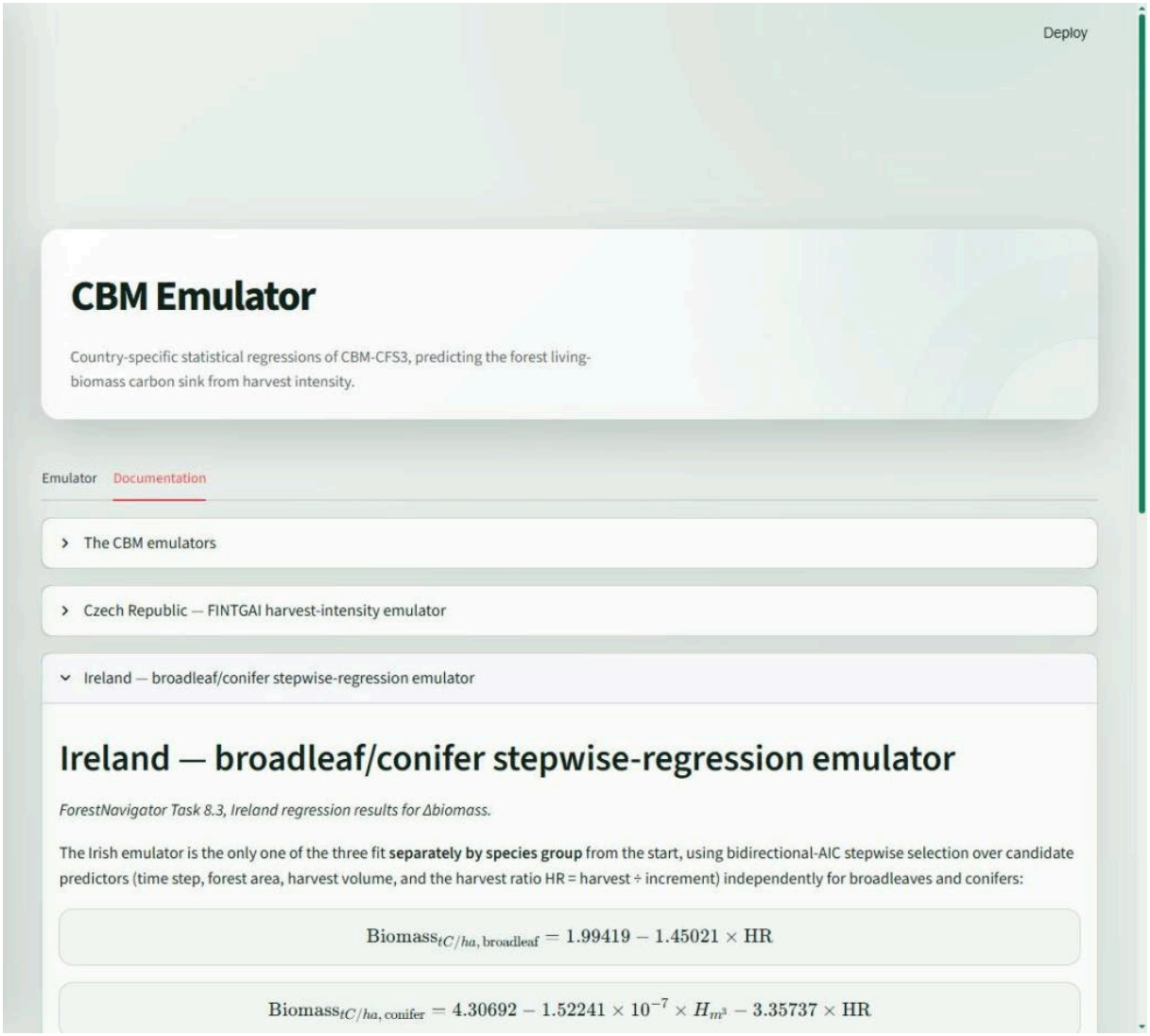



*Figure 16: Ireland broadleaf/conifer stepwise-regression emulator (platform Documentation page, withdrawn interface tab).*

### 6.1.6. CBM-CFS3 – Italy

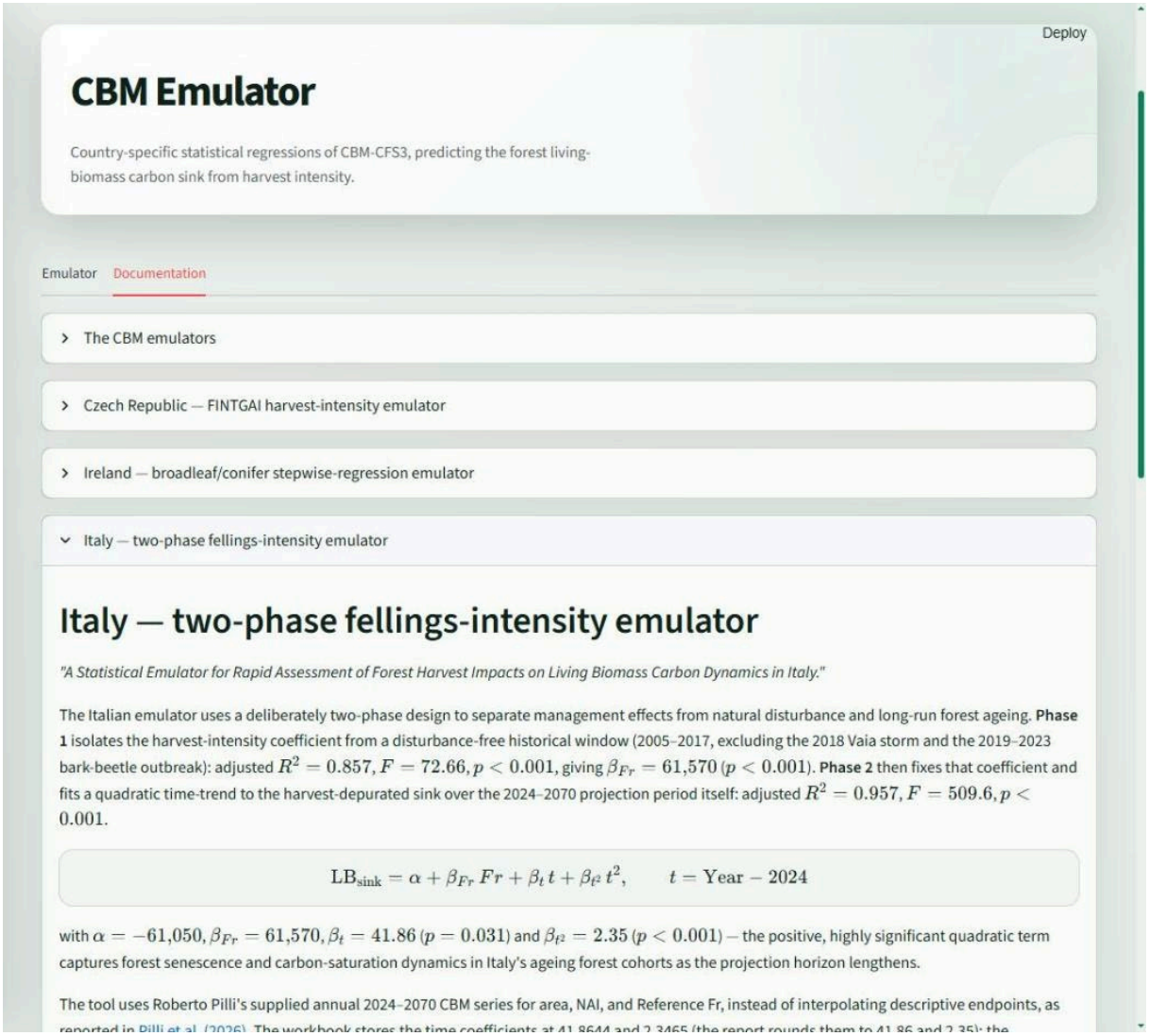



*Figure 17: Italy two-phase fellings-intensity emulator (platform Documentation page, withdrawn interface tab).*

# ForestNavigator Marketplace

## *Exploring key project results*

| TUESDAY OCTOBER 13, 2026 | |
|---|---|
| TIME | ITEM |
| 12:45 - 13:00 | **Arrival at NHOW and Registration** |
| 13:00 - 13:45 | **Welcome, overview of the ForestNavigator project output, and today's aims**<br>Fulvio Di Fulvio, *IIASA* |
| 13:45 - 14:30 | Marketplace session 1: parallel presentations of other ForestNavigator project outputs (not part of Task 8.3). |
| 14:30 - 15:00 | **Tea & Coffee Break** |
| 15:00 - 15:45 | **Toolbox Demonstration**<br>• Near real-time update of EU-level policy pathways under changing conditions - Andre Nakhavali, *IIASA*<br>• Applications in Ireland (Kevin Black, *FERS*), Italy (Roberto Pilli, *RP*), and the Czech Republic (Emil Cienciala, *IFER*) |
| 15:45 - 16:15 | ForestNavigator Exploratory Pathways Results (other project results). |
| 16:15 - 17:00 | Marketplace session 2<br>Delving into the ForestNavigator Emulator (Andre Nakhavali, IIASA)<br>Other parallel sessions continued the topics of Marketplace session 1. |
| 17:00 - 17:30 | **Closing** |

# Final Conference

## *Navigating the Future of the EU Forest Sector*

| WEDNESDAY OCTOBER 14, 2026 | |
|---|---|
| TIME | ITEM |
| 8:30 - 9:00 | **Arrival at NHOW and Registration** |
| 9:00 - 9:15 | **Welcome and aims**<br>Petr Havlík, *IIASA* |

| | |
|---|---|
| 9:15 - 10:00 | **Keynote speech**<br>• EU policies framing the context of forest sector pathways towards EU climate neutrality<br>Frida Sund Falkevik, *DG CLIMA* |
| 10:00 - 11:00 | **Forest Policy Pathways aligned to medium-term EU and national policy ambitions**<br>• Results on resilient EU and national pathways able to reconcile climate mitigation, biodiversity conservation and bioeconomy objectives<br>Julia Bognar, *IEEP*, Fulvio Di Fulvio, *IIASA,* Kevin Black, *FERS*, Roberto Pilli, *RP*, and Emil Cienciala, *IFER* |
| 11:00 - 11:30 | **Tea & Coffee Break** |
| 11:30 - 12:15 | **ForestNavigator Pathways panel discussion**<br>• Discuss pathway modelling results with Amila Meskin, *EUSTAFOR*, Giacomo Grassi, *JRC*, Siim Kuresoo, *FERN*, Simon Martel, *I4CE*<br>*Moderator:* Julia Bognar, *IEEP* |
| 12:15 - 12:45 | **ForestNavigator Portal**<br>• Overview of Data Explorer and Pathway Explorer<br>• Data Explorer examples<br>• Pathways Explorer<br>Kanwal Nayan Singh, *CA* |
| 12:45 - 13:00 | **Closing**<br>• What is next - output<br>• Upcoming webinars<br>Fulvio Di Fulvio and Petr Havlík, *IIASA* |
| 13:00 - 14:00 | **Lunch** |