Essential Forest Mitigation Indicators (EFMIs): a pathway to assess decarbonisation and climate change resilience in European forests

POLICY BRIEF #3

OptFor-EU

Forests are central to Europe's climate change-related goals, providing carbon storage and carbon sequestration, regional climate regulation, biodiversity, and renewable resources. To make these forest ecosystem services operational for forest managers and policy-makers, OptFor-EU has co-developed a novel, science-based set of 21 Essential Forest Mitigation Indicators (EFMIs), designed through a participatory bottom-up process and ready for integration into decision-making and reporting systems. EFMI link forest management practices (FMPs) to decarbonisation outcomes and resilience co-benefits, while enabling local to pan-European upscaling and alignment with relevant EU strategies. EFMI build on the well-established practice of the pan-European criteria and indicators (C&I) for sustainable forest management (SFM) of the Forest Europe process, offering a focused subset tailored to carbon mitigation and climate change resilience within the broader SFM framework.

What are EFMIs and why do they matter?

EFMIs are a streamlined set of indicators co-selected with forest managers, stakeholders and indicator experts to assess the impacts of FMPs on:

- **Decarbonisation** (carbon storage and sequestration)
- **Forest health** and **adaptability to climate change**
- **Biodiversity-supporting structures** linked to resilience and old-growth aspects
- **Regional climate regulation** (temperature, precipitation, soil moisture, evapotranspiration, etc.)

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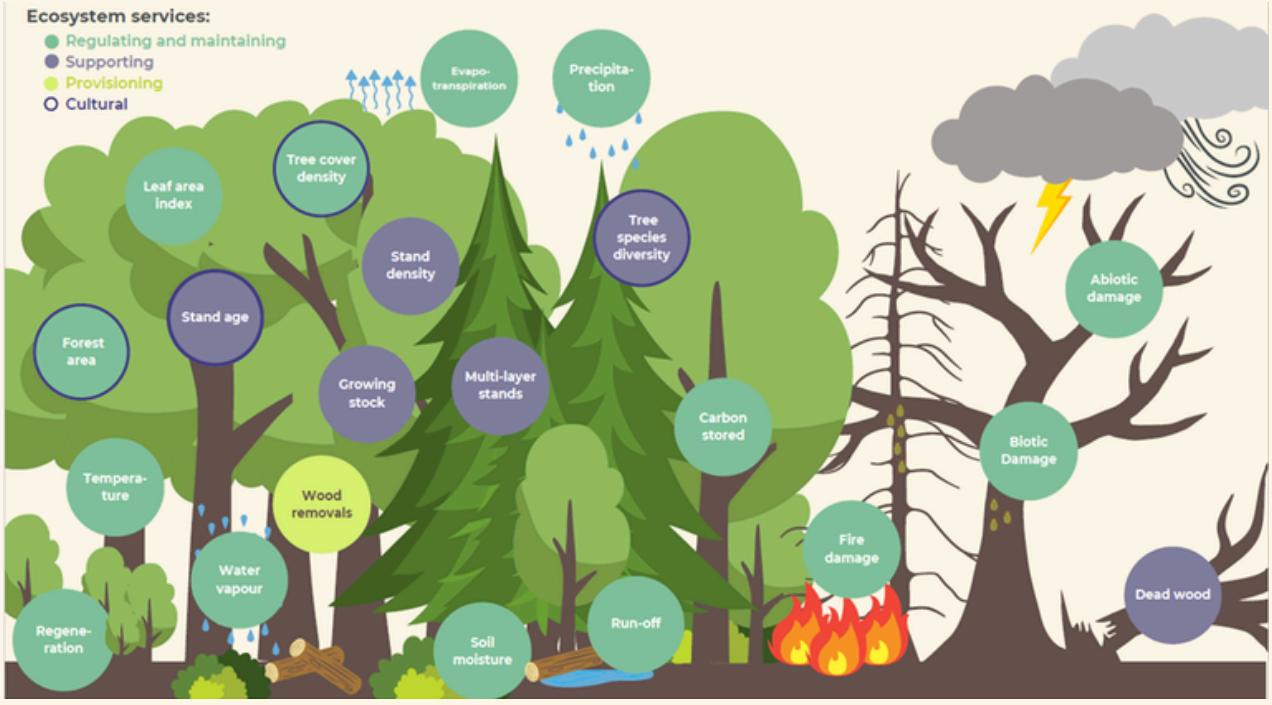
Starting from a pool of 130 potentially suitable indicators compiled across international and national indicator sets and the scientific literature, EFMI were reduced to 21 indicators through internal review, and external surveys with 65 forest managers and stakeholders from our 8 Case Study Areas (CSA), and 21 international indicator experts from all over Europe, USA and from international organisations such as EEA, EFI, FAO or IUFRO. Indicators are grounded in the Common International Classification of Ecosystem Services (CICES) framework and supported by open source data, including from Earth observation, and forest and climate modelling results. EFMI are being integrated in the OptFor-EU Decision Support System (DSS), enabling users to select indicators, set preferences, and explore synergies or trade-offs among FMPs at the level of the OptFor-EU CSAs, national and pan-European scales. As with the pan-European C&I for SFM, EFMI simplify complex datasets into easily comprehensible information that can be monitored consistently over time, communicated to multiple audiences, and aligned with national and international reporting processes and open data sources to facilitate evidence-based decision-making.



The OptFor-EU EFMI presented in a forest context.

Key advantages of the EFMI

Management sensitivity and feasibility: The EFMIs were selected for their sensitivity to FMPs, and for ensuring feasible measurability CSA, national and pan-European levels.

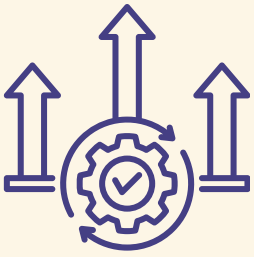
Bridging science, practice and policy relevance: EFMI translate complex ecological, carbon and biophysical processes into operational indicators aligned with the CICES and EU policy needs (e.g., decarbonisation, resilience, old-growth forest protection) as well as the related needs of forest managers and stakeholders.

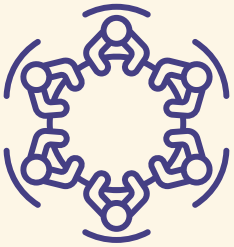
Data and modelling backbone: EFMI leverage harmonised open datasets (including satellite data) and advanced forest and climate models (3D-CMCC-FEM, PICUS; REMO-iMOVE, RegCM, JULES) to quantify impacts of FMPs on carbon and biophysical climate regulation.

Transparency and openess: EFMI related data is based on an open-source code (via Zenodo), database, and detailed indicator factsheets enabling a harmonized calculation, assessment and scaling across Europe.

Inclusion of climate regulation: EFMI quantify regional climate impacts of forest management changes capturing co-benefits of FMPs.

Alignment with established processes: The EFMIs can be cross-walked to existing international indicator sets like the Sustainable Development Goals (SDGs) indicators, Forest Europe indicators, FAO Global Core Set of forest-related indicators, EU Nature Restoration Law indicators, Essential Biodiversity Variable, Essential Climate Variables or the ETCCDI Climate Change Indices, facilitating coherence with reporting obligations.





Communication value: The inclusion of the EFMI in the OptFor-EU DSS EFMI support stakeholder understanding of synergies or trade-offs among FMPs.

Policy recommendations for related indicator development processes

Harmonise indicators and data infrastructure

- Apply the criteria used in OptForEU - suitability to assess the intended objective, sensitivity to forest management practices, and feasibility of data collection - to national and pan-European forest-related indicator selection and revision processes.
- Ensure data harmonization, open standards, and consistent definitions (see OptFor-EU Glossary).
- Align with established international indicator processes to streamline multi-level reporting (national, EU, pan-European global).
- Integrate indicator workflows with official statistics, national inventories, and Earth observation programmes to secure continuity, comparability, and institutional ownership.

Support a participatory indicator co-selection process

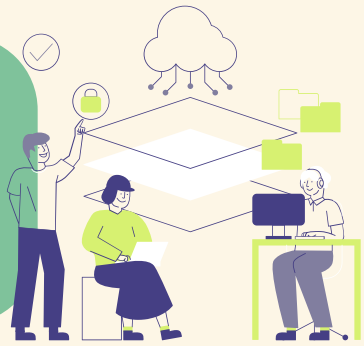
- Build stakeholder co-selection of indicators in planning and implementation to ensure relevance, ownership, and uptake.
- Establish a structured, multi-stakeholder process with clear roles for coordination, experts, stakeholders, and end-users participation, ensuring iterative refinement and review.

Standardise indicator documentation and interpretation

- In the planning and funding of indicator processes, require indicator factsheets to specify units, data sources, directionality of “positive effect” for e.g. carbon mitigation, and an evidence-based rationale for decarbonisation benefits .
- Ensure the consideration and inclusion of indicators related to topics which are high on the political agenda, for instance old-growth characteristics, climate change adaptation and mitigation, and nature restoration.
- Include explicit links to relevant SDGs, EU strategies, and policy targets to ensure traceability from indicators to policy goals.

Implement indicators in decision-support tools

- Embed indicators in decision support systems that allow users to select indicators, apply preference weighting, and explore trade-offs and synergies among forest management practices.



Conclusions

EFMI provide a practical, science-based pathway to align forest management with EU decarbonisation and resilience goals. By embedding EFMI into forest-related monitoring systems, strengthening harmonized open-source data infrastructures, and scaling DSS-enabled decision-making, **policymakers can accelerate decarbonisation-focused forest management while enhancing resilience and regional climate regulation.** OptFor-EU offers the tools, evidence, and open resources needed for implementation across Europe. Continuous institutional commitment, stakeholder participation, capacity building, and harmonised data are essential for developing effective indicator systems as a basis for evidence-based decision-making.

For more information, you can read the report **'Report on a novel set of Essential Forest Mitigation Indicators (EFMI)'** and find the **EFMI code and data processing** on Zenodo

Keywords: Forest Management, Decarbonisation, Climate resilience, Indicators, Monitoring, Decision Support

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About the project

OptFor-EU aims to co-develop a Decision Support System (DSS) with forest managers and other forest stakeholders, that provides them with suitable climate adaptation and mitigation options for science-based optimising forest ecosystem services (FES) (including decarbonisation) and enhancing forest resilience and its capacities to mitigate climate change (CC) across Europe.

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