The challenges of modelling and analysis of carbon-neutral pathway in the LULUCF sector

Forest modelling within the LULUCF sector: new challenges and opportunities

Designing Pathways toward Carbon Neutrality
Ljubljana, 6 to 8 October 2021

Roberto Pilli

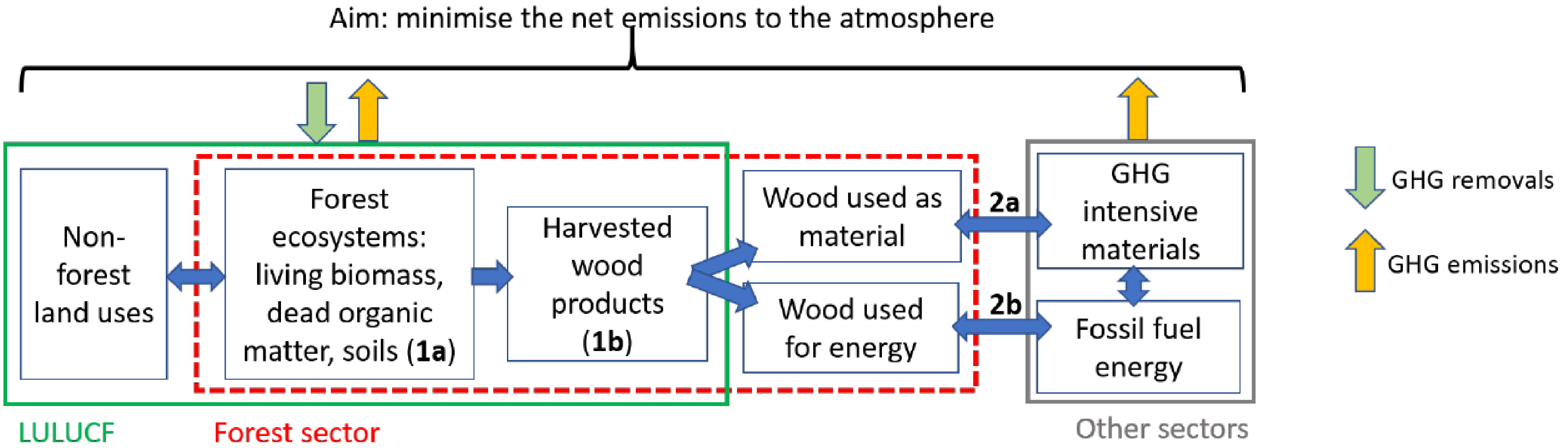
European Commission

- On 14 July 2021, the EC presented its new **Fit for 55** climate package, part of the European Green Deal
- The overall objective is reducing EU net greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels, and become carbon neutral by 2050.
- A new **Forest Strategy** and a revised regulation of the **LULUCF** sector, as well as the **EU Biodiversity Strategy**, are both complementary pillars of these ambitious objectives

- To become ... port and industrial ... 2e yr-1 by 2050.
- Considerin ... 00 Mt CO_{2eq} in the period ... ditional efforts, **which sho ... on sink within the next d**

The forests' role within the Land Use, Land Use Change and Forest (LULUCF) sector

- Assessing the role of the forest-based bioeconomy in mitigating climate change requires a **"system-perspective",** considering all possible options: increasing carbon stocks ('net sink') in forest land and in Harvested Wood Products (HWPs), and using wood to substitute other materials or fossil fuels



https://publications.jrc.ec.europa.eu/repository/handle/JRC124374

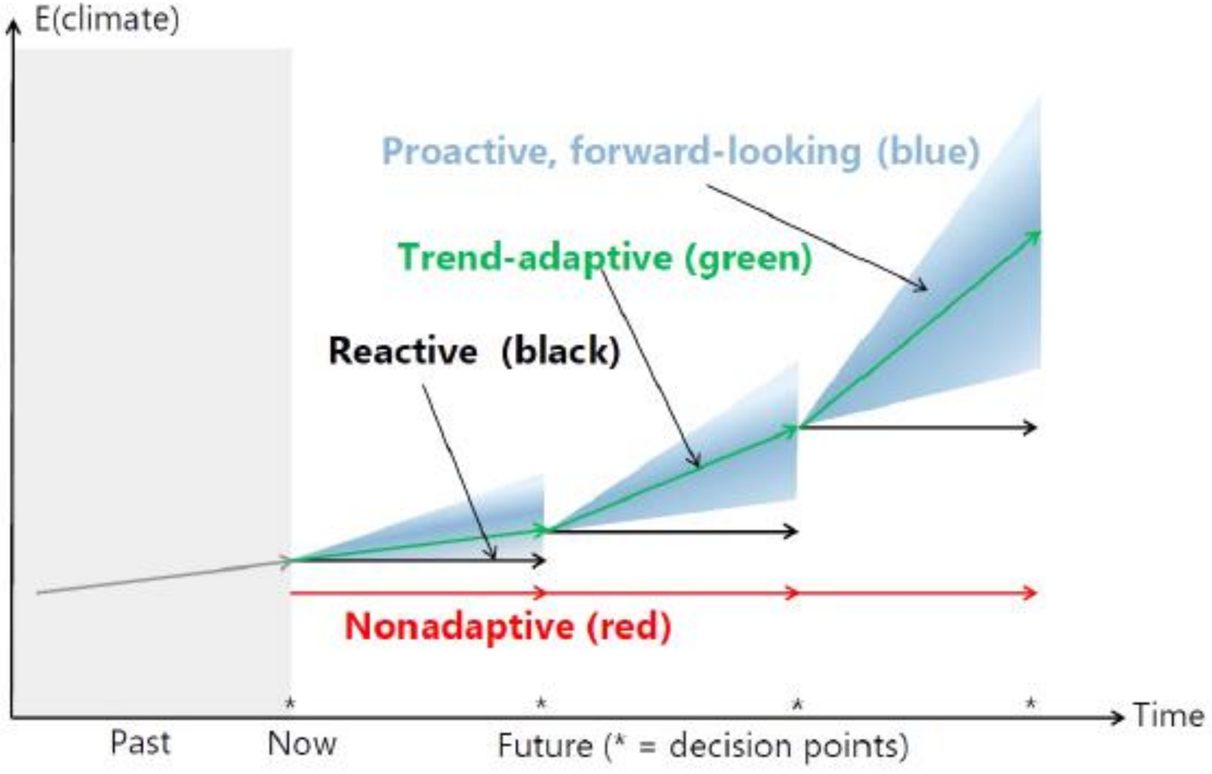
Yousefpour, R., C. Temperli, J. B. Jacobsen, B. J. Thorsen, H. Meilby, M. J. Lexer, M. Lindner, H. Bugmann, J. G. Borges, J. H. N. Palma, D. Ray, N. E. Zimmermann, S. Delzon, A. Kremer, K. Kramer, C. P. O. Reyer, P. Lasch-Born, J. Garcia-Gonzalo, and M. Hanewinkel. 2017. A framework for modeling adaptive forest management and decision making under climate change. *Ecology and Society* 22(4):40. https://doi.org/10.5751/ES-09614-220440

Synthesis

A framework for modeling adaptive forest management and decision making under climate change

Rasoul Yousefpour[1], Christian Temperli[2,3], Jette Bredahl Jacobsen[4], Bo Jellesmark Thorsen[4], Henrik Meilby[5], Manfred J. Lexer[6], Marcus Lindner[7], Harald Bugmann[2], Jose G. Borges[8], João H. N. Palma[8], Duncan Ray[9], Niklaus E. Zimmermann[2,3], Sylvain Delzon[10], Antoine Kremer[10], Koen Kramer[11,12], Christopher P. O. Reyer[13], Petra Lasch-Born[13], Jordi Garcia-Gonzalo[8,14] and Marc Hanewinkel[1]

Red expectation under "no-change decision making" where past treatments are repeated as long as they appear to work.
Black expectation refers to "reactive decision making" where decisions are changed based on the observed change in the past.
Green refers to "trend-adaptive decision making" where adaptation to the predicted trend.
Blue-grey shadows denote "forward-looking adaptive decision making" including a range of possible futures management options and where the expectations get broader and more uncertain!



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Challenges …

Short-term forest management

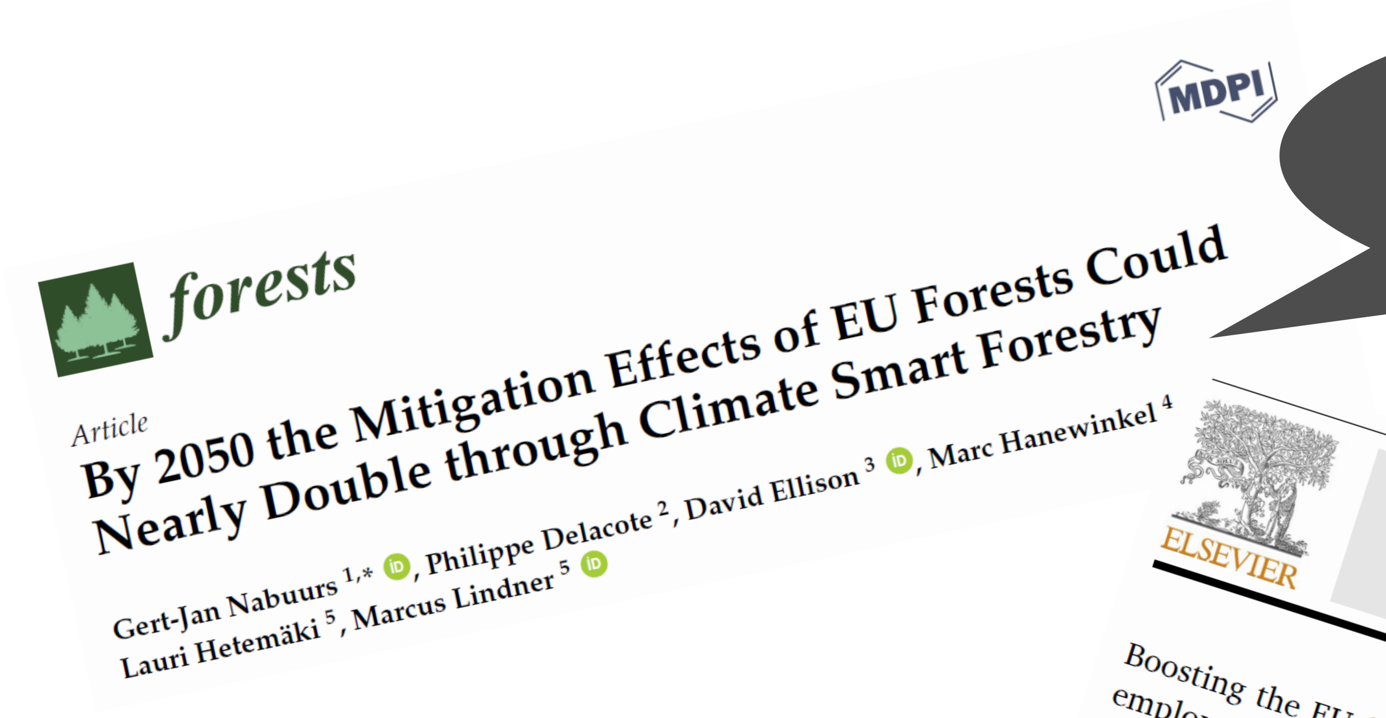
- The short-term evolution of forest C sink is directly determined from forest management activities and, when occurring, natural disturbances
- Assessing the impact of forest management practices on the future forest C sink is also challenging because of the uncertainties linked to policy and economic drivers, which directly affect the future harvest rate.

Long-term forest management

- We aim to investigate the long-term evolution of the forest C sink, linked to the complex interactions between climatic variables (e.g., temperature, precipitation, CO2 concentration, …) and forest ecosystems.
- Due to the uncertainty on the future evolution of climate change and the relative impact of these variables on forest growth, we need to assess these aspects combing different climatic scenarios.

For these reasons, various studies - even if not accounting for the additional effects of climate change, and therefore considering only the short-term evolution of the forest C sink – may provide different, and sometimes opposite, results!

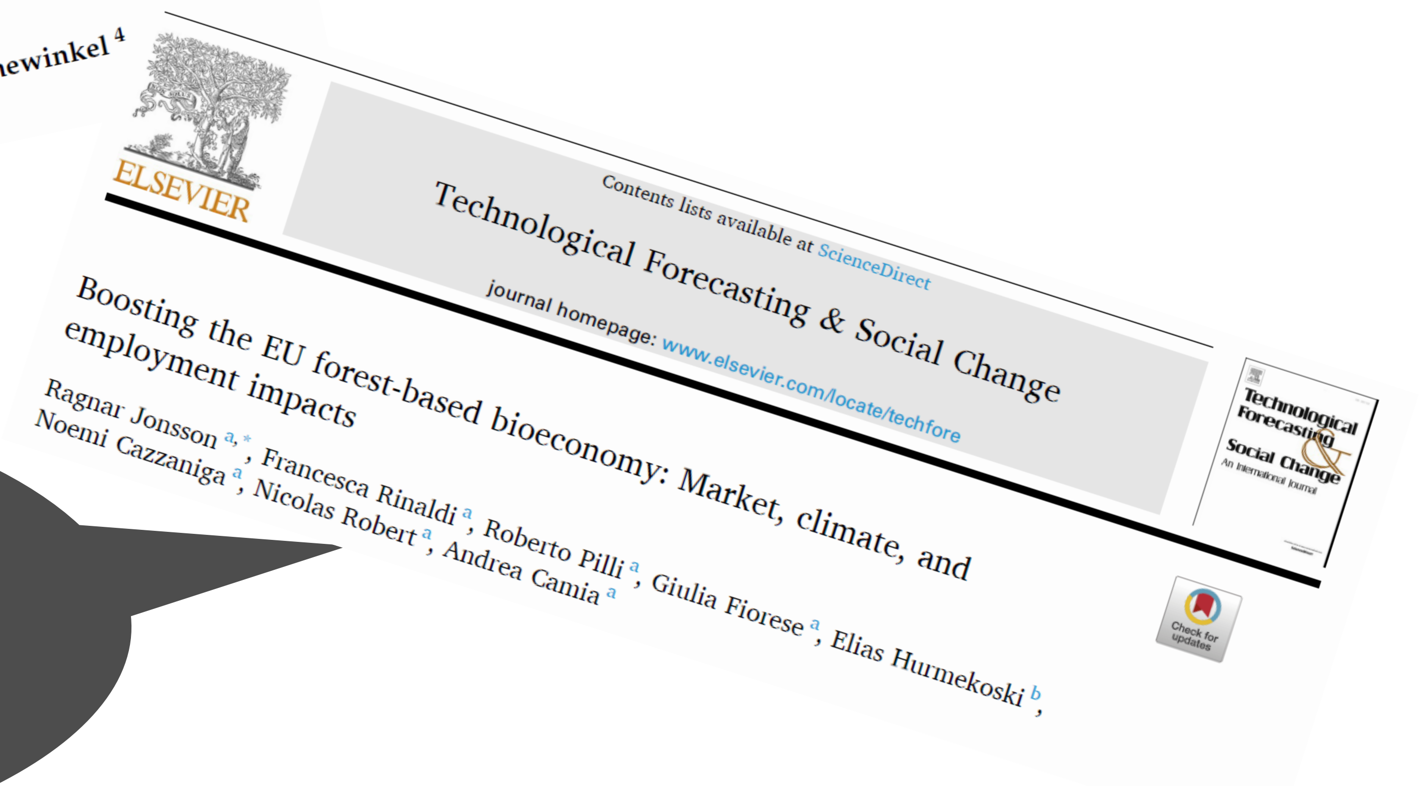
For example …


Article

By 2050 the Mitigation Effects of EU Forests Could Nearly Double through Climate Smart Forestry

Gert-Jan Nabuurs [1,*], Philippe Delacote [2], David Ellison [3], Marc Hanewinkel [4], Lauri Hetemäki [5], Marcus Lindner [5]

estimated that the EU28 forest C sink could potentially increase by about 172 Mt CO_2 yr^{-1} by 2050.



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Boosting the EU forest-based bioeconomy: Market, climate, and employment impacts

Ragnar Jonsson [a,*], Francesca Rinaldi [a], Roberto Pilli [a], Giulia Fiorese [a], Elias Hurmekoski [b], Noemi Cazzaniga [a], Nicolas Robert [a], Andrea Camia [a]

… based on different methodological assumptions and harvest scenarios, estimated a reduction of the EU 28 forest C sink between -50 and -180 Mt CO_2 yr^{-1} in 2030, compared to 2015.

- These differences can be further amplified when empirical models are applied within long-term scenario analysis.

even assuming the same harvest level similar models may produce different results, because of different assumptions on management strategies applied at local level, which may, in turn, affect the long-term evolution of the age class distribution.

Blujdea et al. Carbon Balance Manage (2021) 16:25
https://doi.org/10.1186/s13021-021-00188-1

RESEARCH

Carbon Balance and Management

Open Access

Two large-scale forest scenario modelling approaches for reporting CO_2 removal: a comparison for the Romanian forests

Viorel N. B. Blujdea[1*], Richard Sikkema[2,5], Ioan Dutca[1,3] and Gert-Jan Nabuurs[2,4]

Check for updates

Taylor & Francis
Taylor & Francis Group

JOURNAL OF SUSTAINABLE FORESTRY
https://doi.org/10.1080/10549811.2020.1792935

OPEN ACCESS

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Calculating the Additional Carbon Sequestration of Finnish Forestry

Timo Pukkala

... also determining a common, possibly "neutral", management scenario, i.e., a businnes-as-usual scenario, representing a benchmark for developing further management strategies, is quite challenging

… a compromise solution ..

- Forest C sink is mostly affected from actual and past management practices, which determine forest composition and age structure and it is influenced, at local level, from **economic drivers** and stochastic **disturbance events**.
- For modelling the medium- to short-term evolution of these variables, **empirical**, forest stands growth models are generally best suited.
- These models, however, simulating the forest growth based on past observations, cannot easily determine the possible distortions due to climate changes, which can modify the current vegetation's growth rate (Cuddington et al., 2013).

- The long-term evolution of the forest C sink is affected from climate change conditions and long-term management strategies, which may affect forest composition, age structure, management system, etc.
- For modelling the long-term evolution of these variables and large-scale management strategies, **process-based** climate models are best suited
- These models, however, mostly grounded on ecological theories generally miss detailed information on management practices and forest conditions, as determined from direct field measurements (Pretzsch et al. 2008).

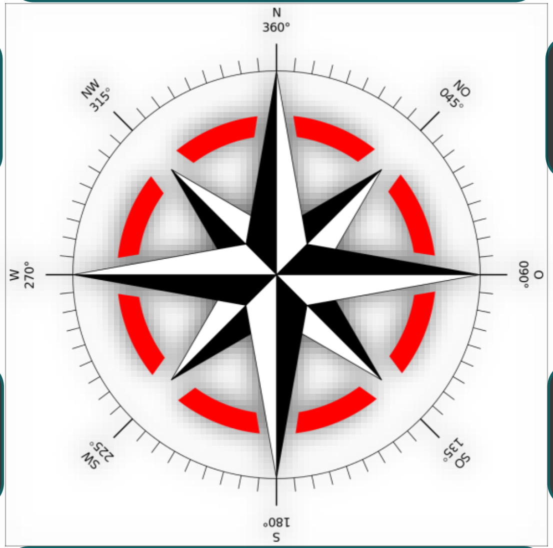
- A compromise solution, is building a **meta-modelling framework**, merging the strategic information provided from process-based models, with the tactic accuracy provided from empirical models.
- This approach requires to balance different, and partially opposite, methodological assumptions.

A possible meta-modelling framework:

MODELLING NATURAL DISTURBANCES[5]

INVENTORY-BASED MODELS (IBMs) [1]

PROCESS-BASED MODELS (PBMs)[2]



FOREST LANDSCAPE MODELS (FLMs)[3]

FOREST ECONOMIC MODELS (FEMs) [4]

MULTI-FUNCTIONAL FOREST MANAGEMENT TOOLS[6]

[1] IBMs: simulate the short-term evolution of forest C sink, under different forest management activities, based on past observations …

[2] PBMs: focus on climatic variables (e.g. temperature) and/or biogeochemical processes (e.g. nitrogen cycle). This enables simulate forest responses to variations in environmental conditions and future climate change …

[3] FLMs: simulate forest stand dynamics in relation to forest landscape processes, in a spatially explicit (i.e., mapped) framework. FLMs typically simplify site-scale processes …

[4] FEMs: derive projections for the consumption, production and trade of wood-based products under different scenarios.

European Commission

Strategic forest monitoring, reporting and data collection

Today the information concerning the status of forests in the EU, their social and economic value, as well as the pressures they face and ecosystem services they provide, is patchy. Since 2007, when the Forest Focus Regulation expired[51], no comprehensive reporting requirements exist. In addition, there are challenges related to the use of remote sensing data together with ground-based data (i.e. lack of interoperability, common definitions, ambiguity in data interpretation, lack of long and comparable very high resolution time-series, limitations of the current standard forest products from Copernicus). Also, there is insufficient planning for the forests, which would address in a coordinated manner and provide a comprehensive picture of the multifunctionality of forests in the EU, especially regarding climate mitigation and adaptation, ecological condition of forests, forest damage prevention and control, and forest

Regarding the monitoring, the focus should be on regular and more frequent cost-efficient reporting and update of data on priority EU policy-relevant topics, such as effects of climate change, biodiversity, health, damages, invasive alien species, forest management, and the biomass use for different socio-economic purposes. Monitoring has to be done with high spatial and temporal granularity. Timeliness is particularly important also due to the rapid unfolding of forest natural disturbances. The framework will benefit from the EU Space Programme components and should leverage Galileo and Copernicus services to improve these processes.[52]

EUROPEAN COMMISSION

Brussels, 16.7.2021
COM(2021) 572 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

New EU Forest Strategy for 2030

{SWD(2021) 651 final} - {SWD(2021) 652 final}

Strategic forest monitoring, reporting and data collection

- Harvest levels and removals of woody biomass at EU and country level are highly uncertain (see Camia et al., 2018)
- Spatial predictions of forest variables are required for supporting modern national and sub-national forest planning strategies, especially in the framework of a climate change scenario.
- NFI could evolve in a permanent monitoring system, where a sample of the total number of field plots is visited in the field every year in order to complete the revisit of all the plots in 5–10 years
- Combining traditional NFI plot data, with remote sensing technology and auxiliary variables is essential.

Maintaining or enhancing the current forest mitigation potential, is **challenging** and urgently requires **alternative management strategies and new modelling tools**, merging traditional scientific objectives – generally linked to a climate change perspective – with practical applications to forest management and planning activities