EUROPEAN FOREST INSTITUTE

La Machine à Carbone

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Colloque “La Forêt Européenne: entre passé et future”
Fondation Singer-Polignac, Paris, 6-7 Mai, 2024

Forest productivity, carbon budget and the search for the «missing sink»!

Forest Inventory by the Republic of Venice

1489

Ordonnance de Colbert

1669

Sustainable forest management H.C. von Carlowitz

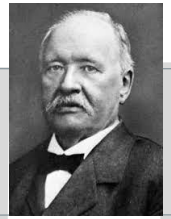
1713

J.Black CO_2 discovery

1754

Lorentz, Hartig, Cotta Dendrometry

1785-1824



Arrhenius Green House effect

1896

Keeling first measure of [CO_2]

1959

International Biosphere Program

1964-1974

Tree eco-physiology CO_2 metabolism

1980's

Eddy covariance Kyoto Protocol

1990's

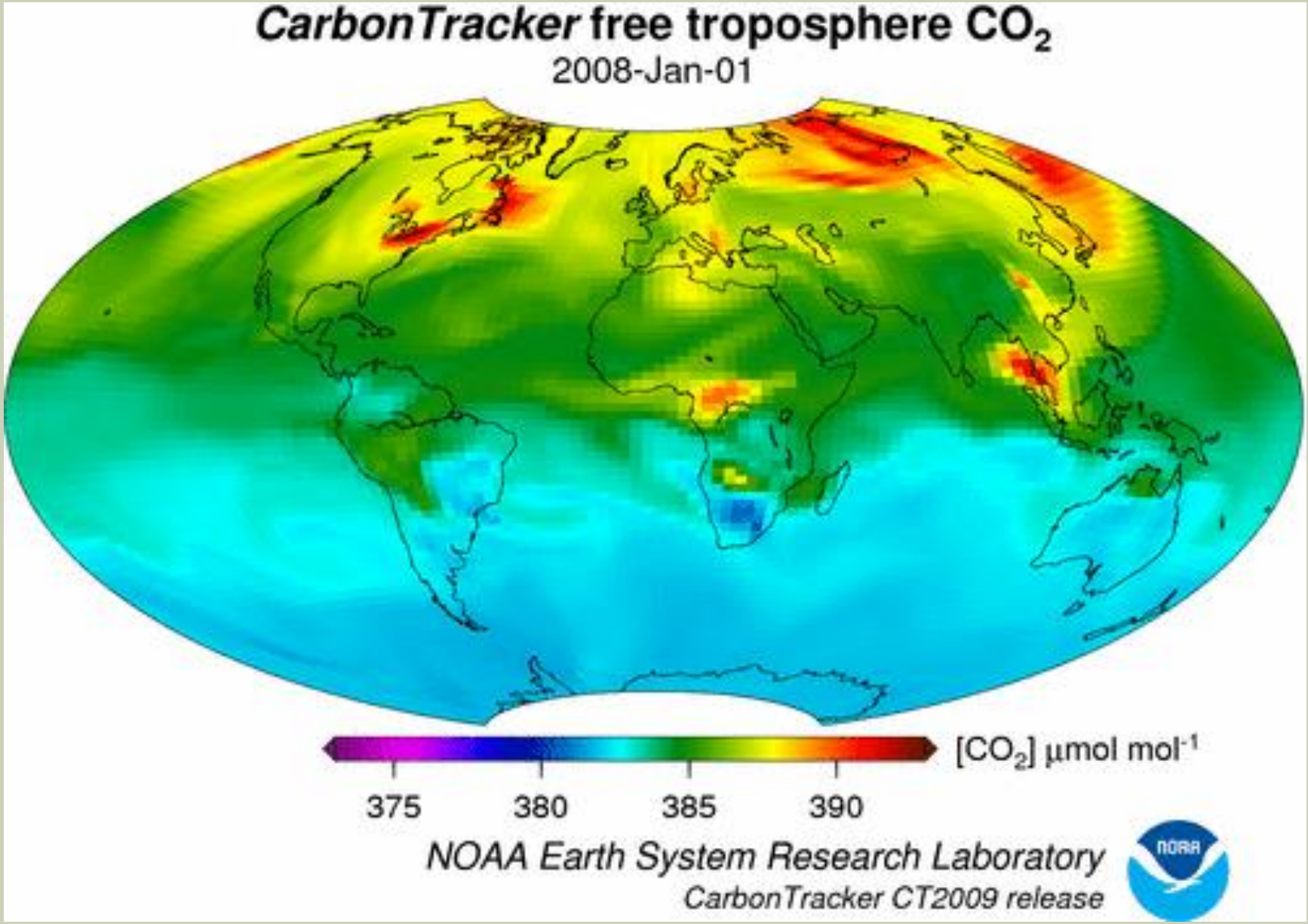
EuroFlux and Fluxnet

1997

Carbon Observatory Large EU Infrastructure ICOS

2016

TIMELINE


CarbonTracker free troposphere CO_2
2008-Jan-01
[CO_2] µmol mol^{-1}
375
380
385
390
NOAA Earth System Research Laboratory
CarbonTracker CT2009 release
NOAA

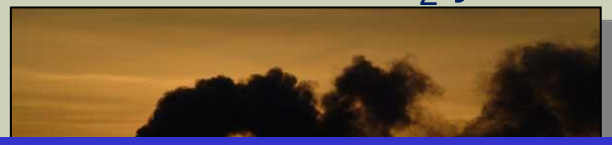
Anthropogenic CO_2 emissions and removals (2013-2022 average)

Sources

4.7±1.8 $GtCO_2$/yr 12%

+

35.3±1.8 $GtCO_2$/yr 88%



18.9±0.4 $GtCO_2$/yr
47%

Atmosphere

12.3±2.9 $GtCO_2$/yr
31%

Forests

Sinks

Forests have become the most important biospheric sink
……but uncertainty for their future capacity of C-removal

Budget Imbalance: 4% (-1.6 $GtCO_2$/yr)

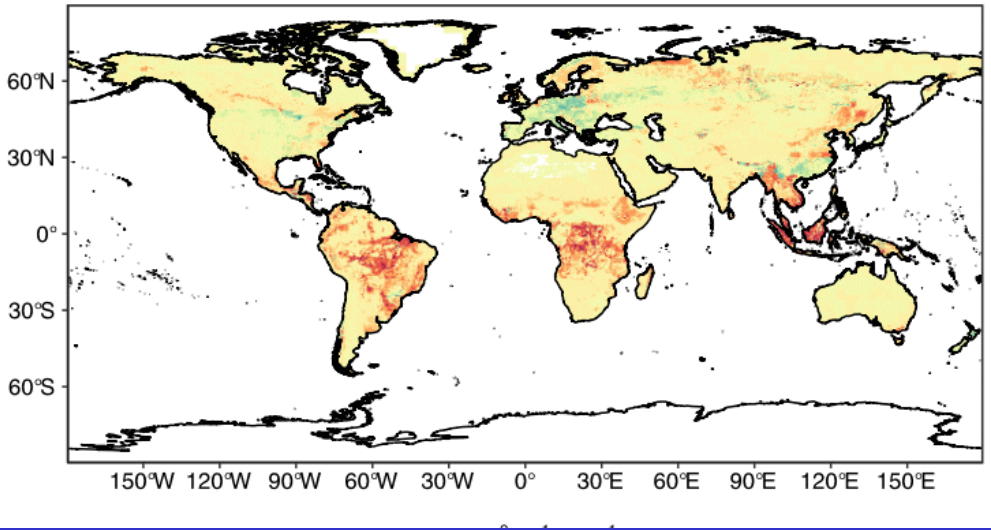
Source: CDIAC; NOAA-ESRL; Friedlingstein et al 2023; Global Carbon Budget 2023

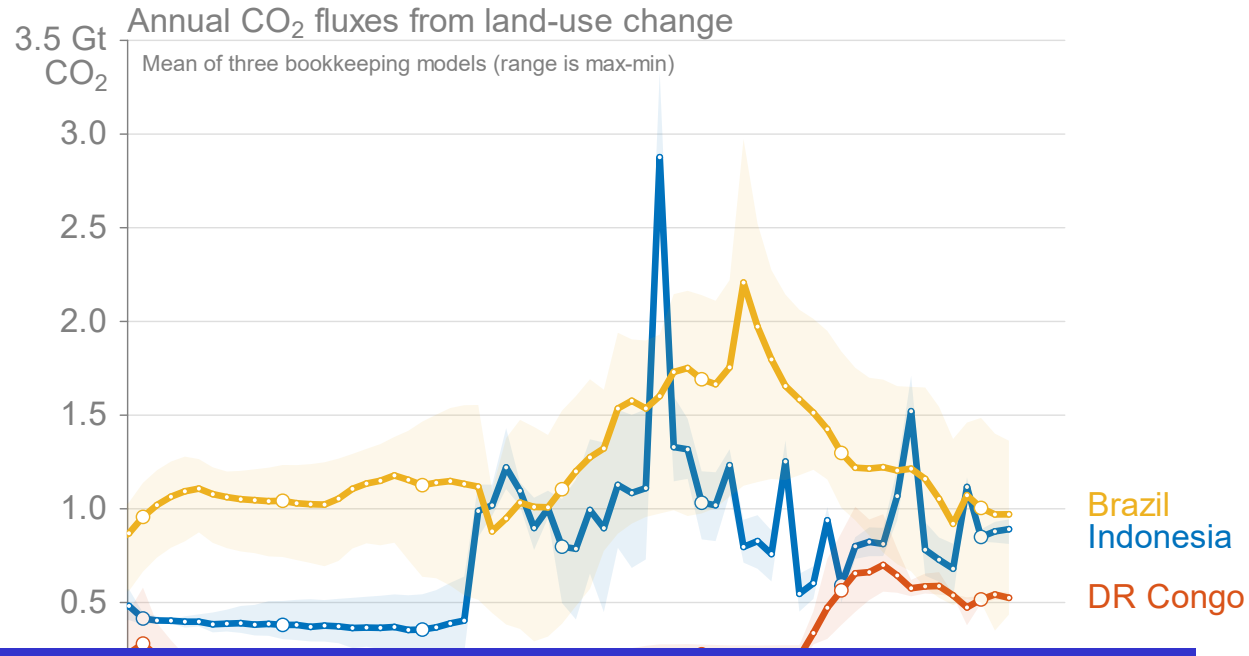
Regional patterns of land-use change emissions

Land-use emissions are high in the tropics, driven largely by deforestation. Net sinks occur in regions of re/afforestation such as parts of Europe and China.

The top three emitters over 2013–2022 – Brazil, Indonesia, and the Democratic Republic of the Congo – contribute 55% of the global net land-use emissions.

Land-use emissions, decadal average 2013–2022





Large global differences among biomes, from tropical forests (sources) to temperate and boreal ecosystems (sinks)

Estimates from three bookkeeping models

Source: Friedlingstein et al 2023; Global Carbon Project 2023

C-Sequestration

NEP = GPP – Ra – Rh

NBP = NEP – Harv – Dist

Net Ecosystem Productivity: medium term

Net Biome Productivity: long term

LATERAL TRANSPORT

DOC, Harvest

DISTURBANCES

Fires, wind parasites

PHOTOSYNTHESIS (100)

TOTAL RESPIRATION (80-90)

R_{aut} (45-55)

R_{het} (35-45)

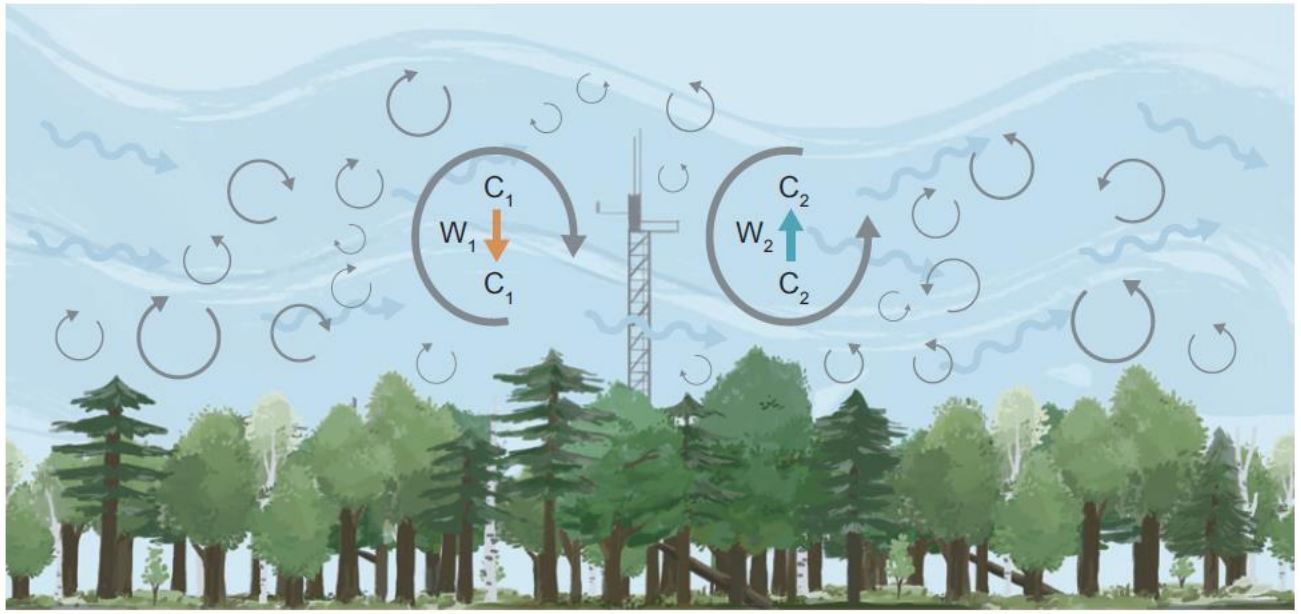
BIOMASS

SOIL

LITTER
Leaves+Roots

How to measure «la machine à carbone»?

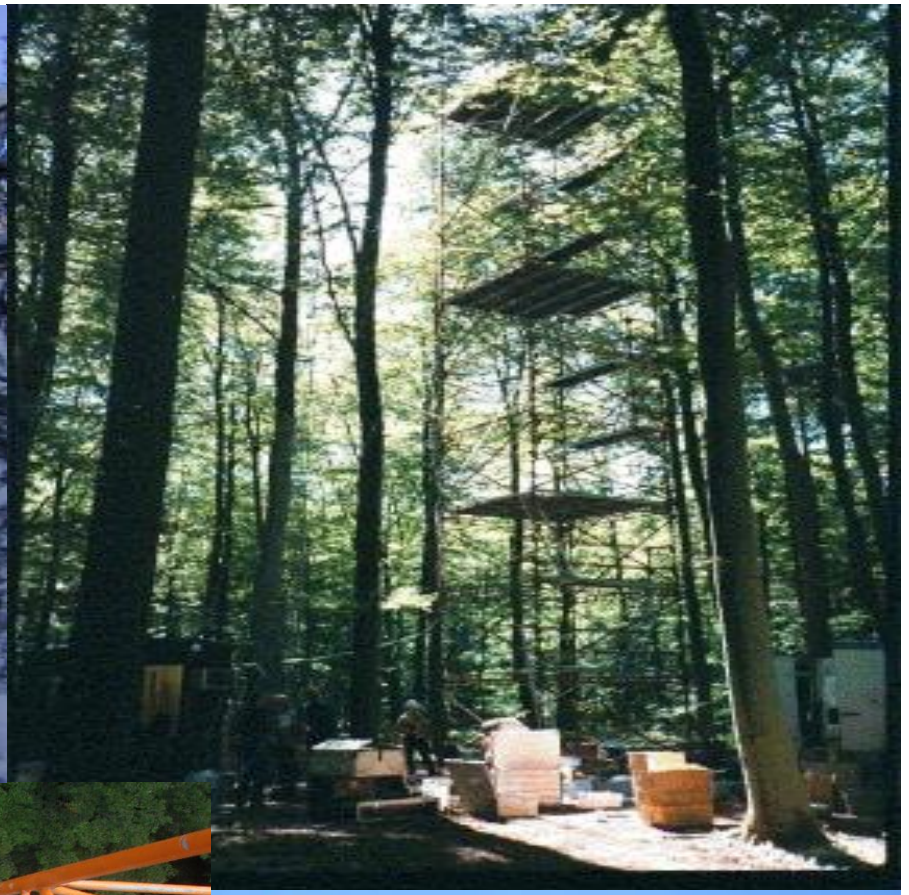
The **eddy covariance** method is the only approach available for the direct measurement of forest net ecosystem CO2 exchange with the atmosphere

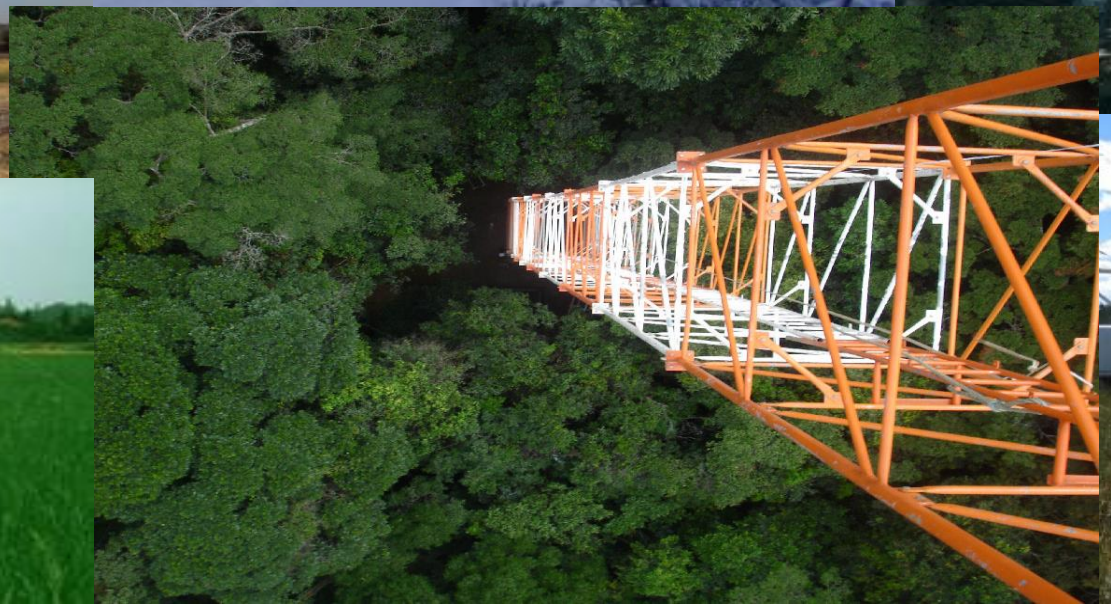


Two independent quantitative methods to validate each other

The **biometric method** through direct sampling of biomass and soil carbon

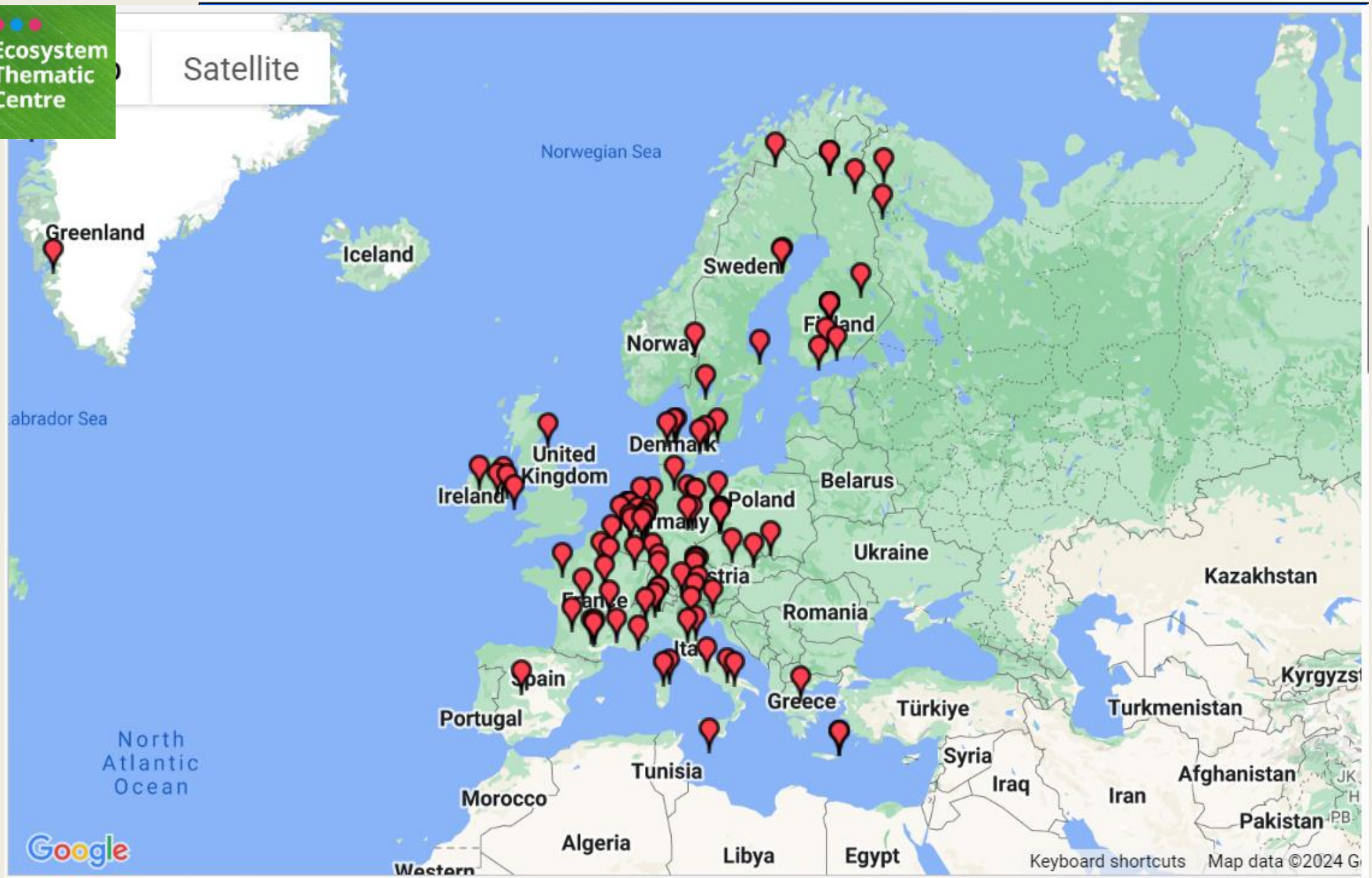






ICOS Ecosystem Thematic Centre

Integrated Carbon Observation System, a large European research infratsructure

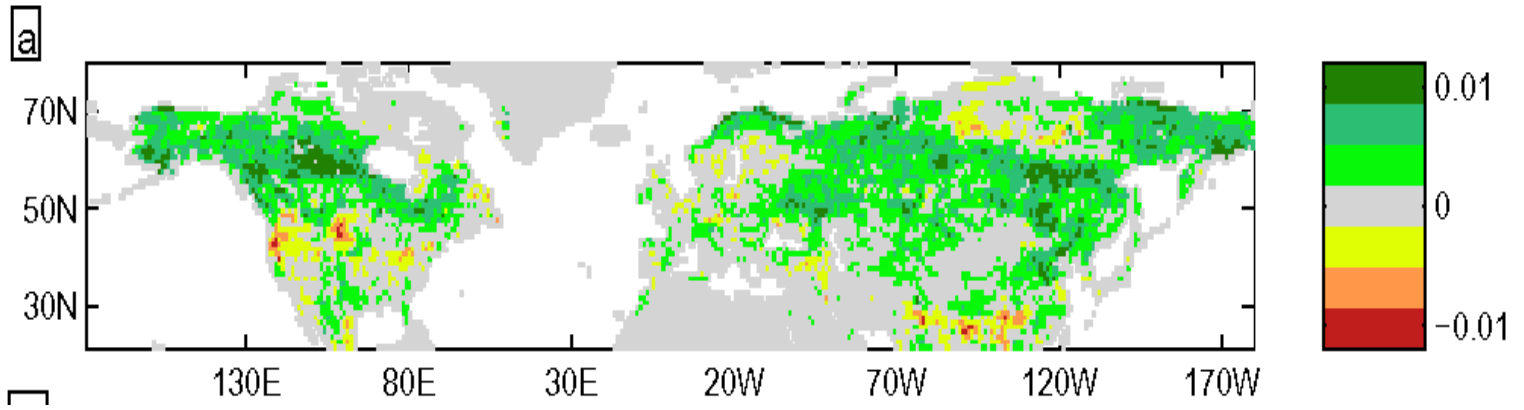


www.fluxdata.org

Location and main drivers of this large terrestrial C-sink?

Location:

- **Temperate and boreal forests** of Northern Hemisphere as substantial carbon sink

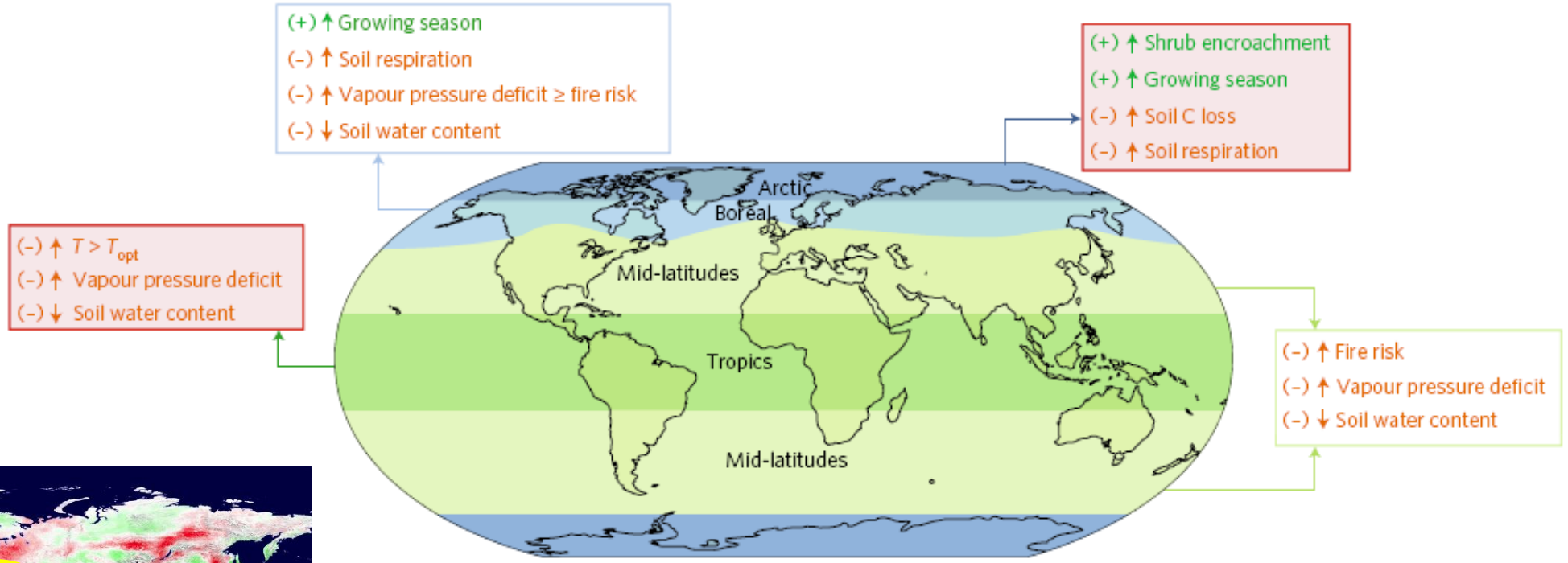


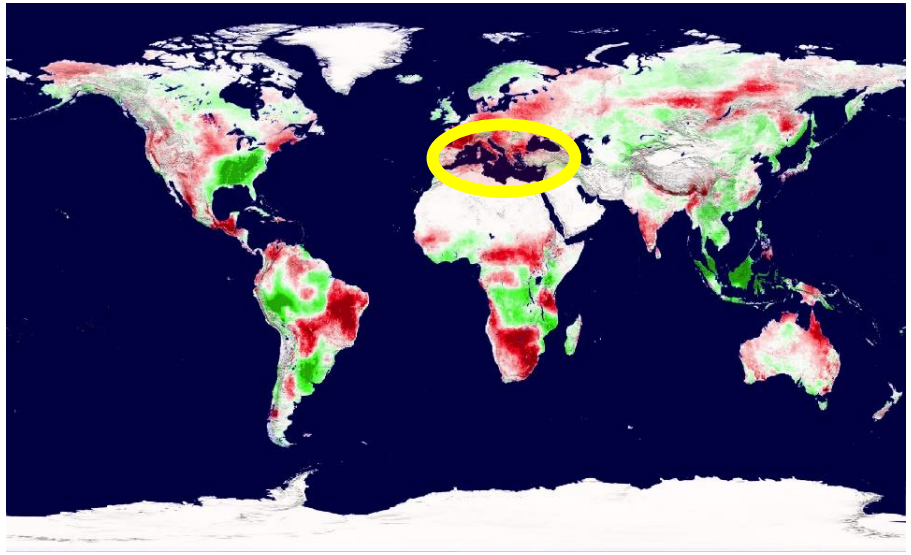
Main drivers:

- **Forest expansion** in abandoned agricultural land
- **Demographic changes** in young regrowing stands after disturbances and harvesting
- **Increasing atmospheric carbon dioxide and temperatures**
- **Nitrogen depositions**, largely the result of anthropogenic activities

(Magnani et al. 2007; Pugh et al. 2019)

Climate change impacts (ex. increasing temperatures and drought) estimated at 30% reduction on mitigation potential of forest Carbon sink in future



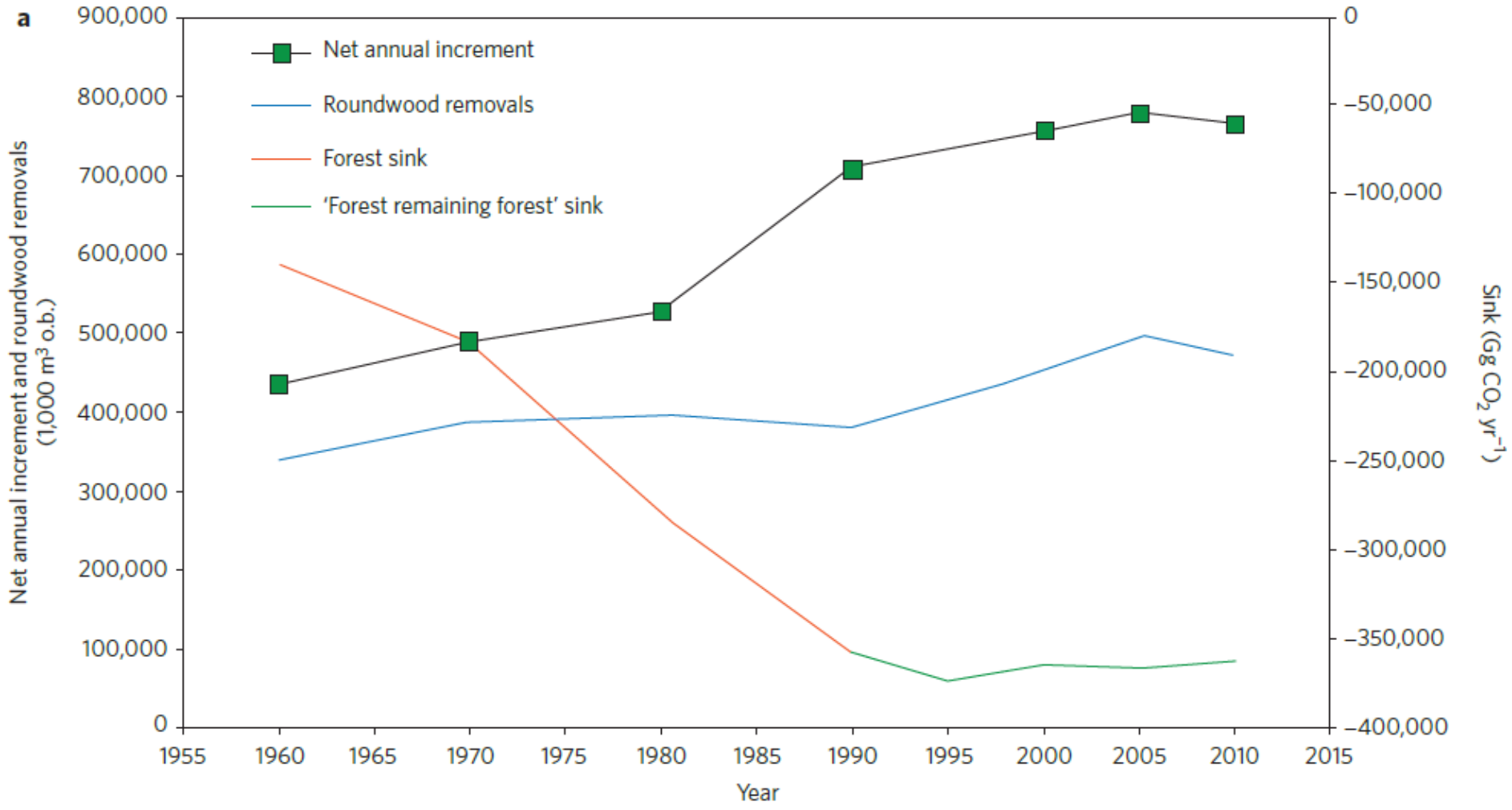


Mediterranean and Central Europe are *hot spots* of possible negative impact of climate on primary productivity and Carbon uptake

(Penuelas et al., 2017; Zhao & Running, 2010)

Signs of saturation effects of forest C-sink, in Europe

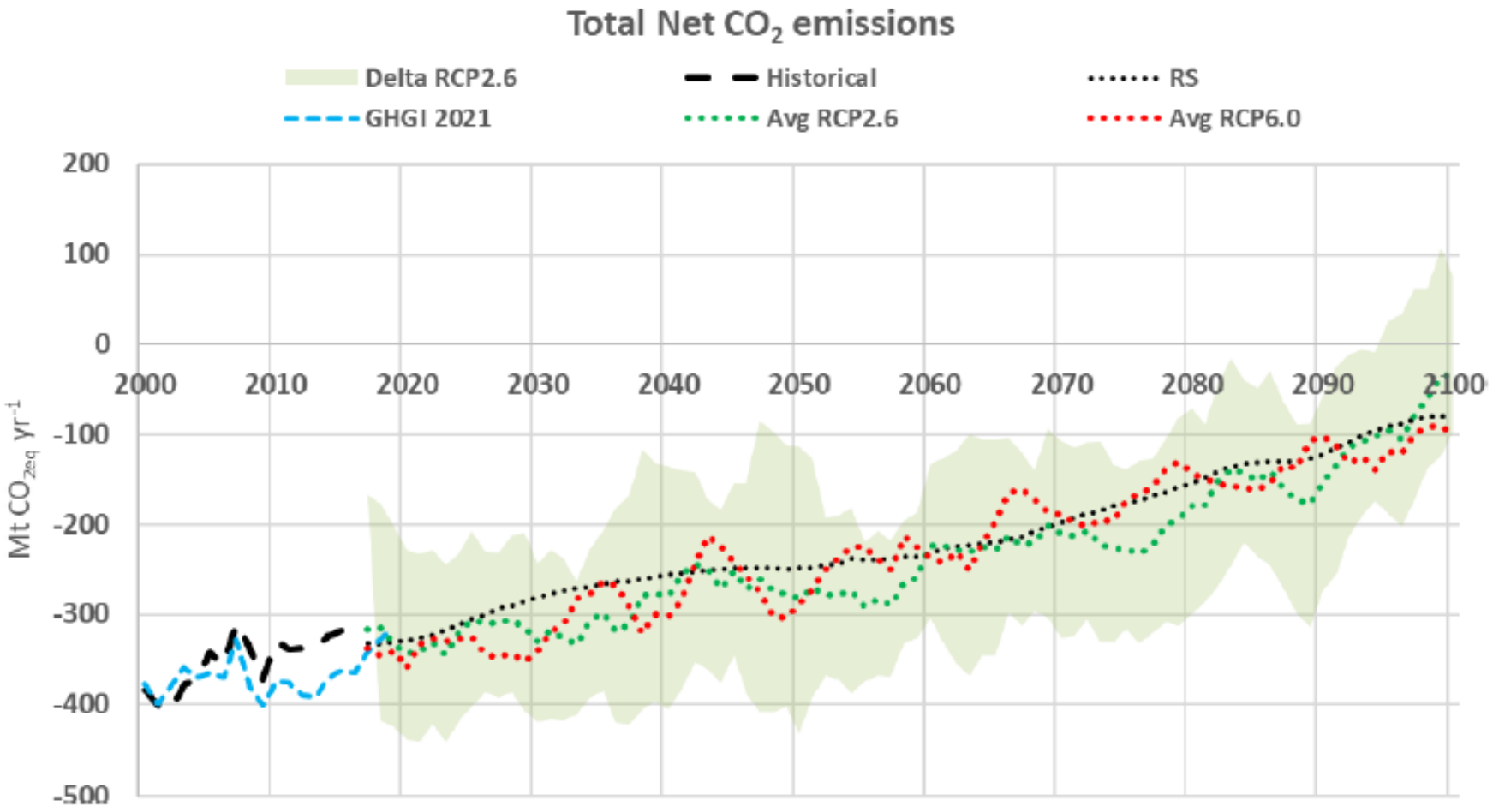
Regrowing forests in EU have shown to be a persistent carbon sink. However, there are **early signs of saturation**.
Forest policies and management strategies need revision if we want to sustain the sink.



(Nabuurs et al. 2013)

Carbon budget of EU forests up to 2100

Expected **decrease of forest C sink by 2100**.
Main driver is the **ongoing ageing process of the European forests.**
In addition, **climate change** may further amplify or mitigate this trend, but large uncertainty in climate projections.
A **change in management practices would be needed** to reverse an otherwise declining trend in the sink.



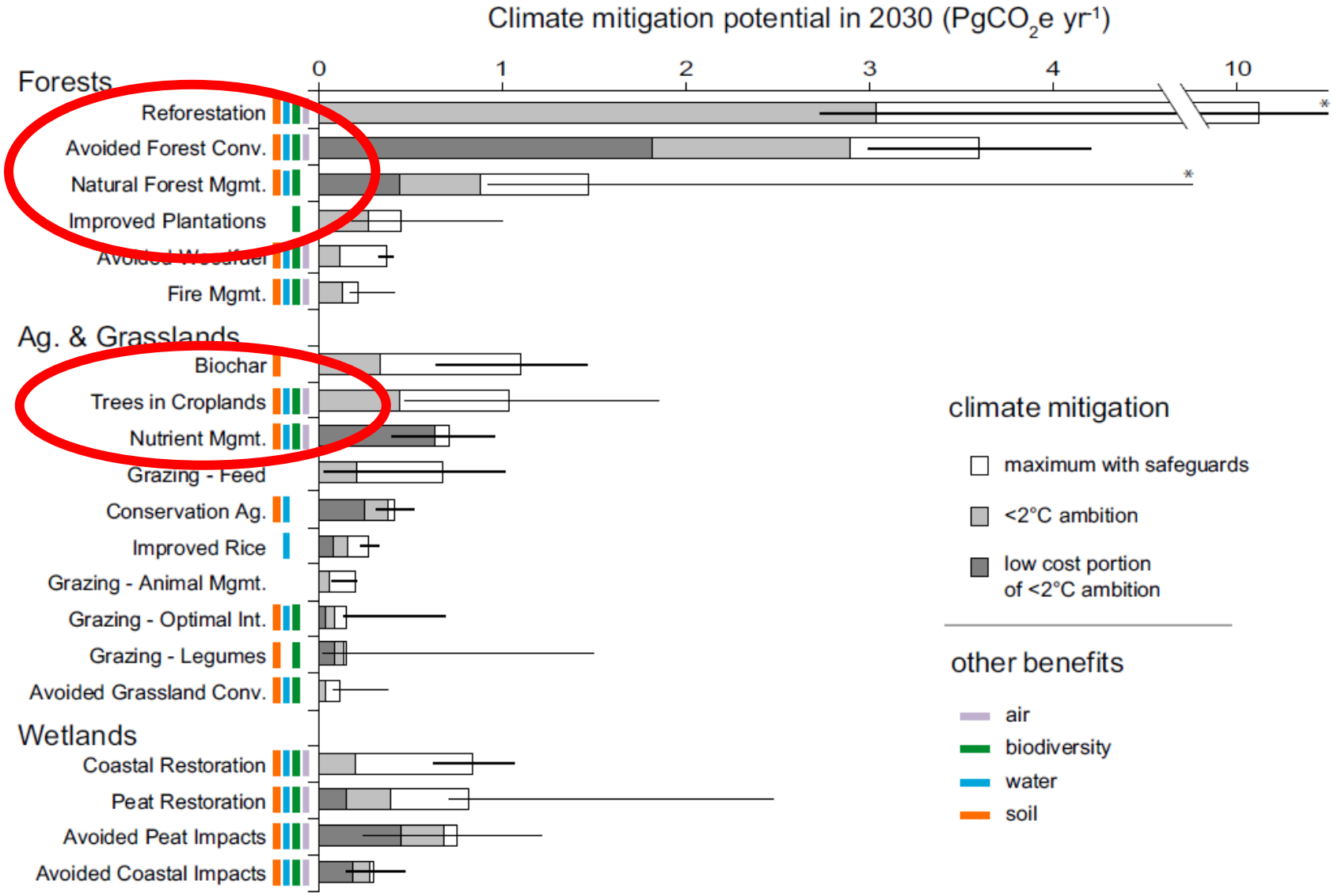
The European forest carbon budget under future climate conditions and current management practices

Roberto Pilli[1], Ramdane Alkama[2], Alessandro Cescatti[2], Werner A. Kurz[3], and Giacomo Grassi[2]

Natural Climate Solutions

Better stewardship of land is needed for the Paris Climate Agreement goal < 2 °C

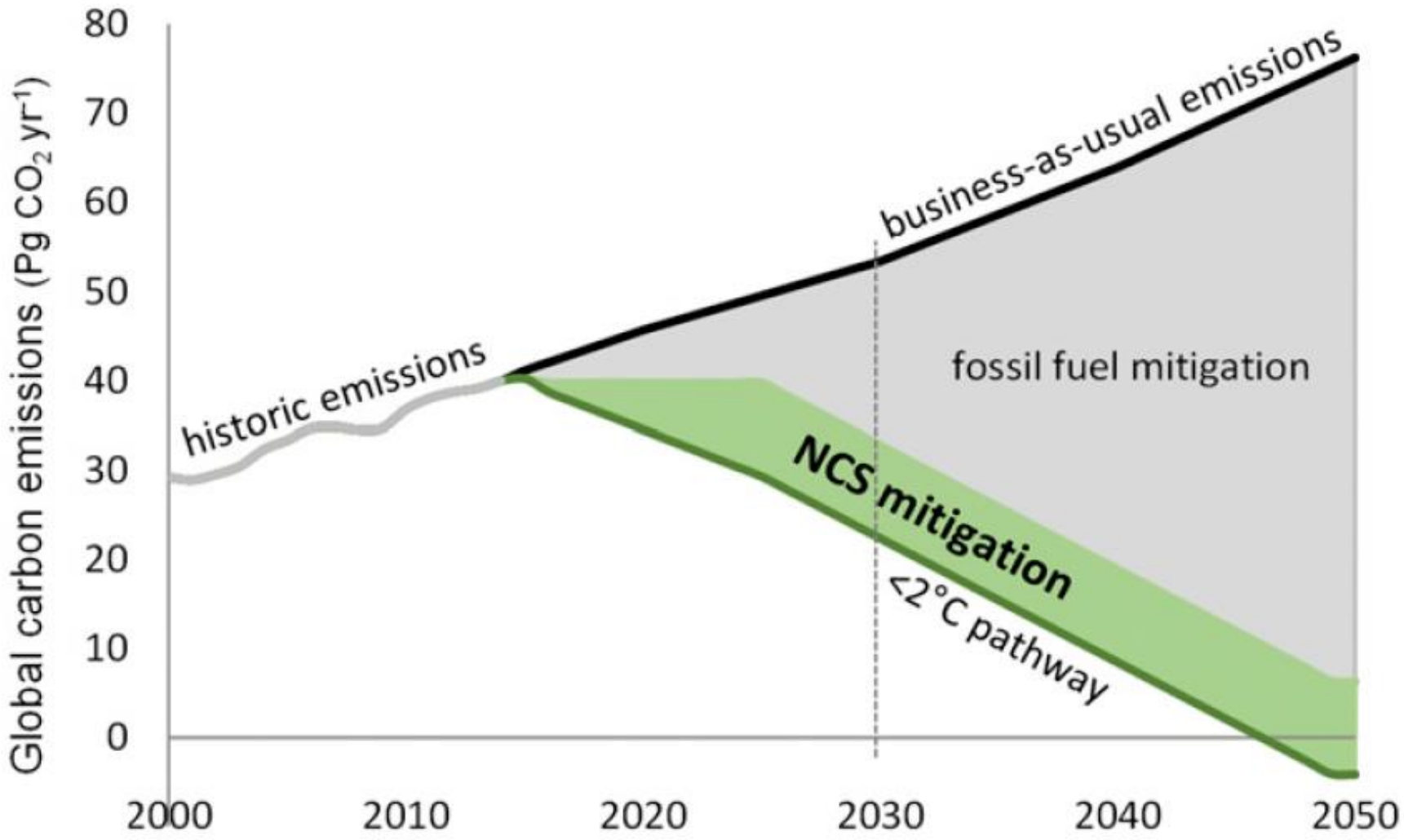
20 NCS have been identified for conservation, restoration, and improved land management that increase carbon storage and/or avoid greenhouse gas emissions.
Maximum potential of NCS is 23.8 PgCO2e y^{-1} almost doubling the present forest C-sink.
Immediate action is needed.



(Griscom, Schlesinger et al. 2017)

Contribution of NCS to stabilizing warming to below 2 °C

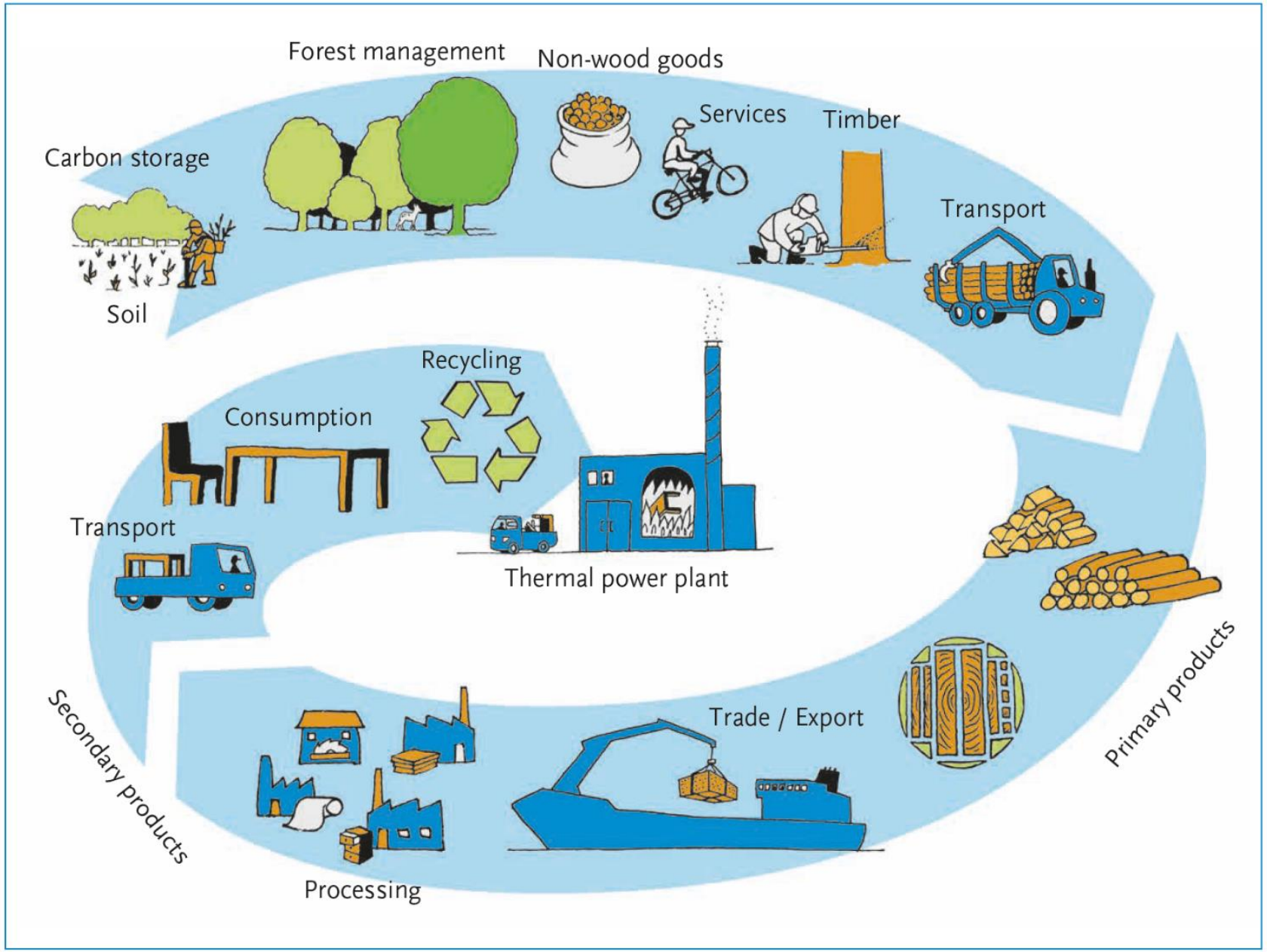
Alongside **aggressive fossil fuel emissions reductions**, NCS offer a powerful set of options for nations to deliver on the Paris Climate Agreement while **improving soil productivity, cleaning our air and water, and maintaining biodiversity**.



(Griscom, Schlesinger et al. 2017)

CLIMATE SMART FORESTRY

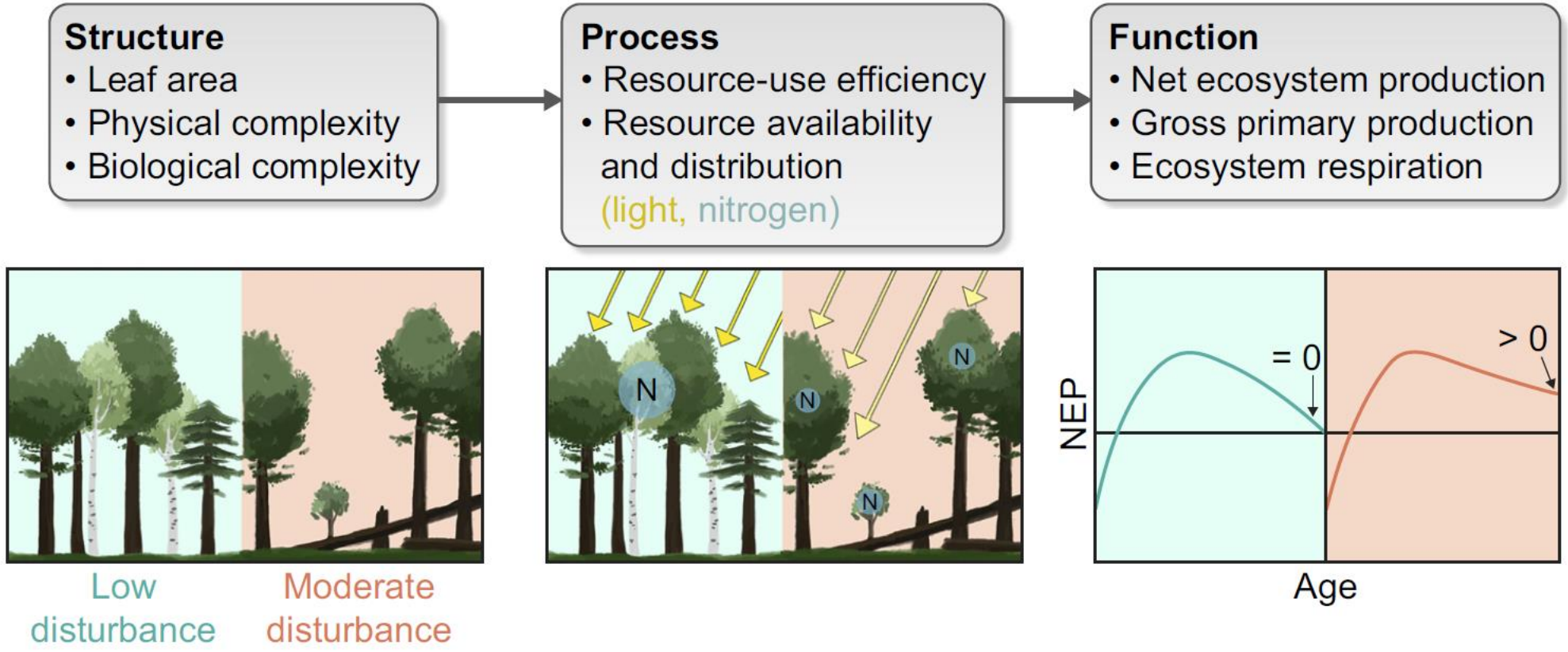
Innovative forest management system to improve **mitigation** (*C-sink*) and **adaptation** to climate change, **while providing ecosystem services and renewable biomaterials** (ex. wood) to reduce the use of fossil materials (ex. cement, steel) and energy (ex. coal) producing large quantities of CO_2 and other GHG.



(European Forest Institute 2016; Nabuurs et al. 2017)

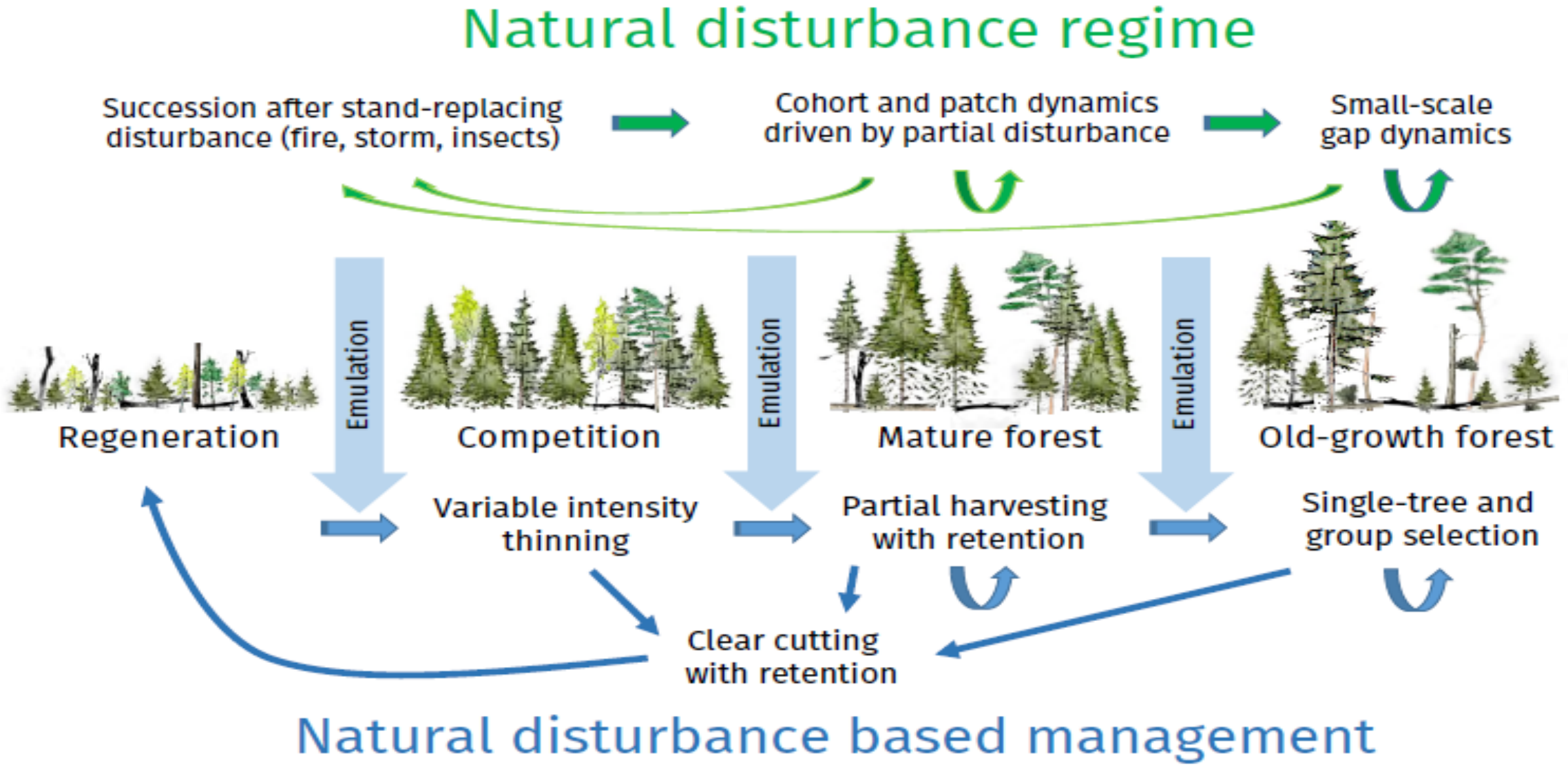
The role of old growth forests
a heated debate

Conservation of aging deciduous forests may therefore **sustain the terrestrial carbon sink**, whilst providing other goods and services afforded by these **biologically and structurally complex ecosystems**



(Curtis and Gough 2018)

Closer-to-Nature Silviculture



Role of the construction sector

Harvested wood products (HWP) contribute to mitigation by storing carbon and replacing energy-intensive materials and fossil energy, reducing GHG emissions.

HWP carbon stock can be significantly increased by prioritizing the use of wood for material purposes, while maintaining constant harvest.

Simulation (interval 2020–2050) shows high mitigation benefits with a **cumulative HWP net CO_2 removals** of −502 Mt CO_2 for Germany, −290 Mt CO_2 for France.

(Bozzolan, Grassi et al. 2023)

To become carbon neutral by 2050, the EU27 net carbon sink from forests should increase from the current level of about 360 to 450 $MtCO_2eq/yr$ by 2050

- ✓ The forest share of the LULUCF sector can be much more **increased compared to the present regulation**.
- ✓ But **European policy has not integrated yet forest potential into the EU climate policy** framework.
- ✓ A wide range of measures can be applied to **provide positive incentives** for integrating these climate objectives into the **EU forests and forest sector** framework.
- ✓ With the right set of incentives at EU and Member States levels, current research can support to **achieve an additional combined mitigation impact through CSF** of 441 Mt CO_2/year by 2050.
- ✓ **Better involvement in the EU Strategies** (Forest, Climate, Biodiversity, Bioeconomy) all the **actors and stakeholders of forest-based chain value**.
- ✓ **Recognizing ES offered by forest managers/owners** (ex. avg. payment by MS/EU per ha of forest: 26 euro. Social cost of Carbon: ca. 180 euro per ton CO_2; avg. Carbon sequestration per ha of forest 2-4 ton $CO_{2)}$

Merci
à Vous!

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1. World forests play a fundemental role in regulating our Climate System.

2. Boreal and Temperate Forests are net sink of carbon. Tropica forests although potentially more relevant for carbon sequestration result in carbon sources due to tropical deforestation and forest degradation.

3. The role of deforestation on Climate Change is worse than currently considered.

4. Projected Climate changes are toward more pessimistic scenarios and this could have large impacts on forest functions, particularly in relation to extreme events.

5. Need to couple mitigation and adaptation of forest ecosystems, with proactive forest management strategies to maintain and increase the role of forests to meet Paris targets, involving the whole forest-based sector.

6. Importance of scientific pan-European and international scientific cooperation.