Identify strategies that optimize the carbon sink in forests: "the impossible equation?"

Laurent Augusto, Laurent Saint-andré

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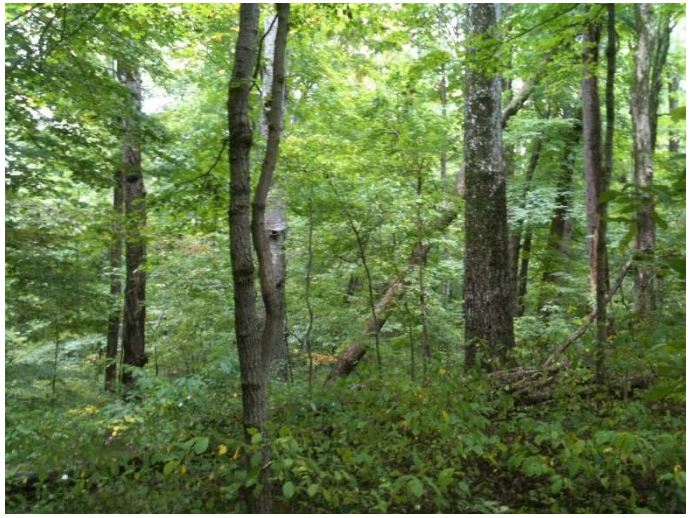

L. Augusto[1] , L. Saint-André[2]

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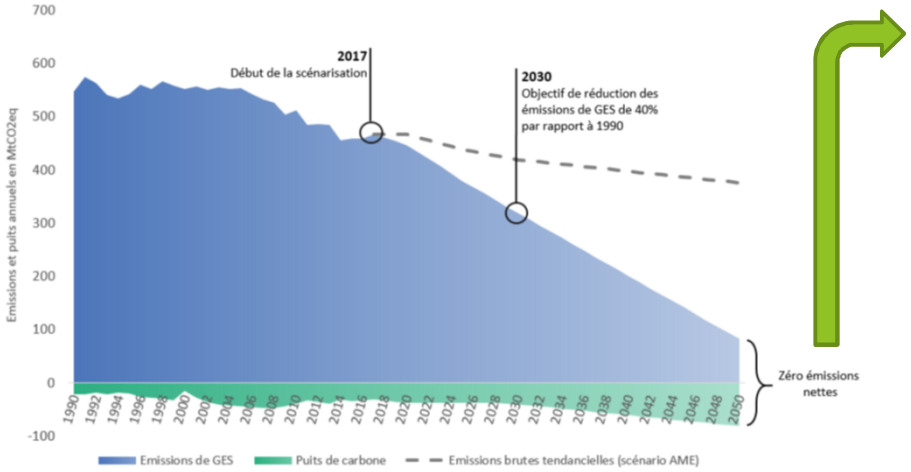
2. INRAE, BEF, UR1138, Champenoux, France

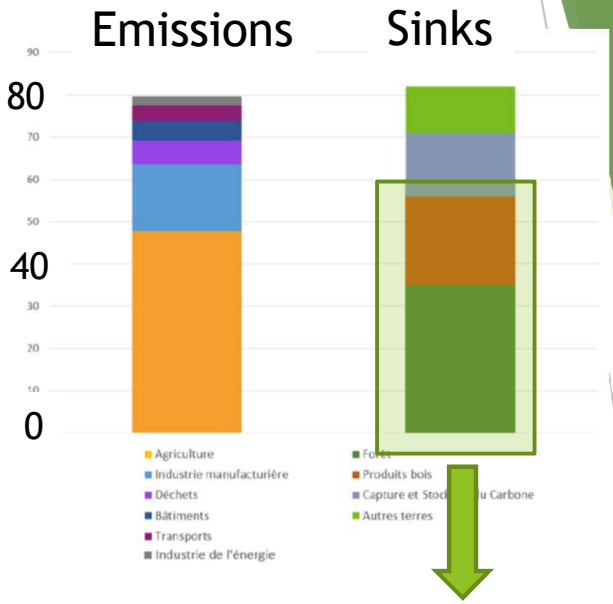
Deepsurf Conference, Nancy, 2022

Context

- National low-carbon strategy to reach C neutrality by 2050



- 2050: Carbon budget of 80 Mt eq CO2

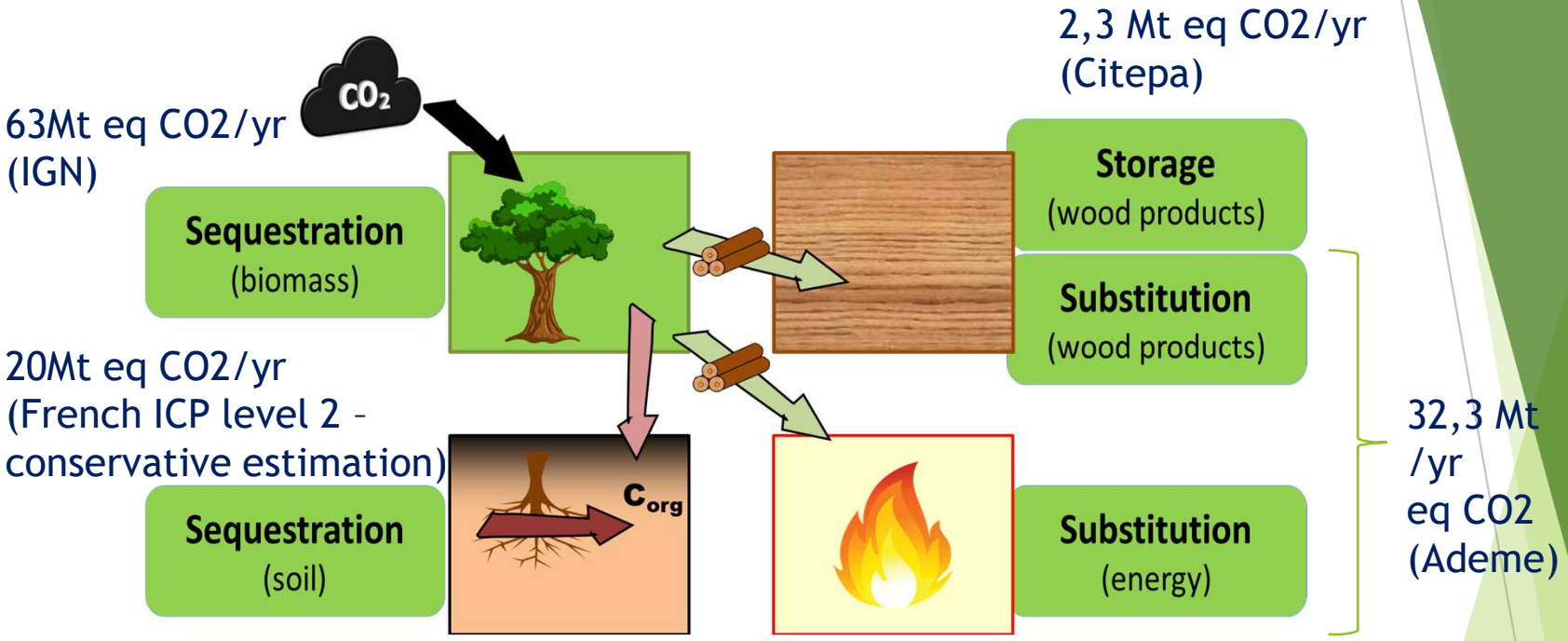


- Sequestration of 55 Mt eqCO2 expected from the forest vegetation and soils, wood products (incl. Substitution)

Two leverages :

- *Decrease emissions*
- *Preserve and increase C sinks in the biosphere (biomass and soils)*

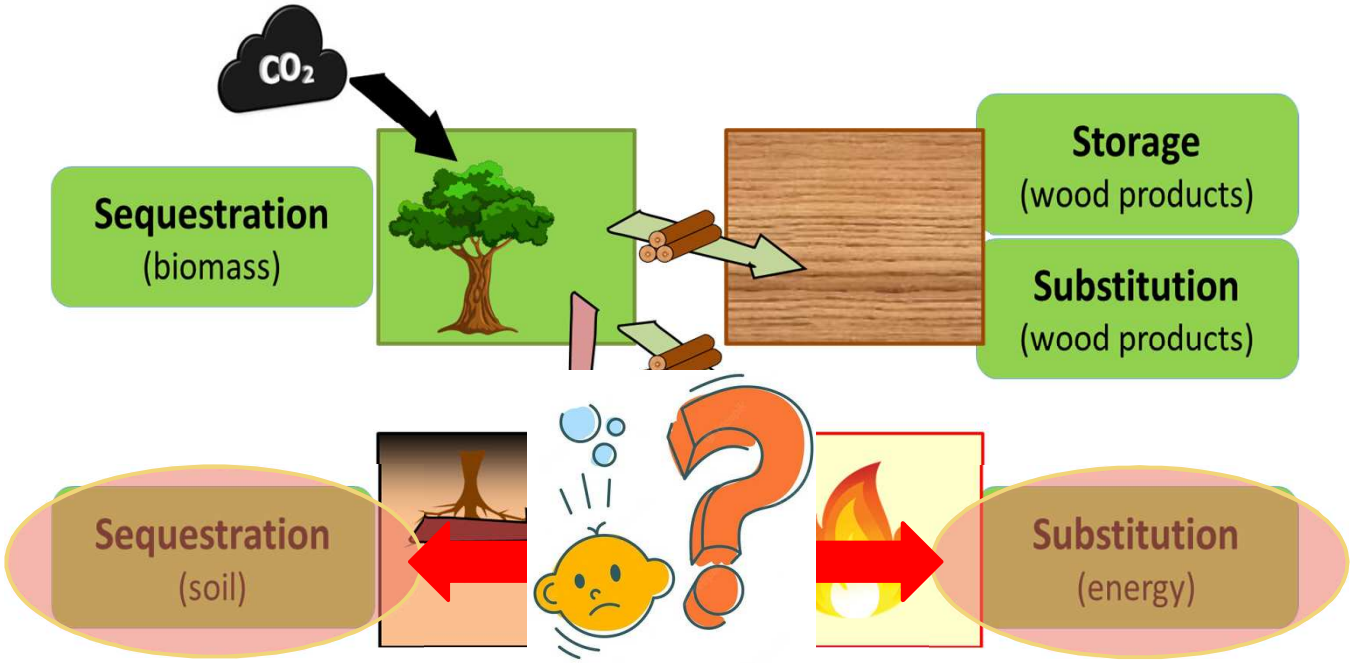
Forests play a major role in climate change mitigation through their carbon (C) cycle.



The 3S (Sequestration, Storage, Substitution) :
the main levers to mitigate the increase of atmospheric CO2

But, It is difficult to optimise all levers (3S) at the same time: **the so-called "3S dilemma"**

“3S dilemma” : example between soil C sequestration and substitution for energy purposes



SCIENTIFIC REPORTS

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Forest soil carbon is threatened by intensive biomass harvesting

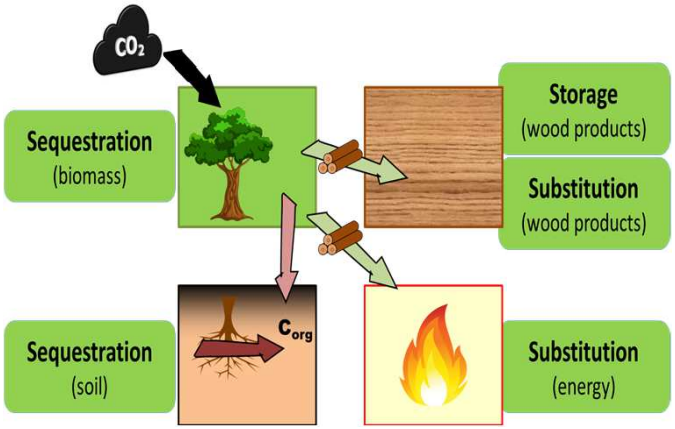
David L. Achat[1], Mathieu Fortin[2,3], Guy Landmann[4], Bruno Ringeval[1] & Laurent Augusto[1]

How can we identify strategies that optimise the climate change mitigation role of forests?

- Coupling models of an extremely different nature
- Some processes are still difficult to simulate in the long term
- The range of climate scenarios is vast
- Difficulty in taking into account catastrophic events or threshold effects in simulations

Biophysical part

- Climate, process-based, phenomenological, resource and biogeochemical models
- How to simulate stochastic events?
- Some processes are not yet sufficiently known to be reliably simulated



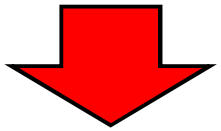
Socio-Economical part

- Socio-economic and sectoral models
- How can we predict the actual modalities of energy and ecological transitions
- How can we simulate the effects of substitution and long-term storage?

To enable simulations, it is essential to make assumptions on which to build these simulations.

With the same tools, different assumptions will deliver different answers

- Probability of extreme events?
- Drought resistance of species?
- Stimulatory effect of CO2 on growth ?
- Long-term dynamics of soil organic carbon ?
- Effects of forestry on soil organic carbon ?
- Life span of wood products ?
- Which fossil fuels are substituted by wood energy?
- How effective are biomass mobilisation policies in regions affected by the phenomenon of non-management?
- Forest land dynamics?
- What is the evolution of the demand for wood products?



Sequestration (biomasse)

Sequestration (sol)

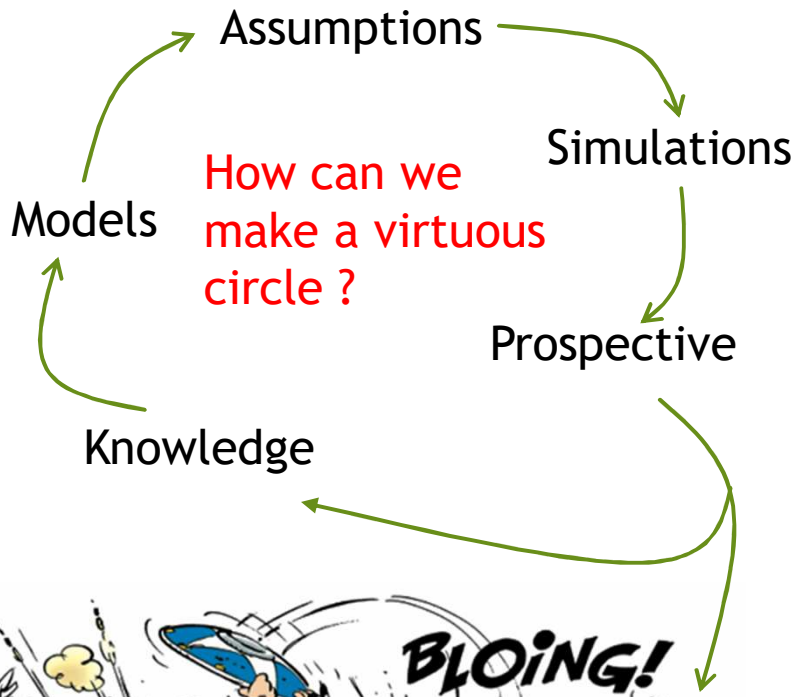
Stockage

Substitution (energie, wood product)

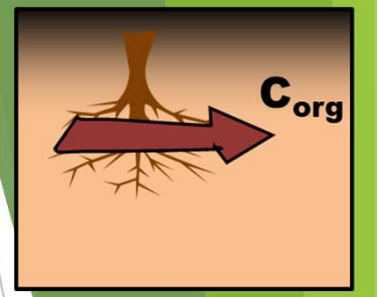
Available simulations are then **projections**, built on **working assumptions** (some of which are **debatable**): **two studies may give two different answers.**

The state of the debate on carbon in forests : Scientists, experts, professionals, citizens, ..., everyone has an idea, but it is rarely the same one!

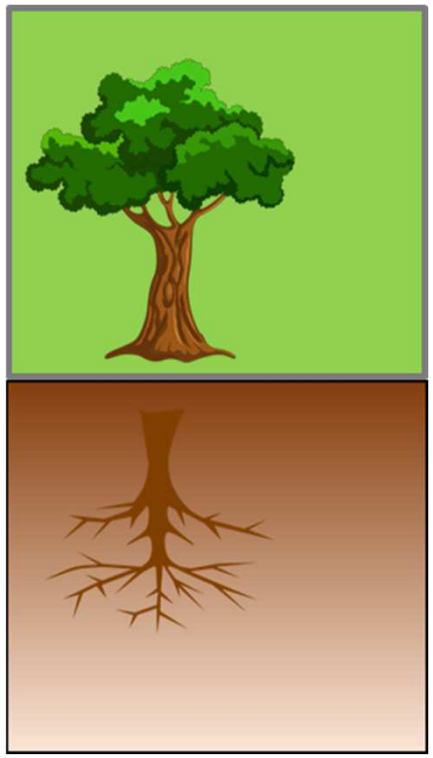
The carbon factory



Should we recommend nothing on the grounds that we cannot model everything with certainty?



Séquestration
(sol)



AboveGround Biomass

Wood residues

Litter

Soil Organic Carbon (SOC)

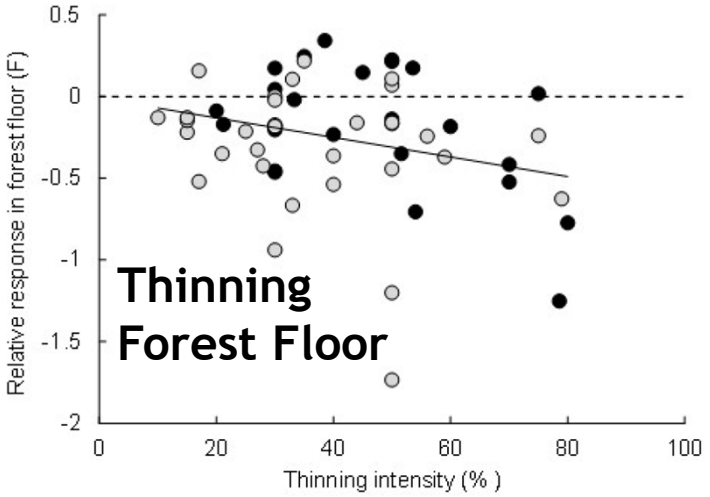
(fires, storms, diseases, droughts, forest managements)

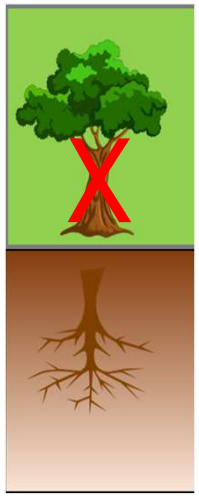
Vulnerability

Potential for a long term sequestration

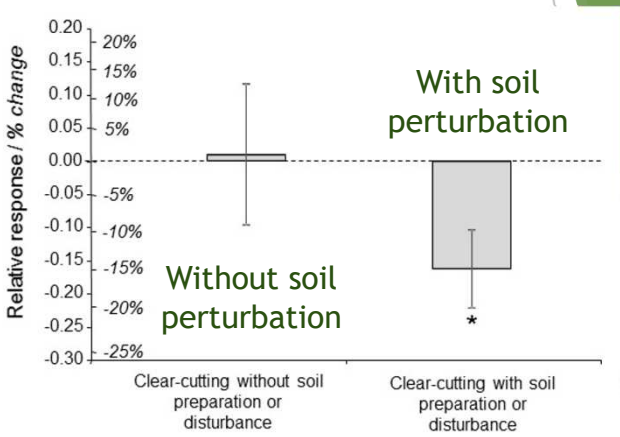
The example of soil carbon sequestration, what we know, what we do not know exactly and what could we do ?

Impact of forest management
Thinnings and clearcuts : large consensus in the literature





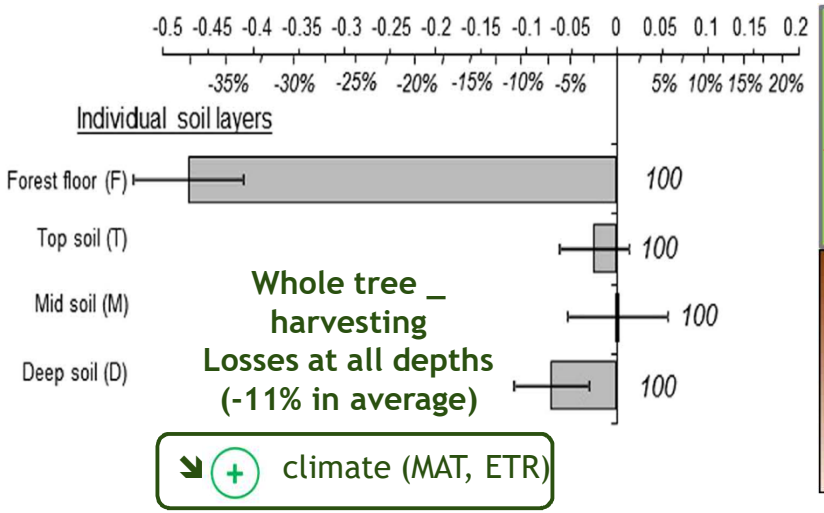
Clear cut
Topsoil SOC



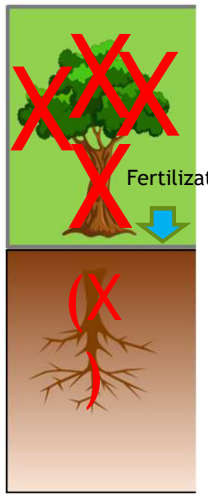
Take home message 1 : Thinnings have no impact on the forest floor, provided that the intensity of the cut is low or moderate; Thinning does not quantitatively impact the SOC pool

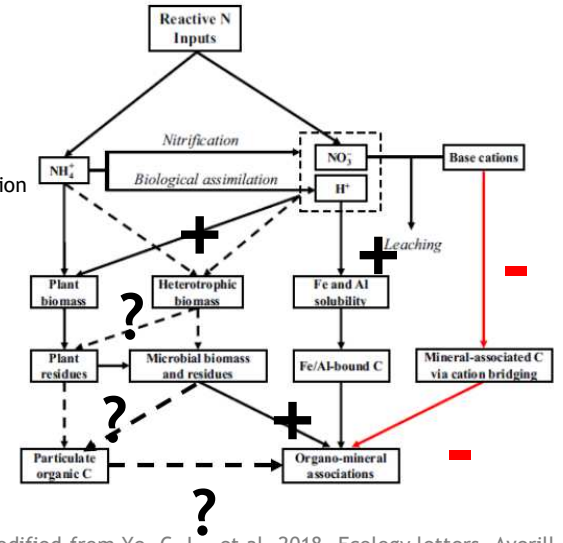
Take home message 2 : Clearcuts that leaves harvesting residues on the soil generally do not affect C sequestration, as long as they do not disturb the soil. The risk of C loss increases with the initial size of the C pool.

Impact of forest management
Whole - tree harvesting : large consensus in the literature, Fertilization with N : few papers



[Achat et al. (2015) - Sci. Reports]





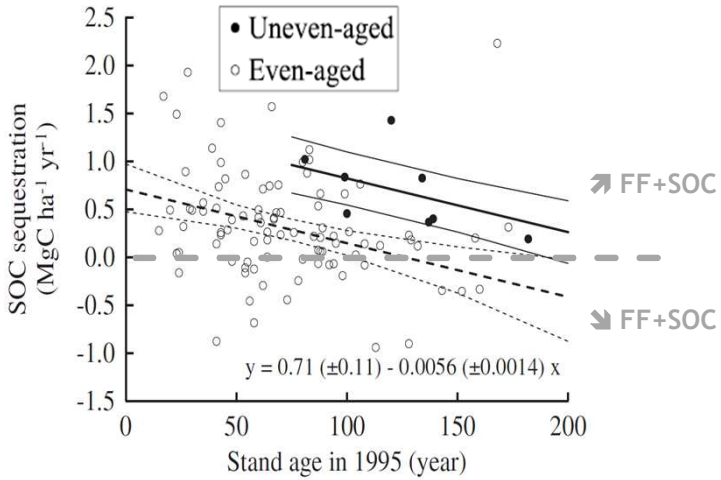
Modified from Ye, C. L., et al. 2018, Ecology letters, Averill and Waring, 2018 Global Change Biology, Janssens et al 2010, Nature Geosciences

Take home message 3 : Whole tree harvesting negatively affects the SOC, the impact increases under warm climates

Take home message 4 : The impact of N fertilization on SOC is unclear (dose effect with a bell curve)

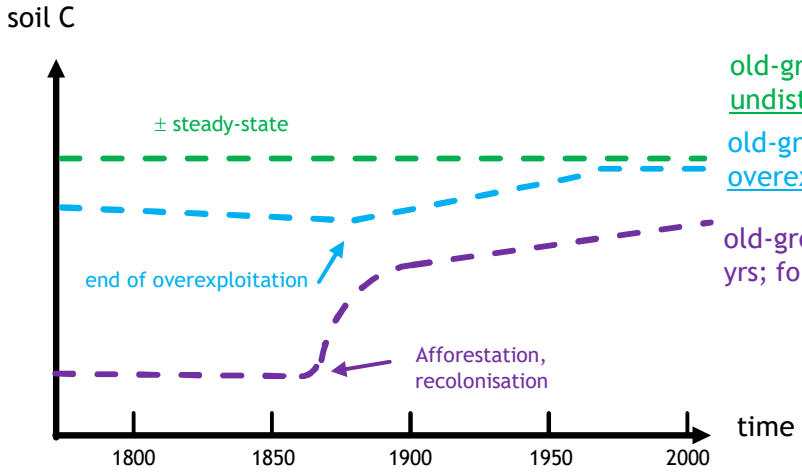
Impact of forest management
Rotation length – few papers, unclear effect

RENECOFOR: ↗ SOC up to ~100 years



[Jonard et al. (2017) - Sci. Tot. Env.]

Take home message 5 : Extending rotations -and thus tending towards old-growth forests- can improve SOC sequestration over the long term (up to 50-100 years?). But strong interaction with the past history of the forests.

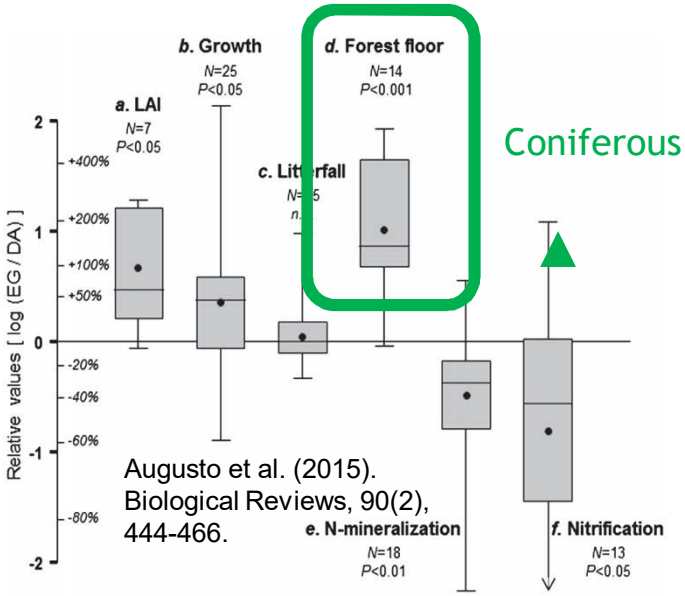


old-growth forest in ancient (>> 200 yrs), undisturbed, forests

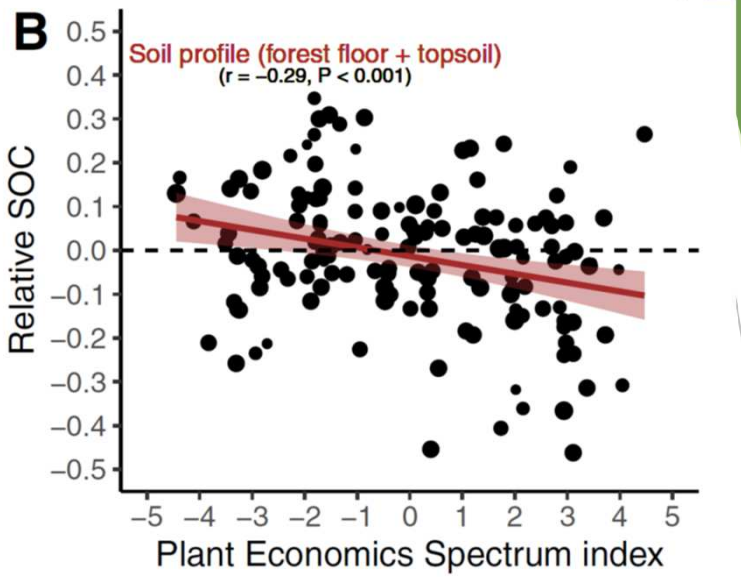
old-growth forest in ancient, but formally overexploited, forests (RENECOFOR case?)

old-growth forest in recent forests (< 200 yrs; formally croplands)

Impact of forest management Species Effect - Literature relatively abundant, clear effect



Augusto et al. (2015). Biological Reviews, 90(2), 444-466.



Augusto and Boca (2022). Nature Com.

Take home message 6 : Identity is generally a more important factor than diversity. Functional diversity in relation with the climate and soil conditions better explain the observed trends than specific diversity.

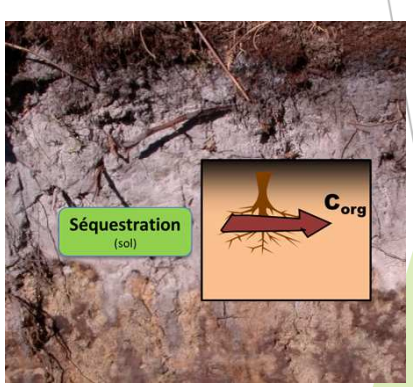
Question: "How to optimise the contribution of forests to mitigation: maximise sequestration in the ecosystem or maximise storage in materials and fossil C substitution? The 3-S dilemma

<u>Conclusions</u> Forest soil carbon:

Soil = a relatively non-vulnerable compartment of the ecosystem but not insensitive to disturbance

Take into account :

- climate
- soil type
- Past land-uses
- regional forest-wood economy



Use soil C as a management indicator
(rich soils = soils more sensitive to losses)

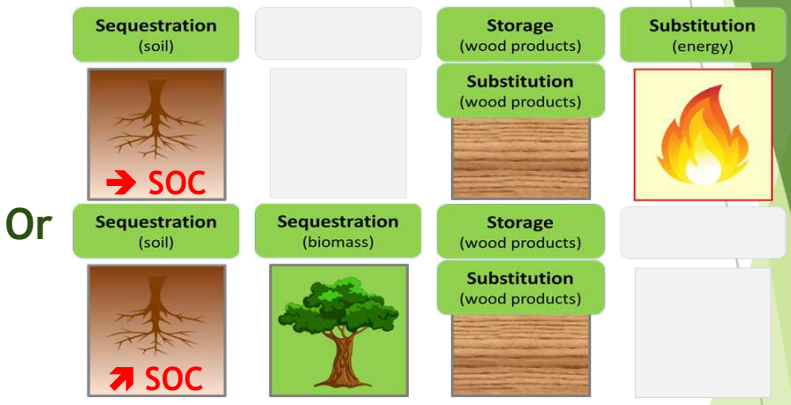
Forest management can modulate the balance between Sequestration and Storage/Substitution in Wood (3S Dilema)

Afforestation of cultivated or degraded soils (poor SOC stocks)

- Fast growing tree species
- Rotation length >50 years to maintain the inherited soil fertility
- Adaptation on the short term to climate changes

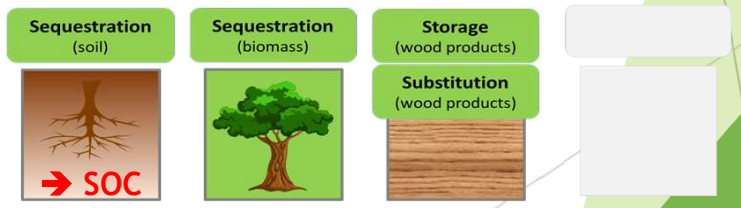
Forests with medium SOC stocks

- No whole-tree harvesting
- Increase SOC stocks with nitrogen fixing species
- Reduce soil perturbations
- Adaptation on the mid-term



Forests with high SOC stocks

- Continous cover
- No soil perturbation during harvesting
- Adaptation on the long term



Need for adaptive forestry, regionalized – co-construction of the roadmaps (work with all forest actors)

Future of the Forest ……

not under a bell jar (full conservation, no action),
nor an overexploitation……

Thanks for listening !