

Role of forests in global carbon cycle and mitigation

Presentation for *Land use and Forests in the Paris Agreement, real world implications of negative emissions and Bioenergy CCS (BECCS)*

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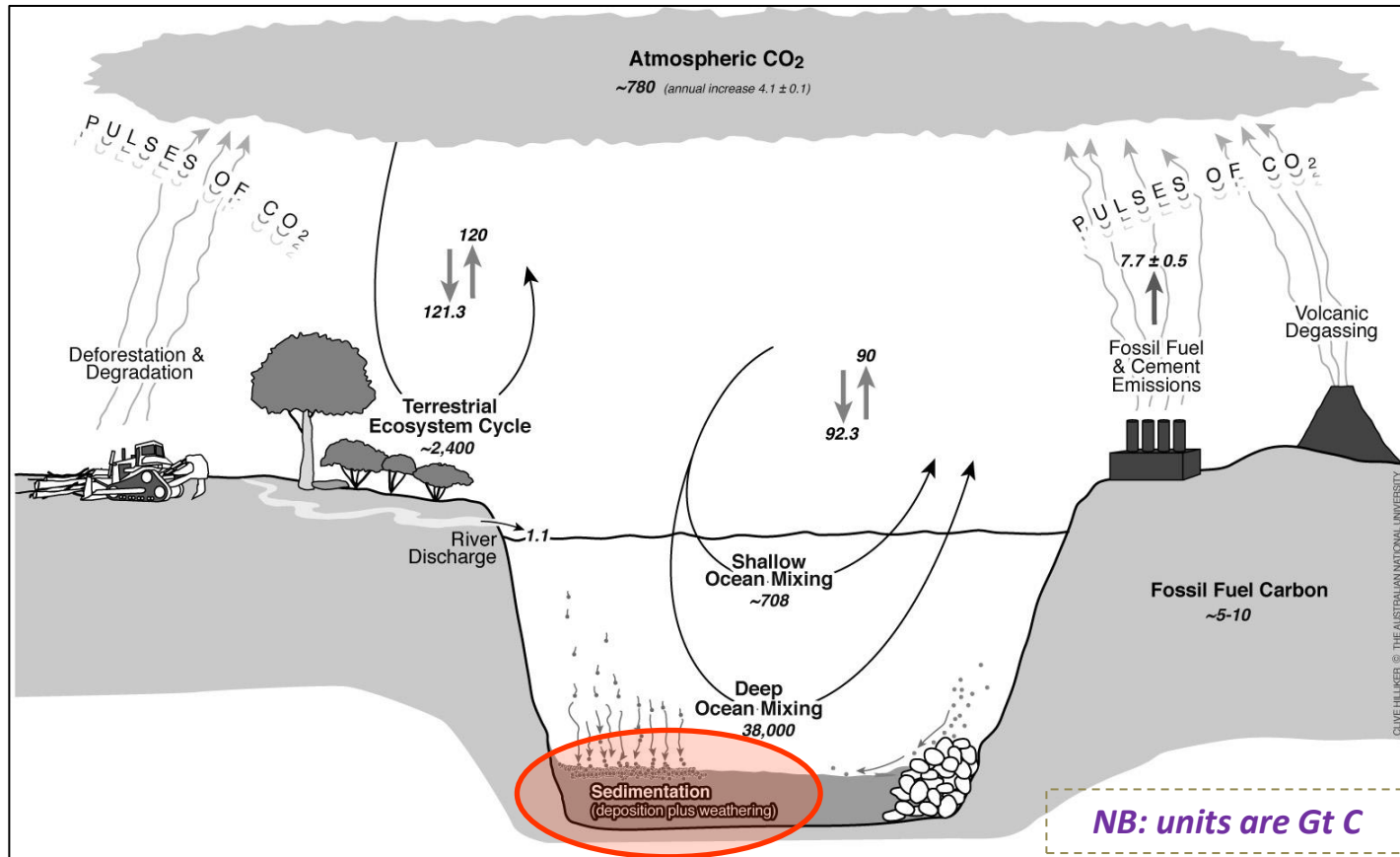
1. The global C-cycle
2. The mitigation value of forests
3. The problem with offsets
4. Some policy implications
5. Can forest sector provide negative sequestration?



1. The global C-cycle

- The role of forests in GHG mitigation can only be properly understood in the context of the global C-cycle
- Natural processes involve flows of carbon between the atmosphere, land and oceans
- Fossil fuel carbon is a separate and additional source of carbon to forest/atmosphere/ocean carbon
- The atmospheric lifetime of the airborne fraction of a CO₂ pulse is incredibly long due to slow-rate of weathering and sedimentation processes

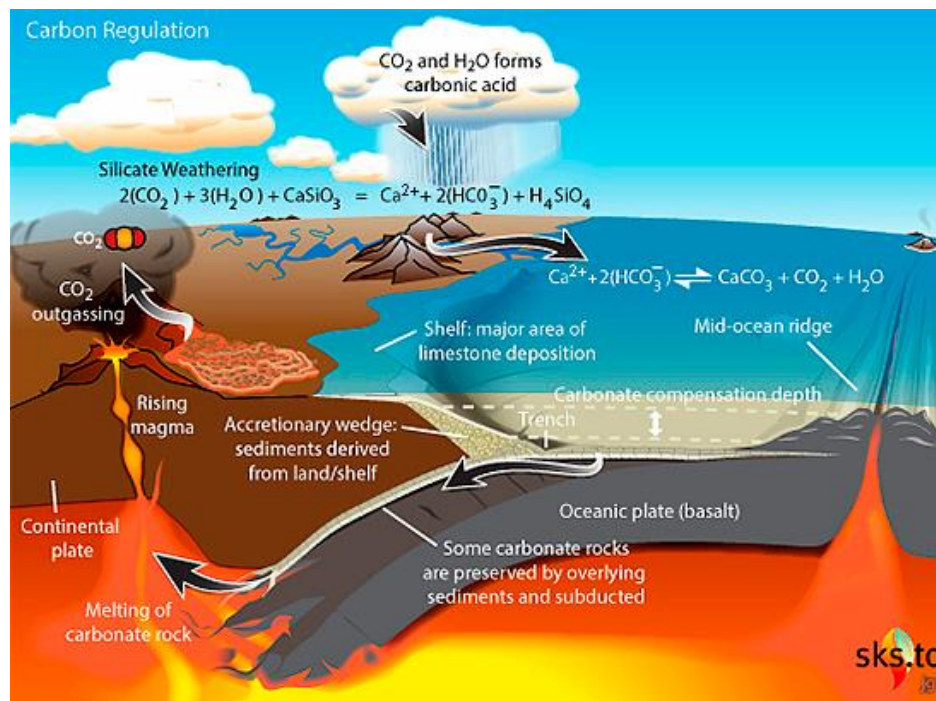
Global C-cycle (simplified)



Of the total emissions from human activities during the period 2004-2013, about **44%** accumulated in the **atmosphere**, **26%** in the **ocean** and **30%** on **land**.

A 'pulse' or unit of CO₂ emitted to the atmosphere is only fully removed from the atmosphere so that it no longer interacts with the climate system when it has completely dissolved in the deep ocean — a process requiring the concurrent dissolution of carbonate from ocean sediments (about 5,000 to 10,000 years) and enhanced weathering of silicate rocks (around 100,000 years). Modelling by Archer and colleagues indicated that 20–35% of the CO₂ emitted will still be in the atmosphere after 2–20 millennia

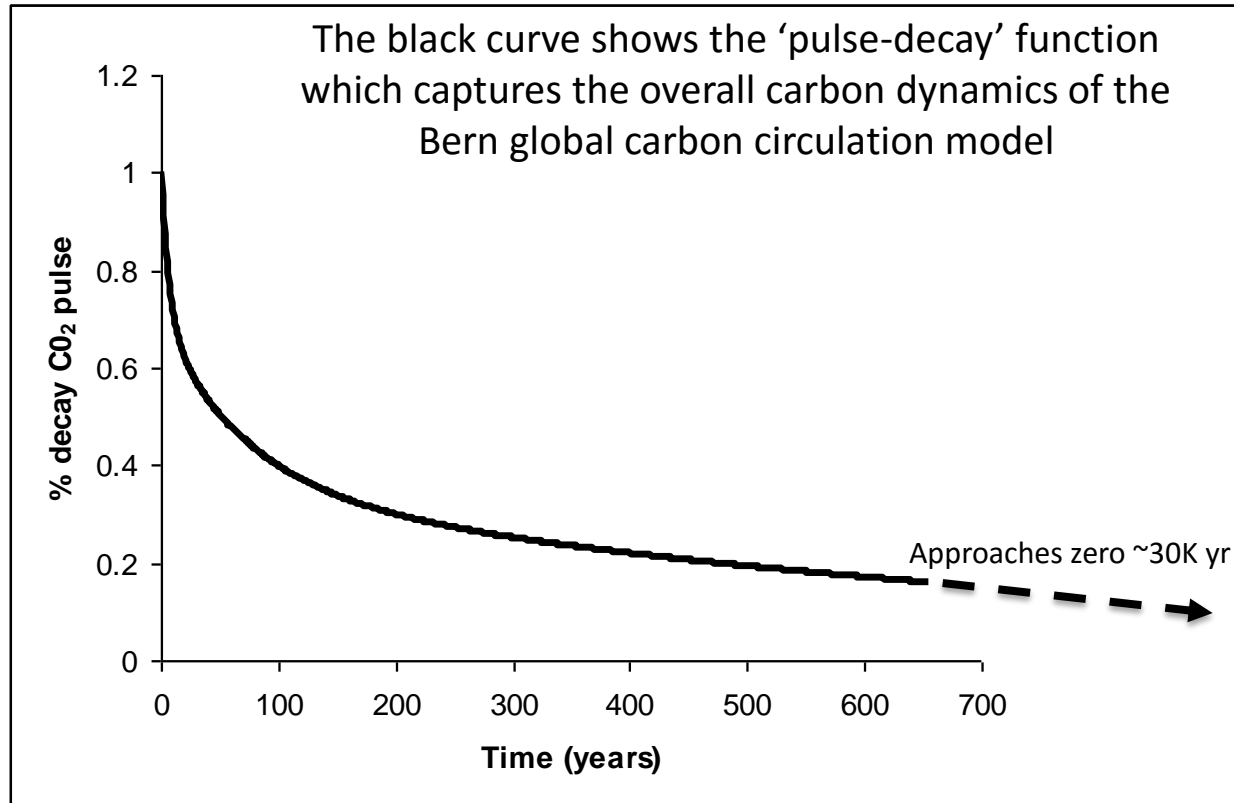
Source: Mackey et al. (2013) *Nature Climate Change* **3**, 847 doi:10.1038/nclimate2006



The weathering of rocks is estimated to involve the drawdown of about 1 Gt atm[CO₂] a year. Source:

<http://www.skepticalscience.com/weathering.html>

Therefore, atmospheric CO₂ is very long lived

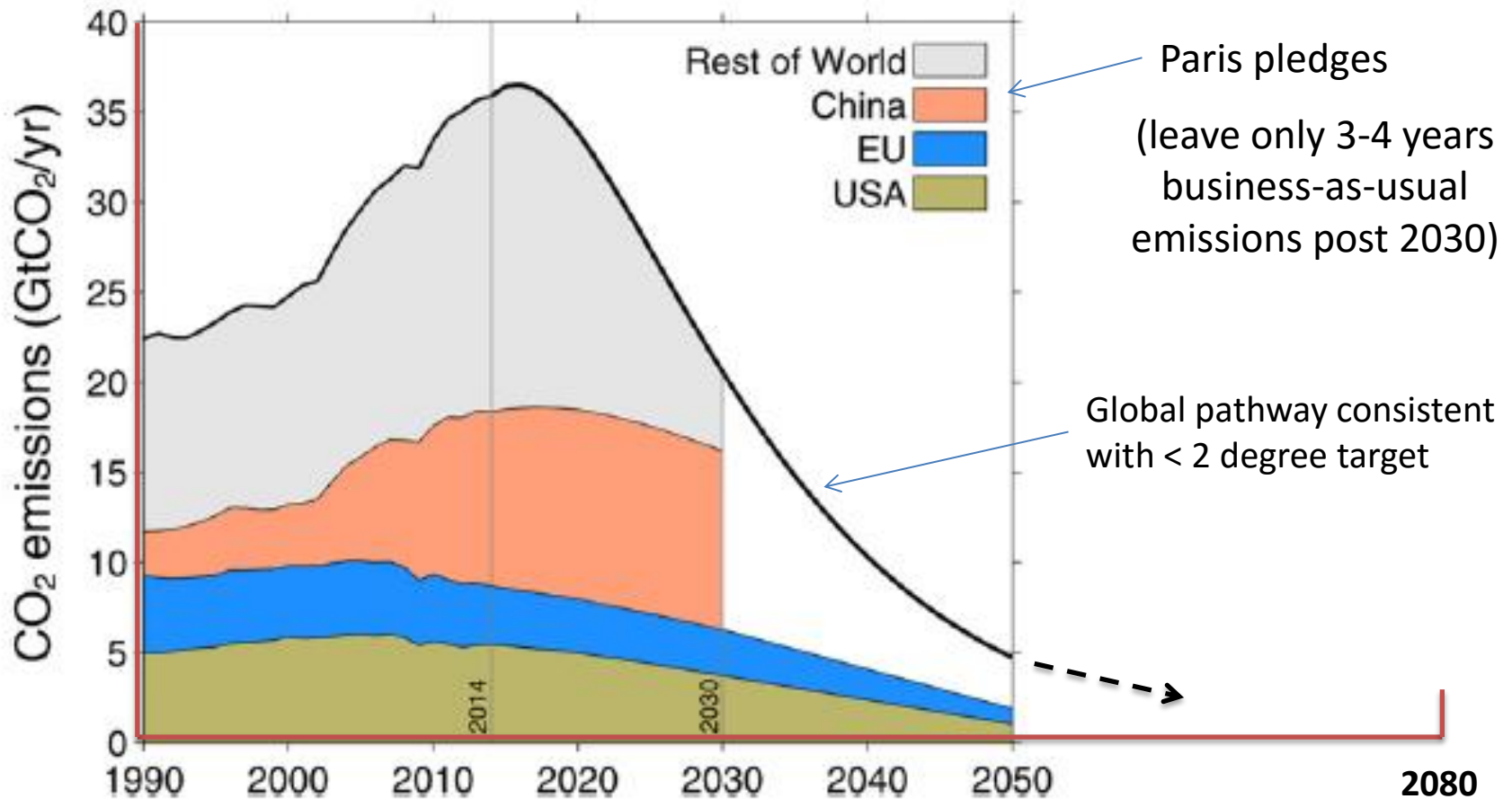


The life-time in the atmosphere of the air-borne fraction of a pulse of fossil fuel CO₂ is about **300** years for the first **75%** and up to **30,000** years for the remaining **25%**.

2. The mitigation value of forests

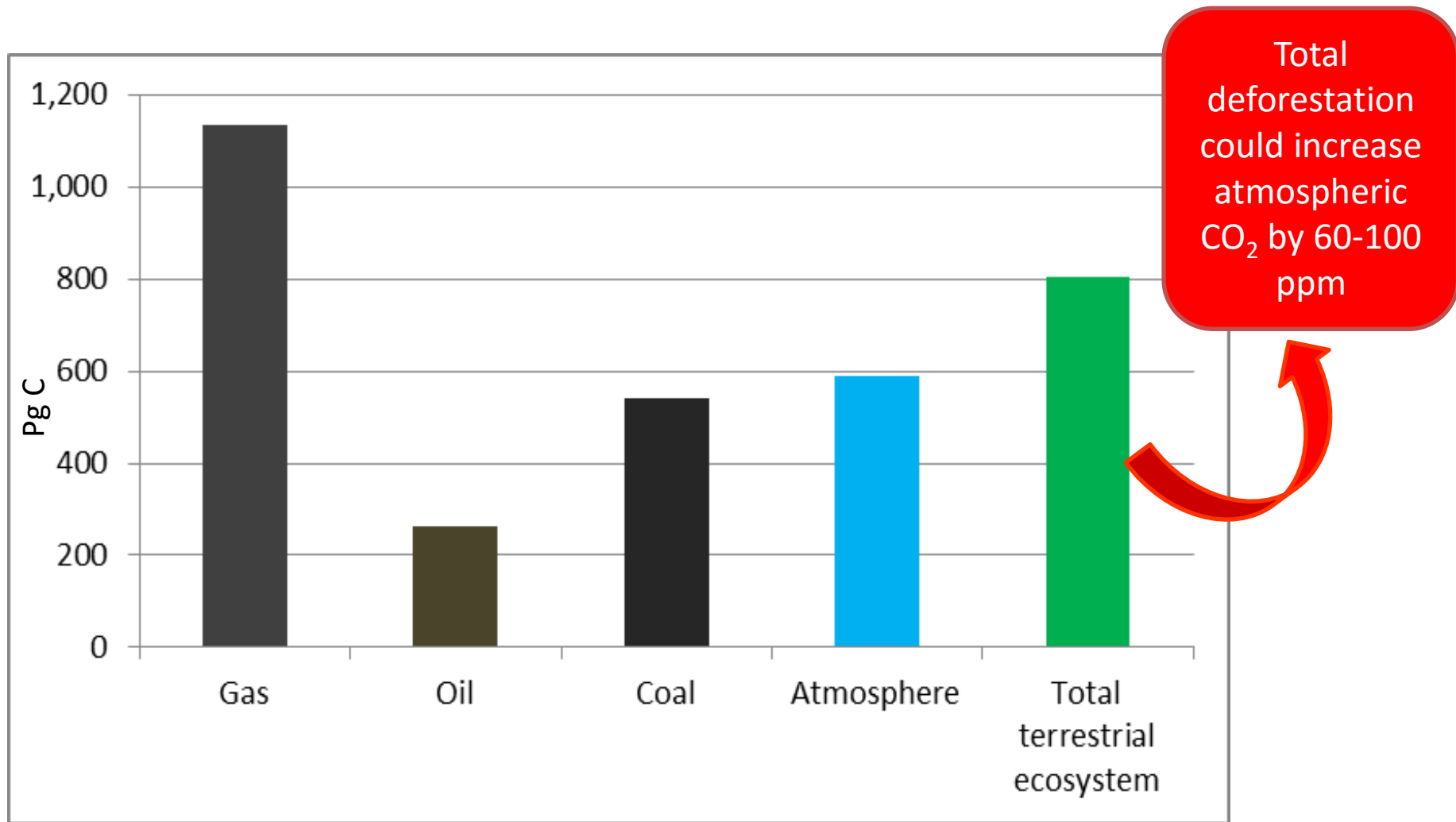
- Deep cuts and rapid in emissions are needed in all sectors if we are to restrict global warming to well below 2 degrees and aspire to 1 degree
- The mitigation value of forest lays in the accumulated stock of ecosystem carbon, not in the short-term rate of forest photosynthesis
- There is a substantial global stock of forest carbon with significant avoided emission potential, which if lost is sufficient to blow the 2 degree target, irrespective of fossil fuel mitigation
- There is significant mitigation potential in reforestation and restoring degraded forests which can also help in the transition to a fossil free world

Deep, rapid and permanent cuts needed in all sectors

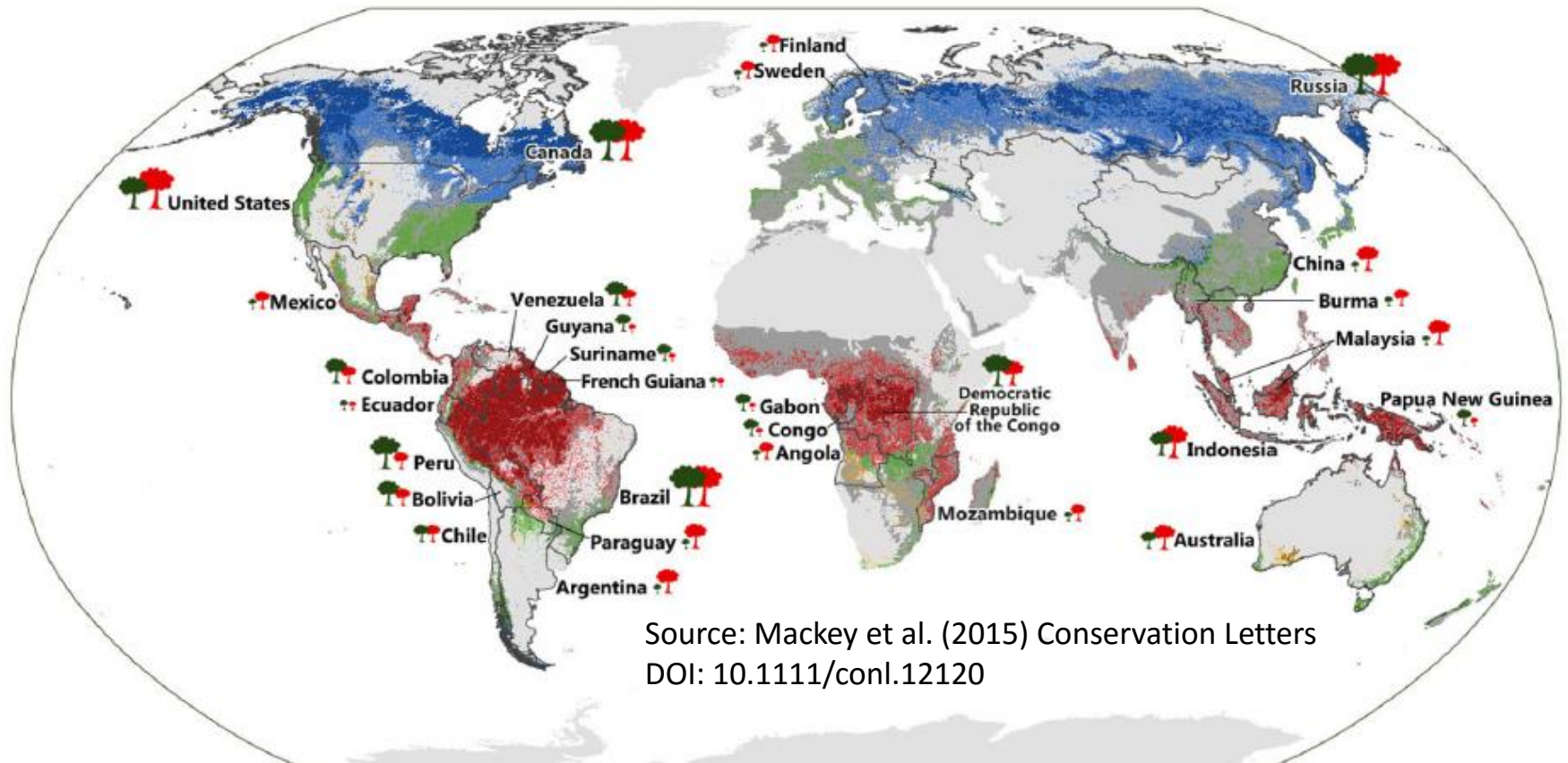


Source: Peters et al. (2015) Measuring a fair and ambitious climate agreement using cumulative Emissions. *Environ. Res. Lett.* **10** (2015) 105004

Current estimates of non-ocean global C stocks



Mitigation potential in all forest biomes



Loss of pre-agricultural forest cover

At least 35%

Remaining forest that is primary forest

36%


Remaining forest that is degraded & regrowth

64%, i.e. 233.7 million ha (2.34 million km²)


Primary forest carbon stocks relative to degraded & regrowth forests

30-70% more carbon


Potential for tropical forests in stabilizing [atmCO₂]



Currently, estimate of emissions from deforestation & degradation account for at least 1/10 of annual greenhouse gas emissions, i.e. > 1 billion tonnes of carbon (or 3.67 billion tonnes of CO₂) each year¹



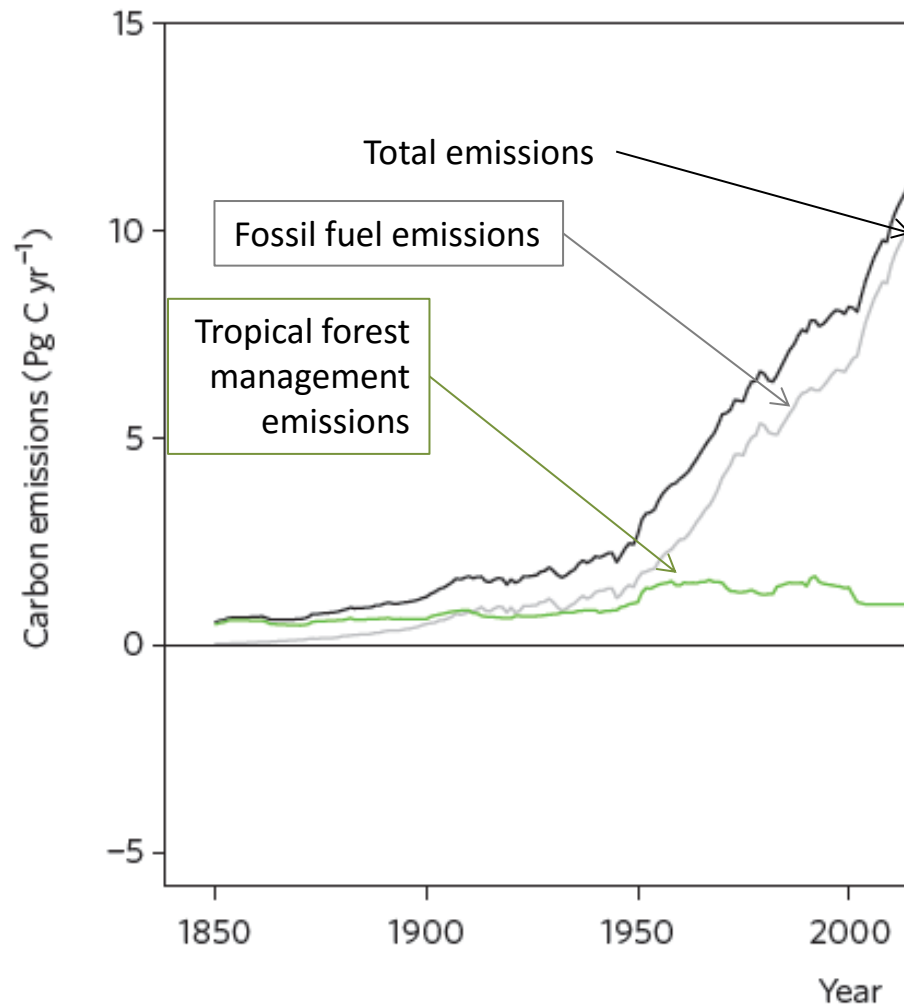
Stopping deforestation and degradation, plus regrowth of secondary forests, plus targeted reforestation would reduce total emissions by as much as 5 billion tonnes of carbon each year, i.e. a reduced source of 1 billion tonnes and an increased sinks of 4 billion tonnes each year



Absorption of carbon by tropical forests could equate to much of the release of fossil fuel carbon between now and 2050, stabilizing and then reducing [atm CO₂] within a few decades, and providing a bridge to a fossil-fuel-free world²

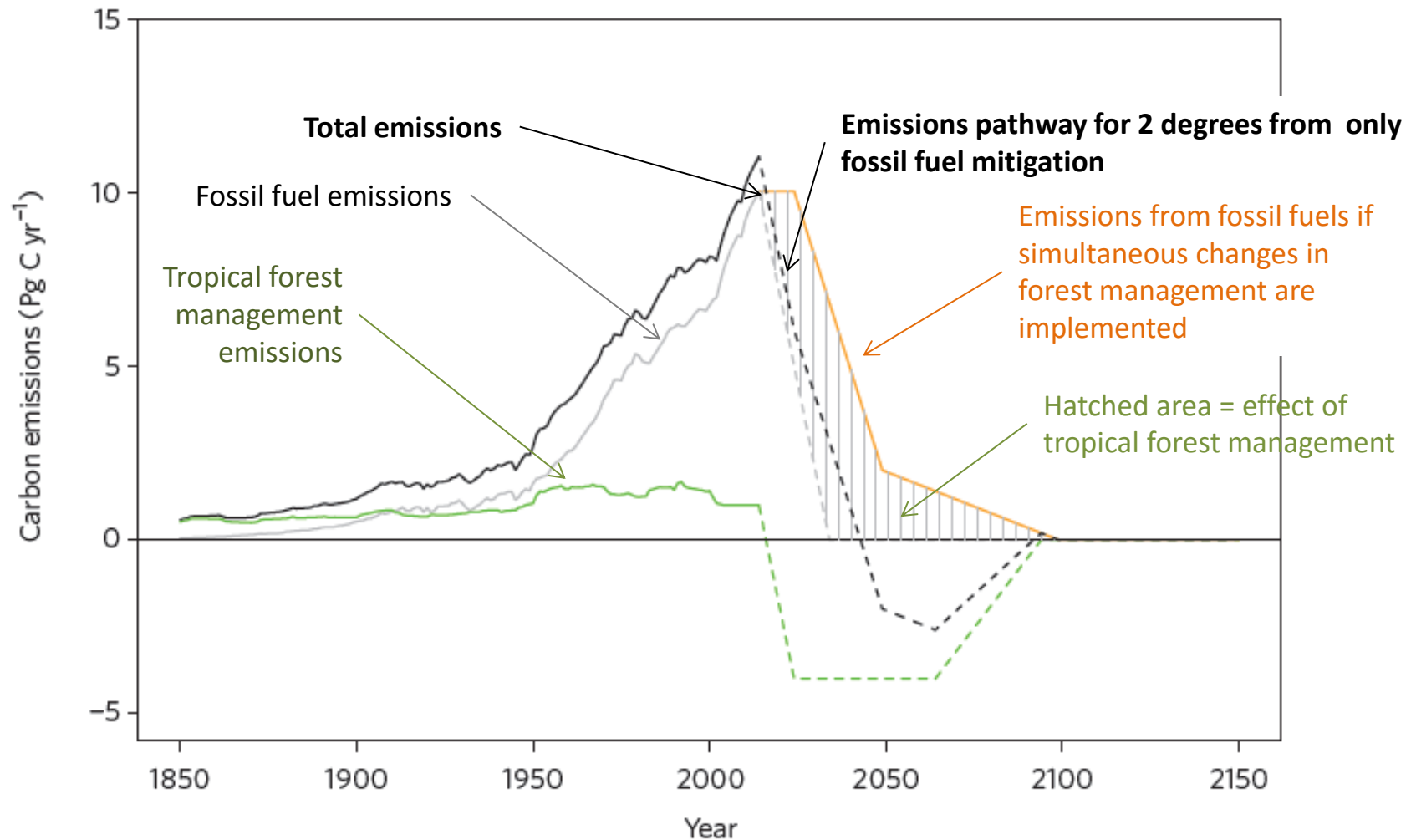
Potential mitigation role forest conservation

Maximum mitigation potential from tropical forests of avoiding emissions through conservation and restoring degraded forests that can provide a bridge to a fossil free world



Potential mitigation role forest conservation

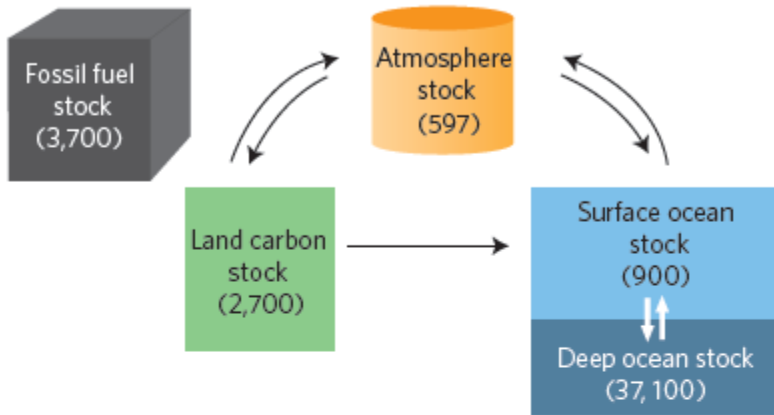
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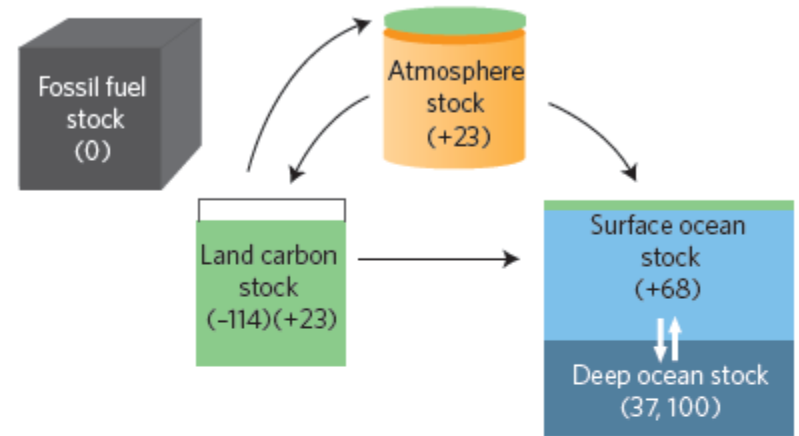
3. The problem with offsets

- There are physical limits to the quantity of carbon that can be sequestered by terrestrial ecosystems such as forests
- The mitigation benefit of forest restoration is in re-paying the land carbon debt, not in offsetting fossil fuel emissions
- Carbon needs to be sequestered “permanently” or at least for very long time periods, to reduce atm[CO₂] and radiative forcing
- Natural forests store stable, long lived carbon stocks
- Most harvested wood products are simply a “delayed emissions”

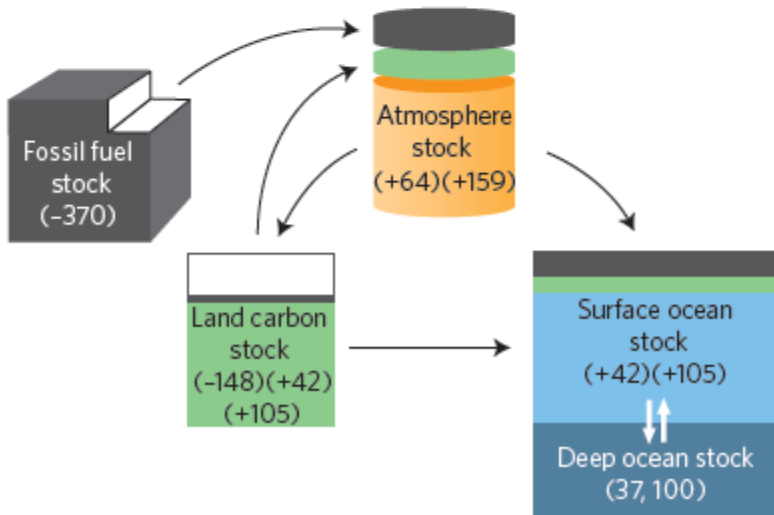
a Pre-agriculture Earth C-cycle



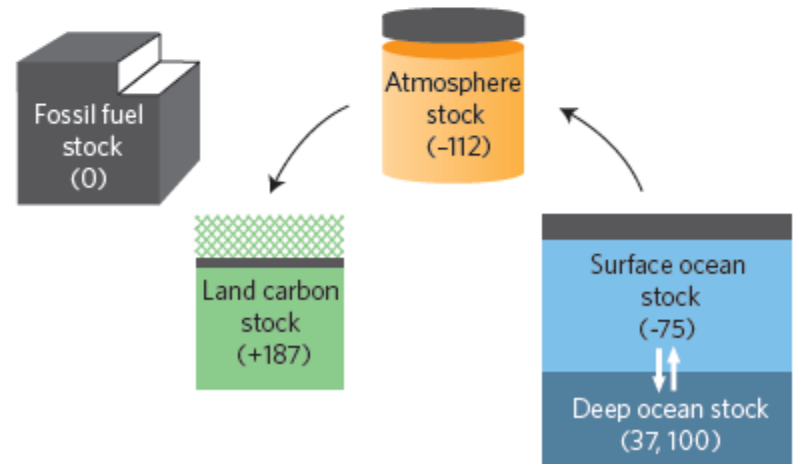
b Pre-industrial Earth C-cycle



c Industrial Earth C-cycle



d Hypothetical re-forested Earth C-cycle



Forest ecosystem carbon stocks



Image Sarah Rees

- Most biomass carbon is in woody stems & roots of big old trees
- Dead biomass and soil-C dominate forest carbon stocks in boreal biome
- Primary forests store 30-70% more carbon than commercially logged forests and plantation forests
- The biodiversity of natural forests provide forest ecosystems with resilience and adaptive capacity, resulting in more stable carbon stocks
- Primary forests take hundreds of years to grow ecosystem carbon stock to natural carrying capacity

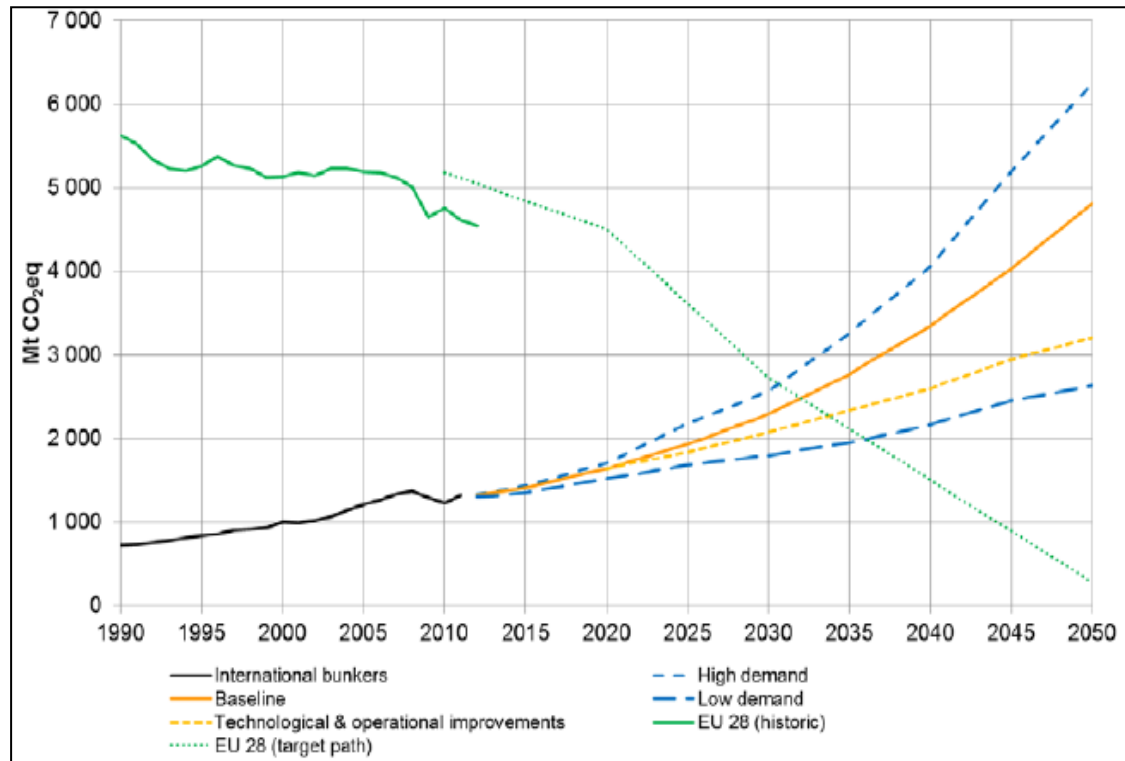
4. Some policy implications

- If the carbon sequestration from forest protection and restoration is not really offsetting fossil fuel emissions, where will the funds come from to provide financial incentives to land managers to change forest management?
- So long as carbon accounting systems focus on flows not stocks, the mitigation value of forest protection and restoration are not recognized and rewarded



Alternative sources of forest management funds: invoke “polluter pays” principle for intractable sectors

International aviation & shipping are world’s 20th largest economy and are major carbon polluters - they should be paying (polluter pays principle) and the money could be used to fund forest protection and restoration



Projected emissions from international bunker fuels and the EU target path

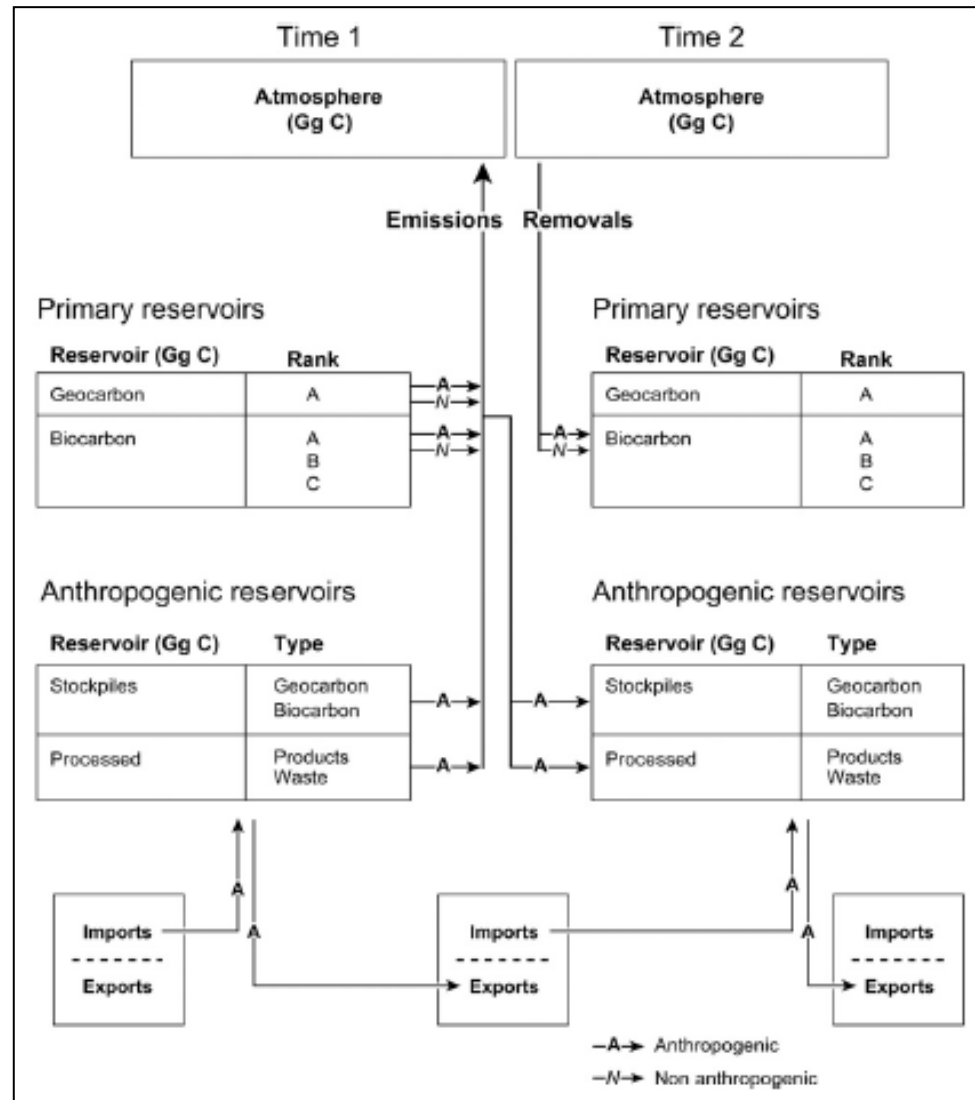
Source: <http://www.europarl.europa.eu/studies>

Carbon stock & flow account framework

Flow inventories are apt for the **fossil fuel sector** where flows are effectively one way, stock changes are almost entirely anthropogenic, and stocks are stable in the absence of human perturbation

For the **land sector**, flow-based GHG inventories obscure fundamental differences between ecosystems: in their carbon stock stability, restoration capacity, and density.

Carbon accounting needs to be comprehensive and includes **stocks as well as flows** for reservoirs, lands and activities continuously over time



5. Can forest sector provide negative sequestration?

- Avoiding emissions by protecting forests and refilling depleted forest carbon stocks through reforestation and restoration together can lead to significantly lower atm[CO₂] levels compared to ‘business-as-usual emissions’ in the coming decades
- We need accounting systems that recognize such forest management actions and policy and rule settings that foster primary forest protection, restoration of degraded natural forests and re-forestation of natural forests in that order
- Short-term carbon sequestration and storage does not change the longer term accumulated stock of atm[CO₂] which is the prime determinant of radiative forcing and climate change so while “wood is good”, wood products have minimal mitigation value. Similarly, improving the management of plantations and other production forests has a negligible contribution to make to climate mitigation
- Forest protection and restoration do not offset fossil fuel emissions as this can only be achieved through long term, slow geophysical processes of silicate weathering and deep ocean sedimentation

Questions

