Potential synergies between mitigation and adaptation for the land sink and how to evaluate opportunities and tradeoffs

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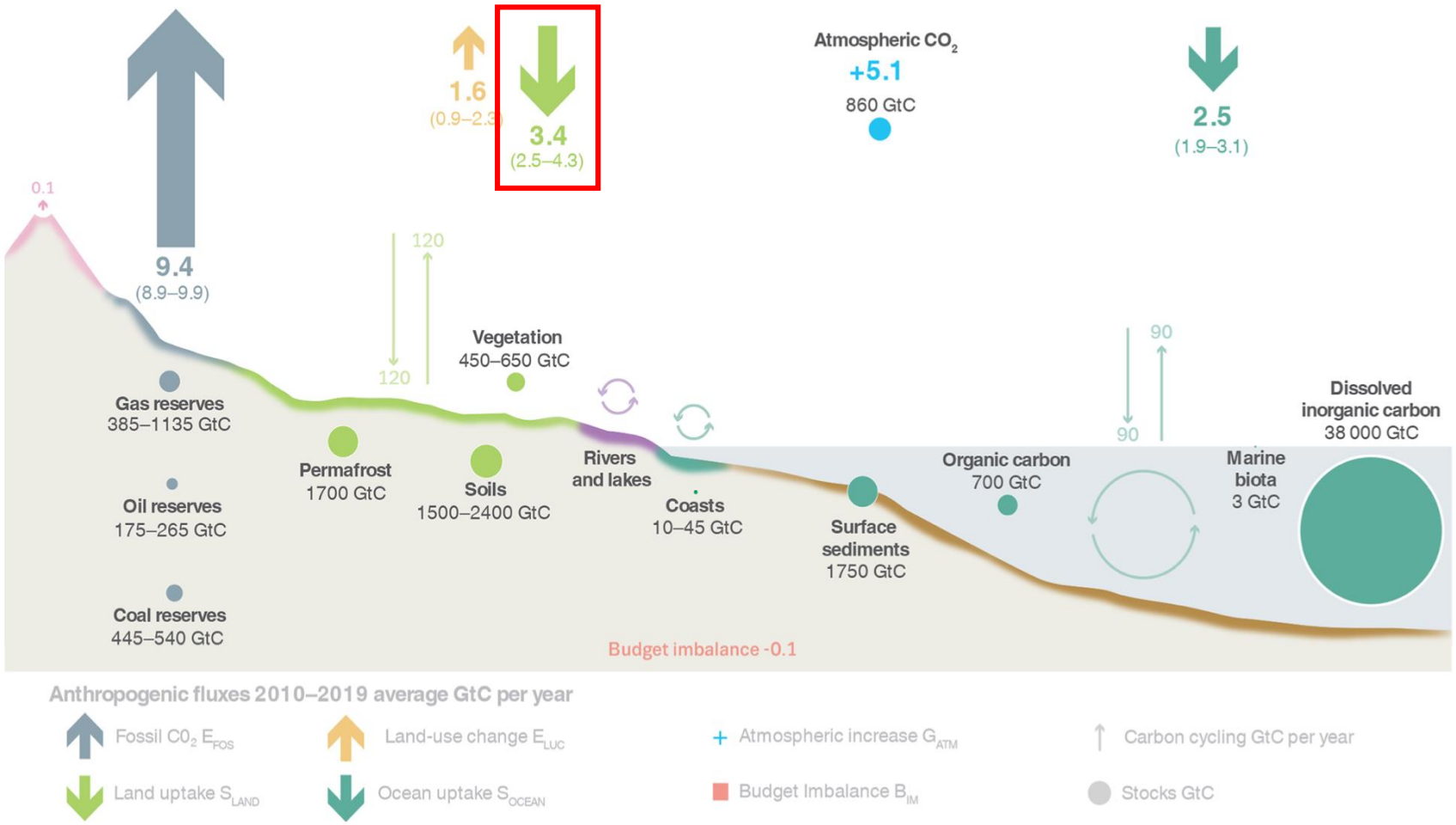
Contributions : W. Anderreg, P. Friedlingstein, J. Pongratz, P. Canadell, A. Bastos, C. Albergel, G. Grassi

LSCE

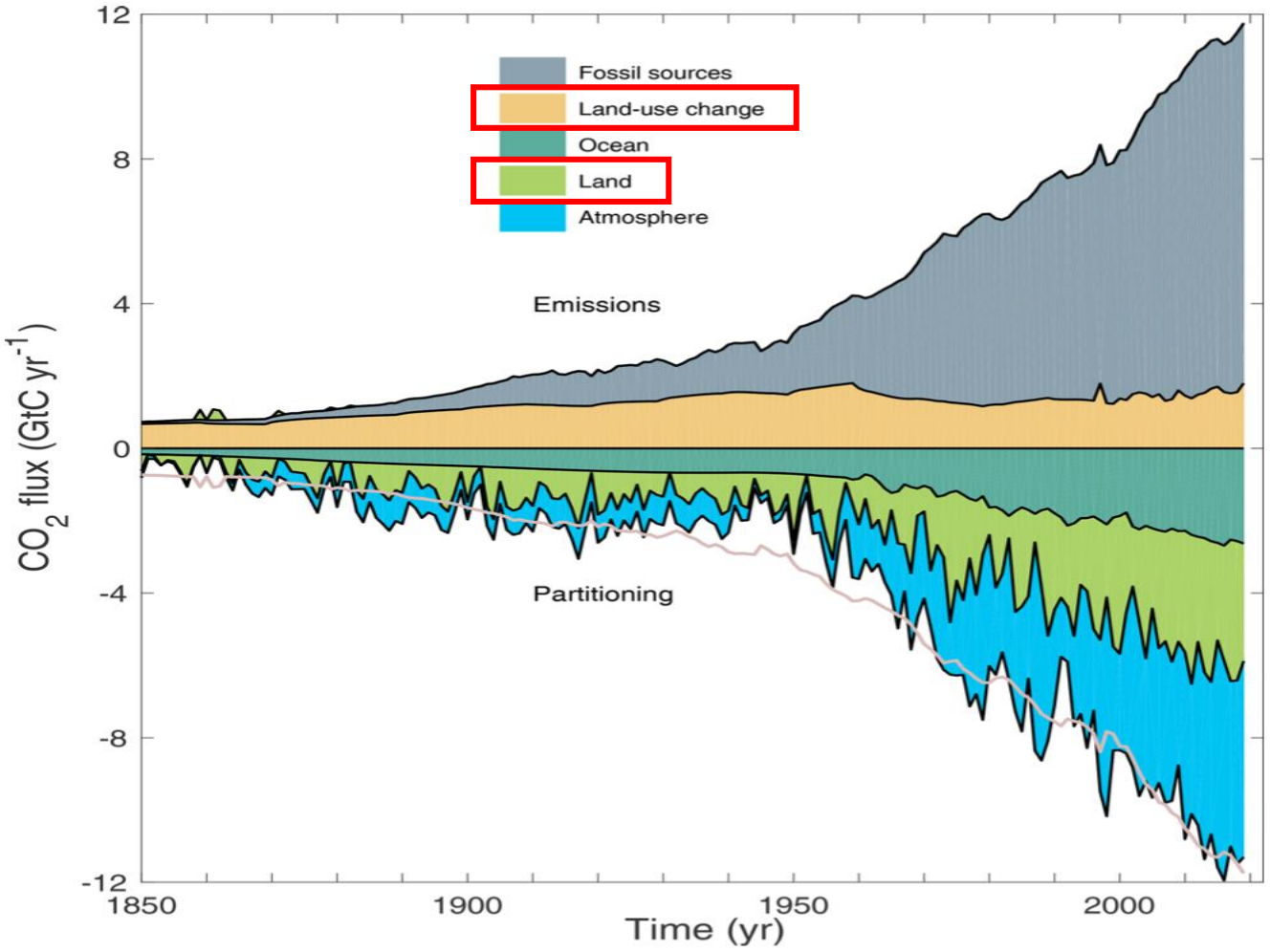
GLOBAL CARBON project

Plants and soils absorb one third of the CO_2 emitted by human activities



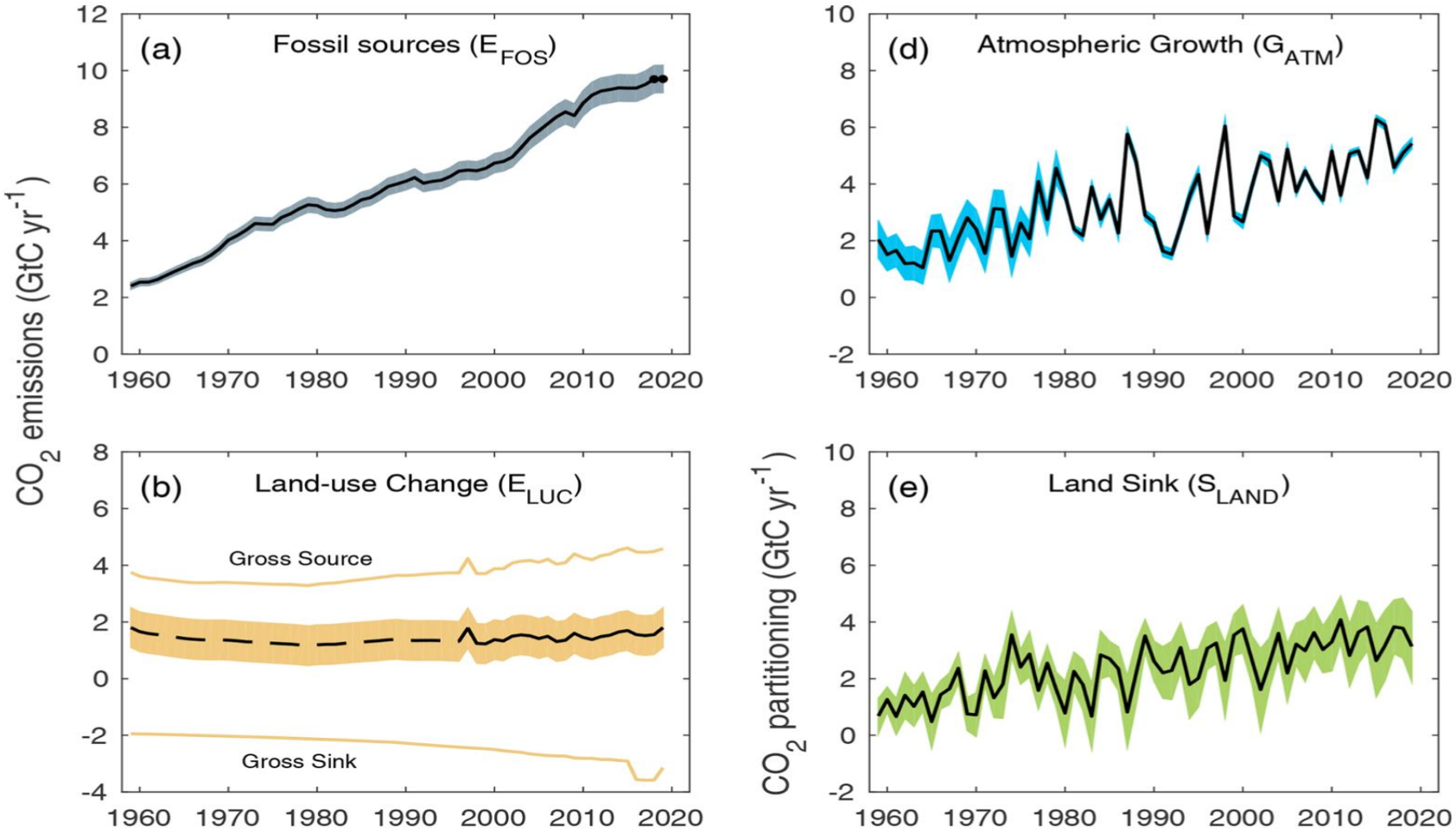
Friedlingstein et al. 2020

The global net land carbon balance is sensitive to climate and anthropogenic disturbances



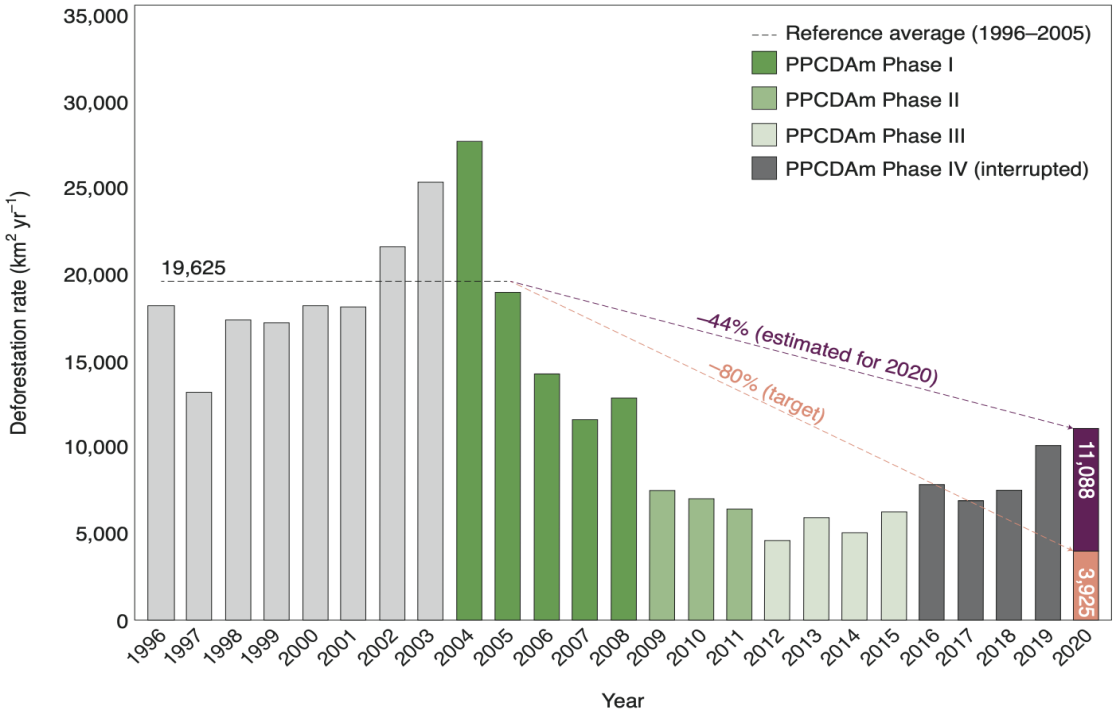
Friedlingstein et al. 2020

Emissions from land use change have not been reduced globally



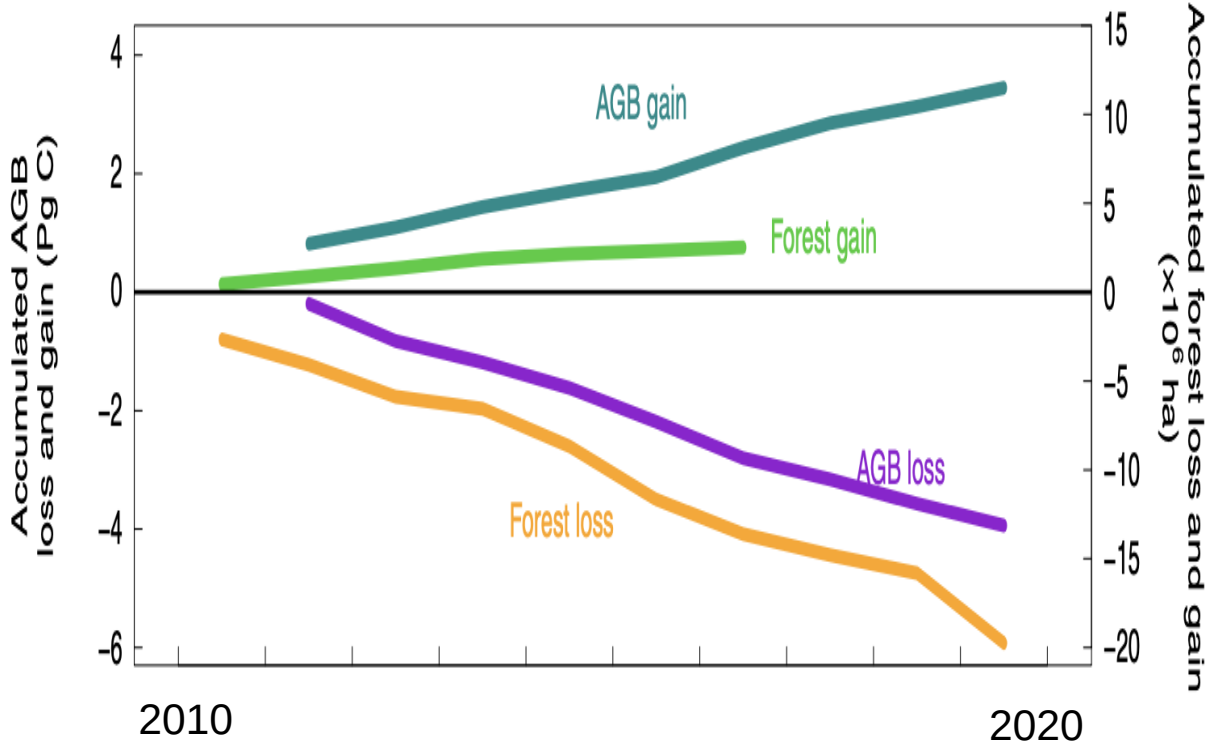
The RECCAP2 initiative of the Global Carbon Project, ESA RECCAP2, NASA CMS, and CEOS actions for the global stock take will bring new data on regional GHG budgets for the three greenhouse gases from atmospheric & land observations and models

No sign of land use emissions decline & degradation is a growing source of concern



Strong decline of Brazilian Amazon deforestation rates after 2004 but recent increase in 2020

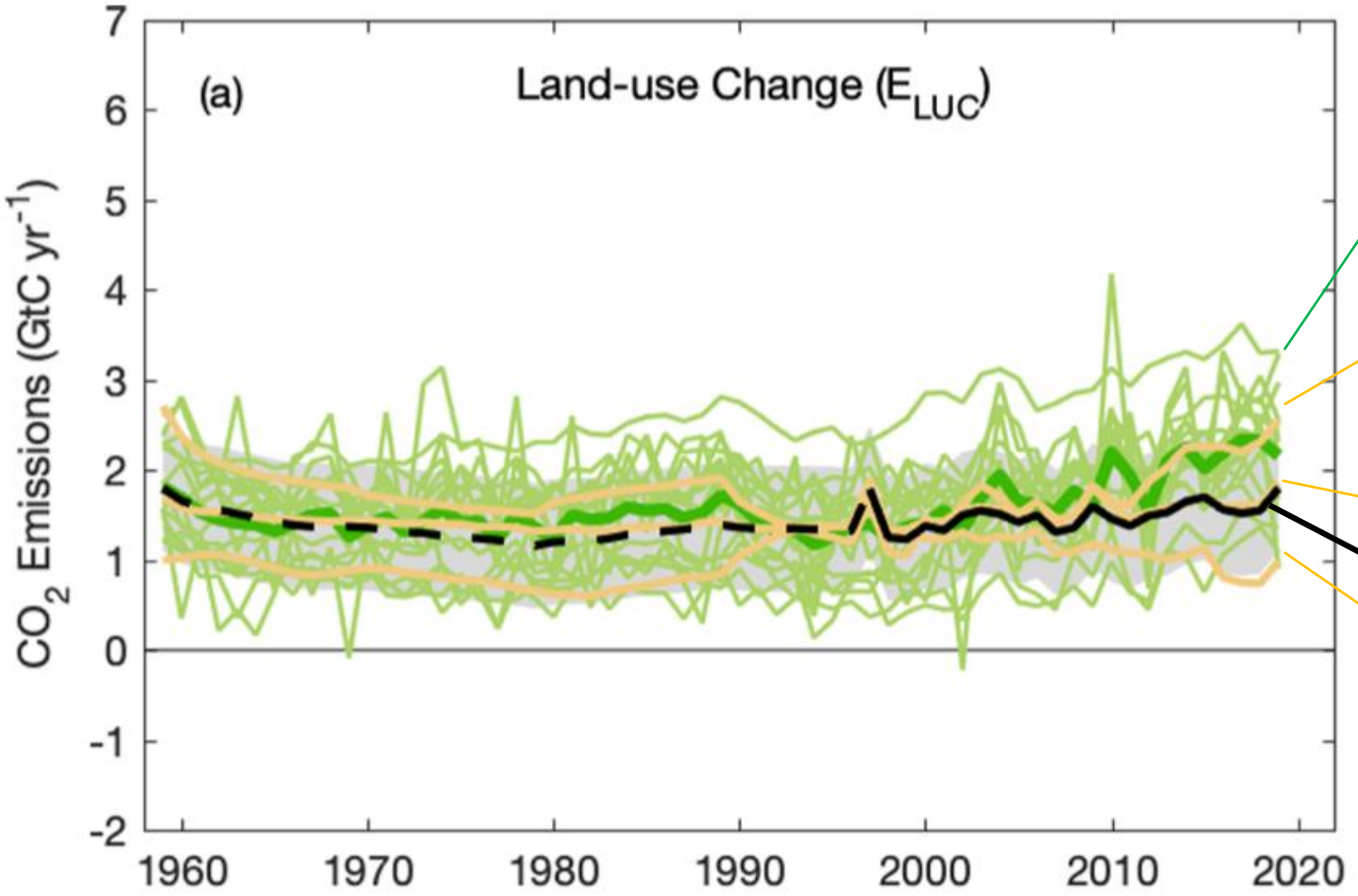
Junior et al. Nature Ecol. Evol. 2020



Net C loss in the Amazon from degradation and climate impacts exceed those from deforestation

Qin et al. Nature Climate Change 2020

Trends of land use change emissions remain uncertain



Global DGVM models part of Earth System Models

Bookkeeping model of Houghton et al. forced by FAOSTAT

OSCAR bookkeeping model

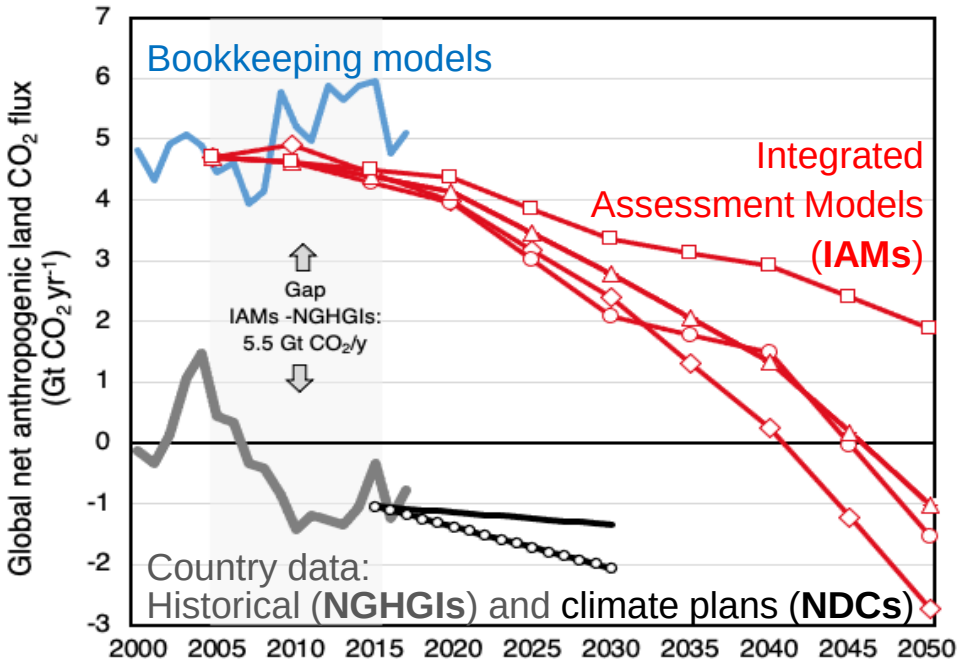
Median 3 bookkeeping models

Bookkeeping model BLUE forced by LUH2 land use dataset (same than used for ESM CMIP6 projections)

Uncertainties arise from :

Differences in LULUC areas datasets used for the global budget, methodologies, labelling issues

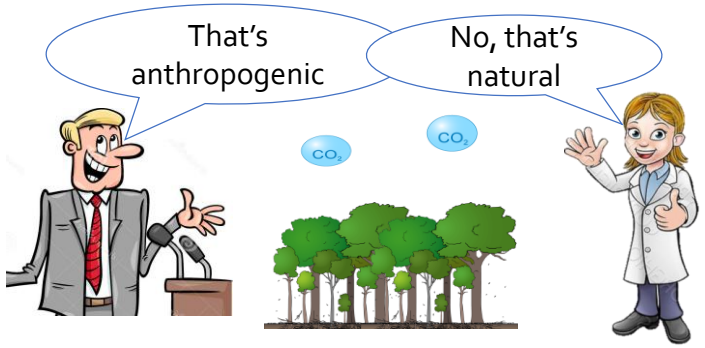
Large difference in land use CO_2 flux between global models and National GHG Inventories (-> see poster by G. Grassi et al.)

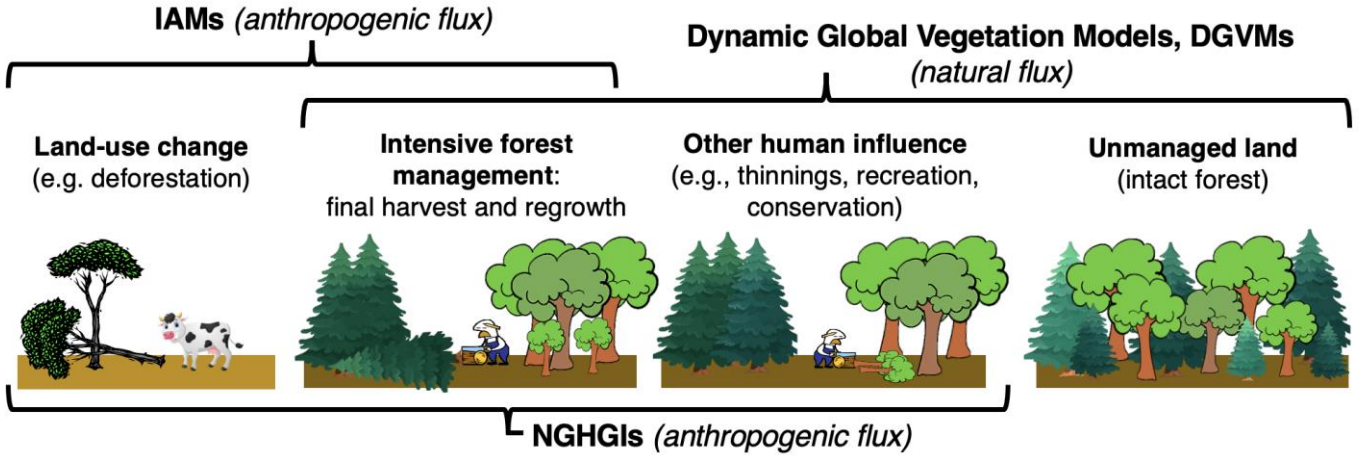


Grassi et al. NatureCC, 2021

Main reason: different communities have developed different approaches to identify the *anthropogenic forest CO_2 sink*.

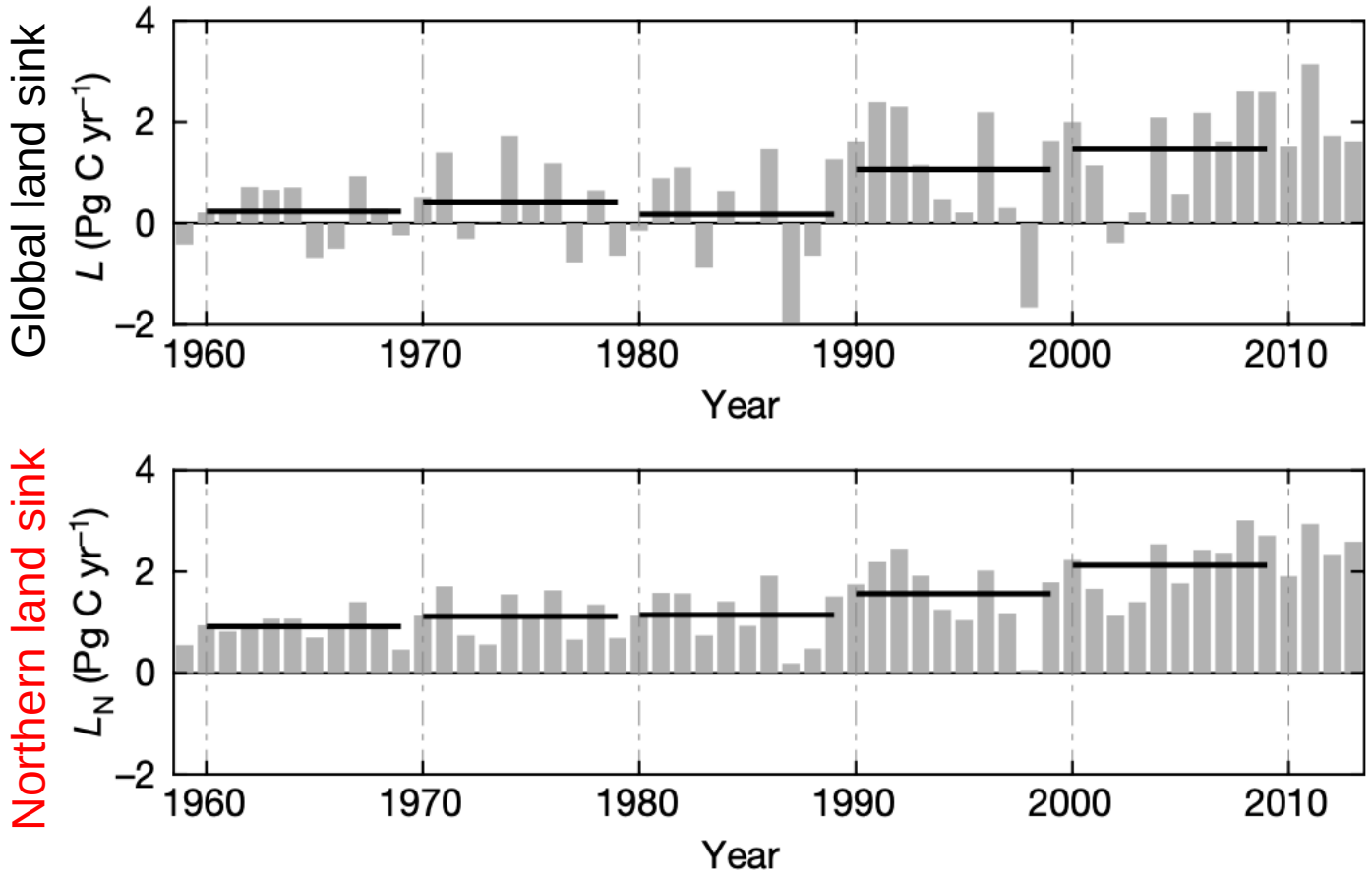
It's mostly a labelling issue: countries consider 'anthropogenic' part of what models consider 'natural'.





Global models consider 'managed' only those forest subject to intensive harvest whereas, consistent with IPCC guidelines, National GHG inventories (NGHGIs) define managed forest more broadly. On this larger area, NGHGIs often also consider the natural response of land to human-induced environmental changes as anthropogenic, while global models treat this response as natural

The atmospheric view : northern land sink increasing & tropical lands turning into a net source (-> poster by J. Pongratz)

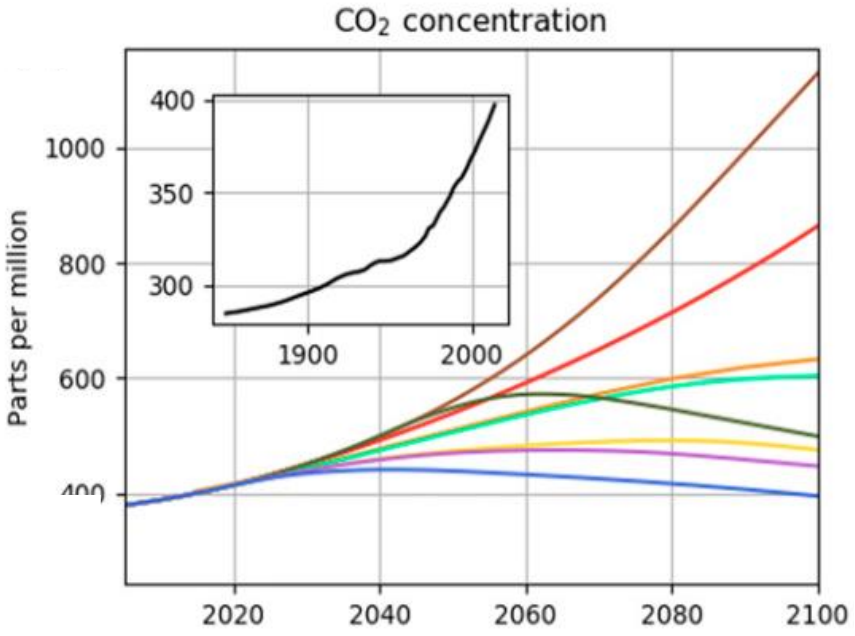


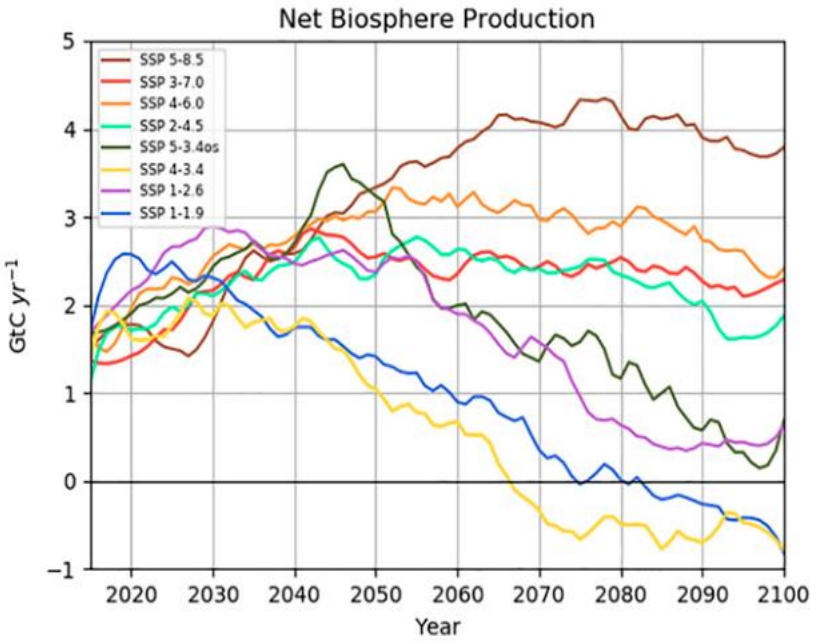
The northern land sink :

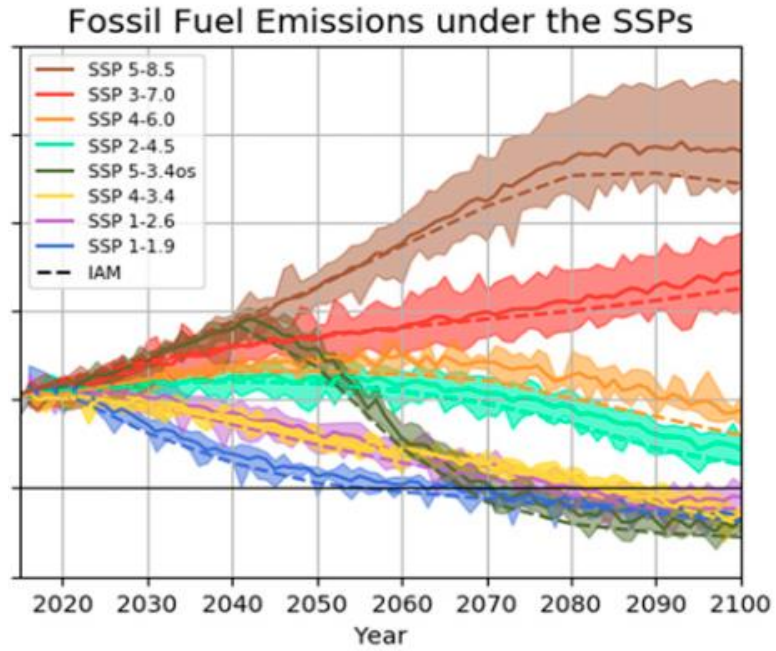
- Absorbed 2.4 Gt C y^{-1} in the last decade, a quarter of global emissions.
- Doubled over the last 60 years, offering a cumulative sequestration of 78 Gt C.
- Increased in the 1990s and again in the 2000s
- Increased faster than the global land sink, implying a weakening of the tropics.

Ciais et al. Nature 2019

Long term projections of the land carbon sink by the latest Earth System Models (CMIP6)



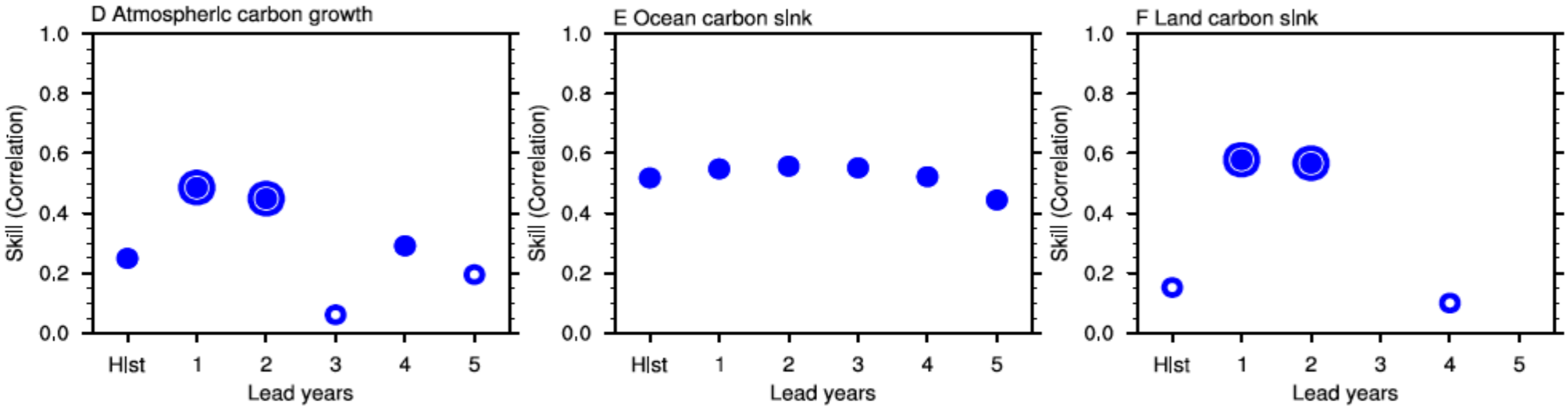




In all ESM models -> <u>the land CO_2 sink peaks and decreases in the future</u>

- Because of negative climate feedbacks in high warming scenarios
- Because of a decrease of CO_2 fertilization and compensatory ocean outgassing in low warming scenarios

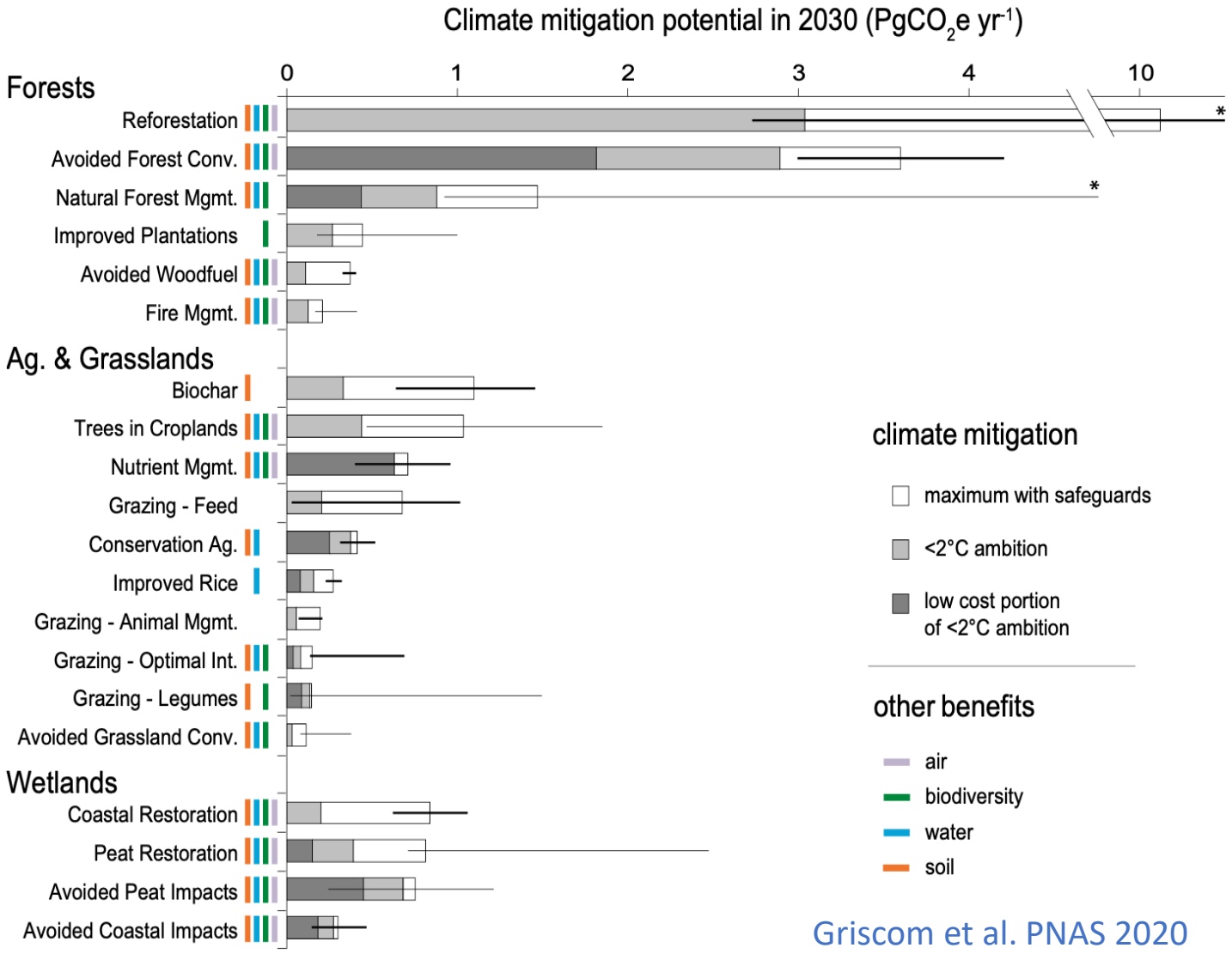
Can we forecast the growth of atmospheric CO_2 and the land and ocean CO_2 sinks in the coming years for the global stock take ?



Li et al., in preparation

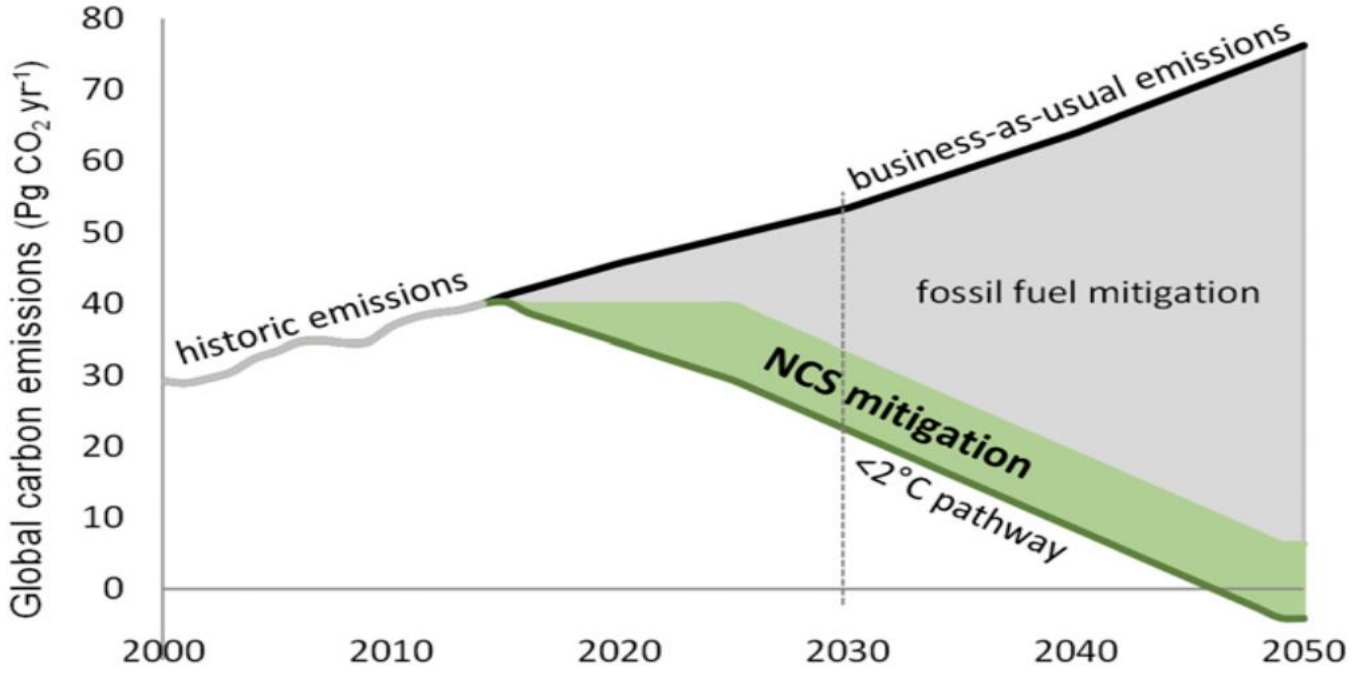
Answer : yes but with a short lead time of ≈ 3 years for land sink and ≈ 5 years for ocean sink

Nature based solutions : potentials



Griscom et al. PNAS 2020

NCS can do part of the job but emissions need to peak and decrease to zero for meeting the Paris goals

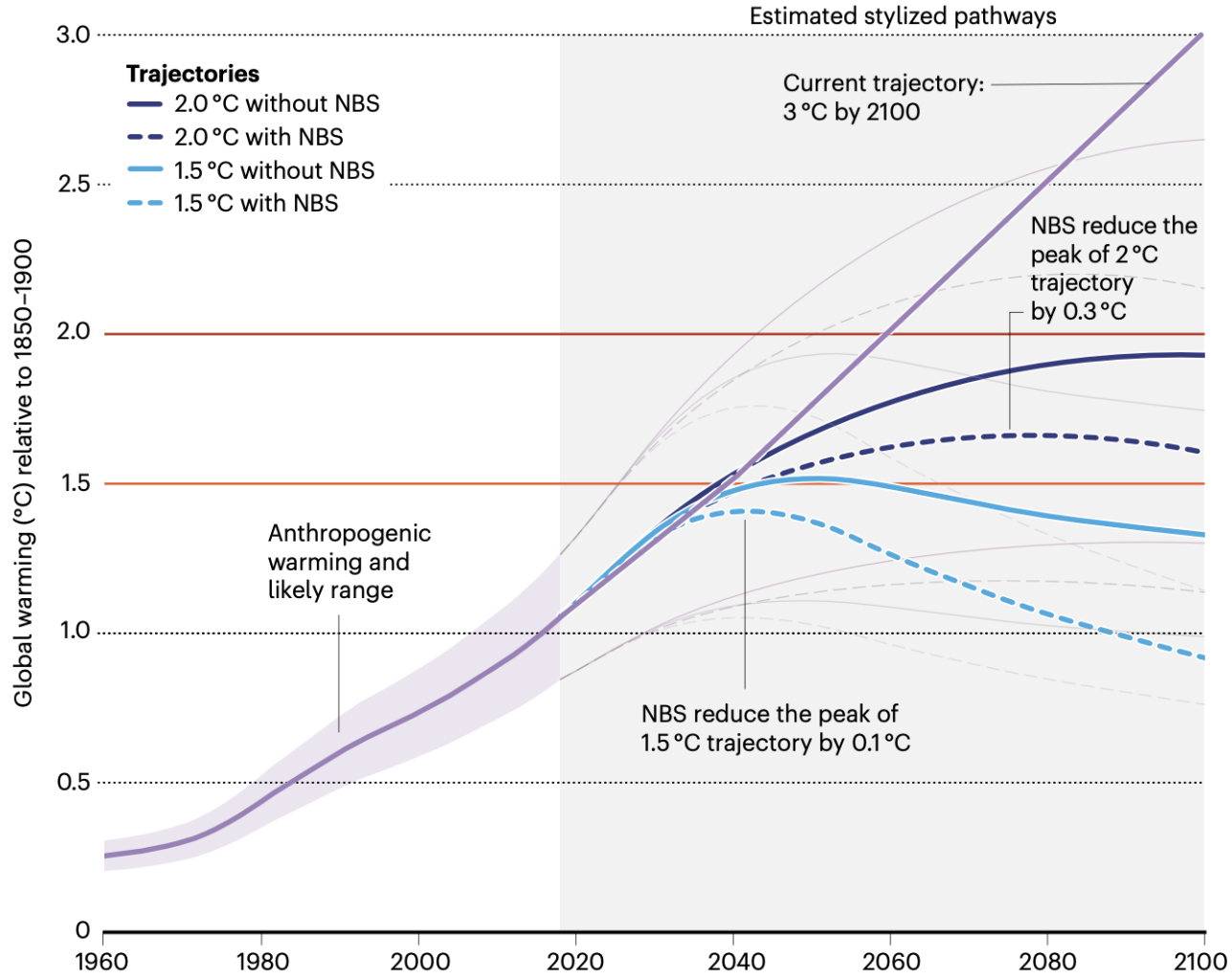


Griscom et al. PNAS 2020

Buying time : If all implemented at scale, rapidly, and at a cost effective rate, NCS would increase by one third our dwindling “carbon budget” to reach a 2°C goal

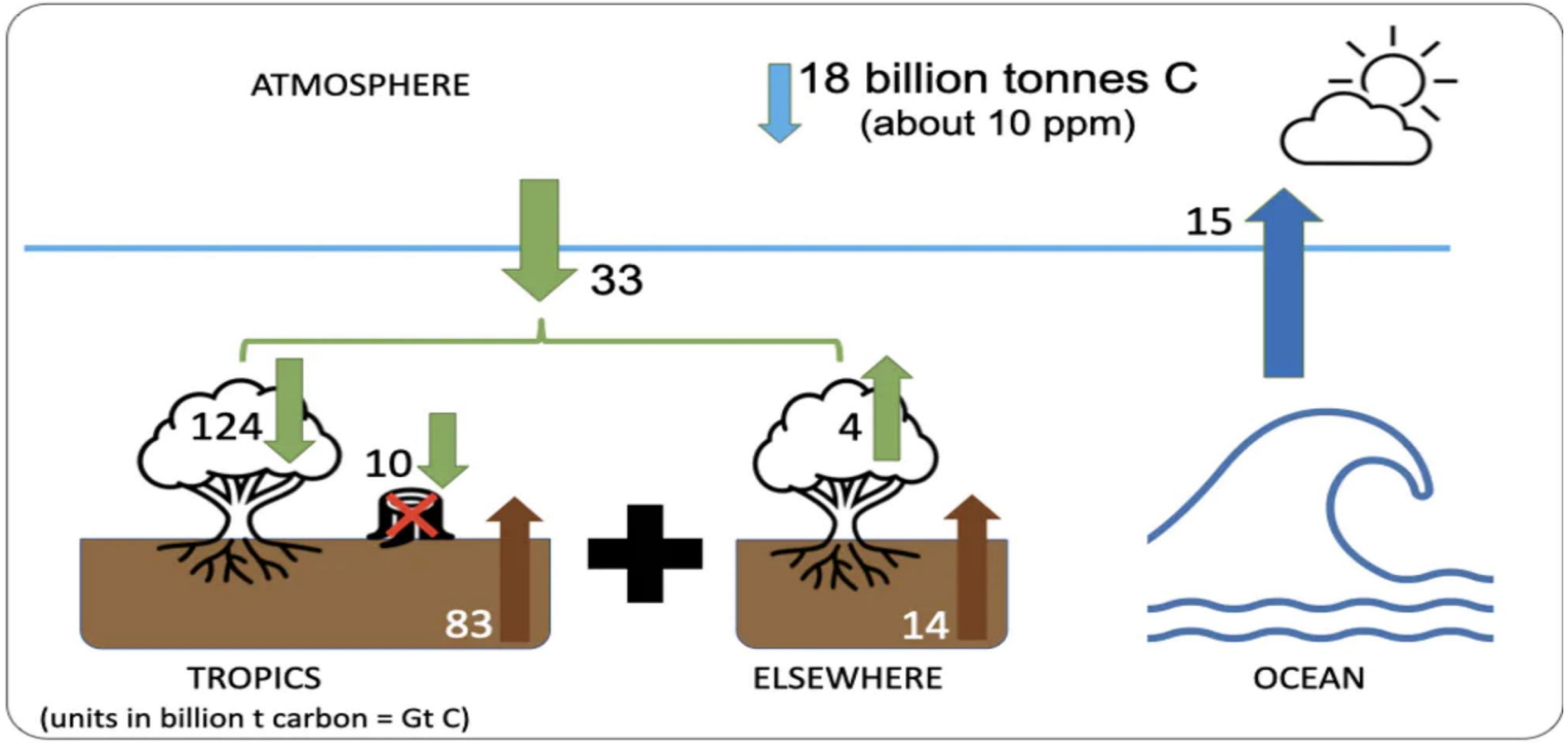
NCS basically get us around 1 wedge (we need 7-11 wedges to just stabilize CO_2 by 2050) ; from Pacala and Socolow 2004 Climate Wedges paper

NCS can do part of the job but emissions need to peak and decrease to zero for meeting the Paris goals



Girardin et al. Nature 2021 (commentary)

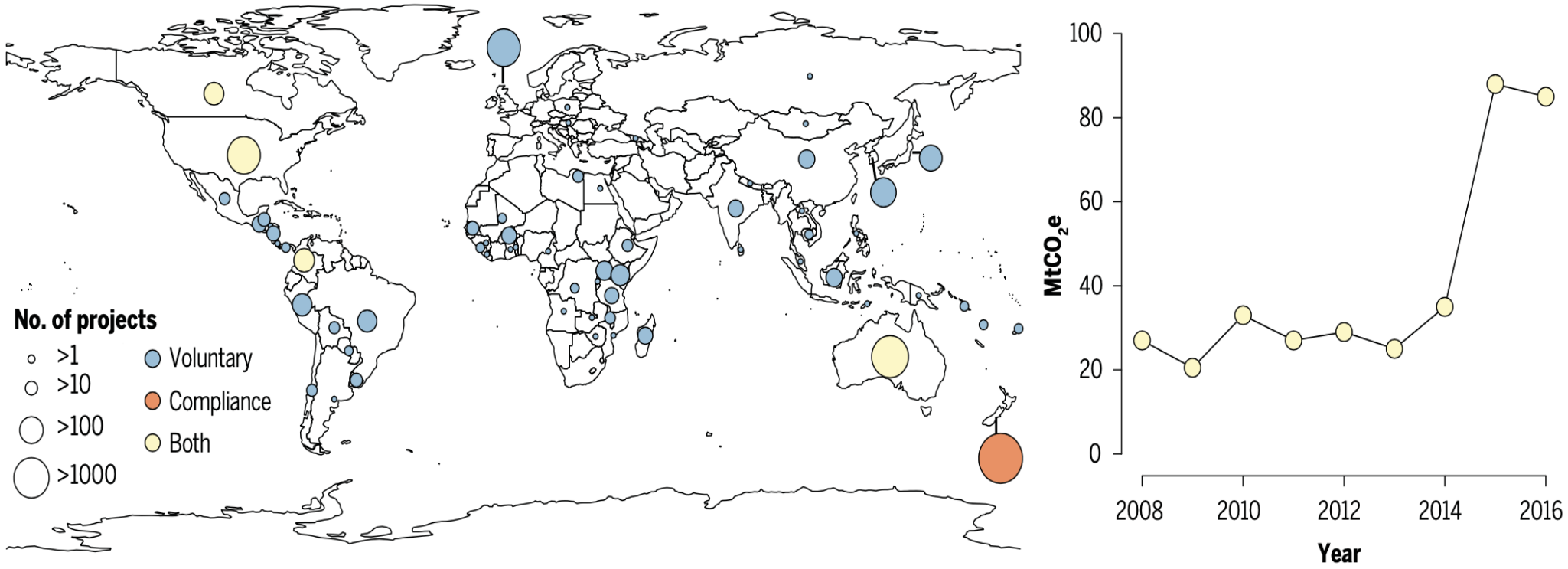
Further, when removing CO_2 from the atmosphere, the Earth System works against us, and the ocean outgases CO_2



Koch et al. Biogeosciences 2021

Reforesting all the tropics would store 33 PgC but it will only reduce CO_2 in the atmosphere by 18 Pg C

Current forest offset projects vs. NCS potentials

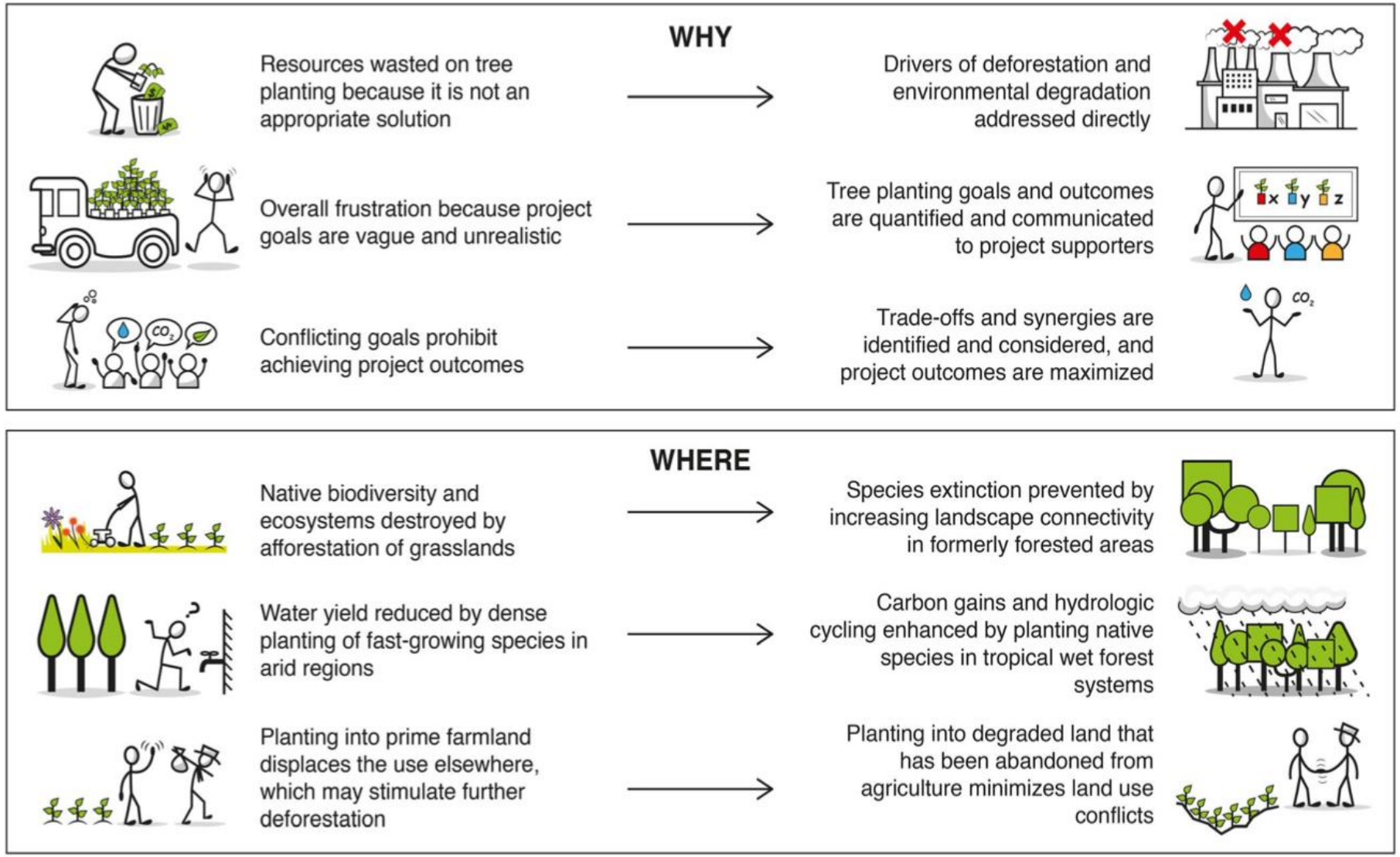


Anderegg et al. Science 2020

Current rate -> 80 Mt CO_2 y^{-1}

Potential at 100 € per ton -> 3000 Mt CO_2 y^{-1}

Guidance & trade-offs for successful tree planting initiatives

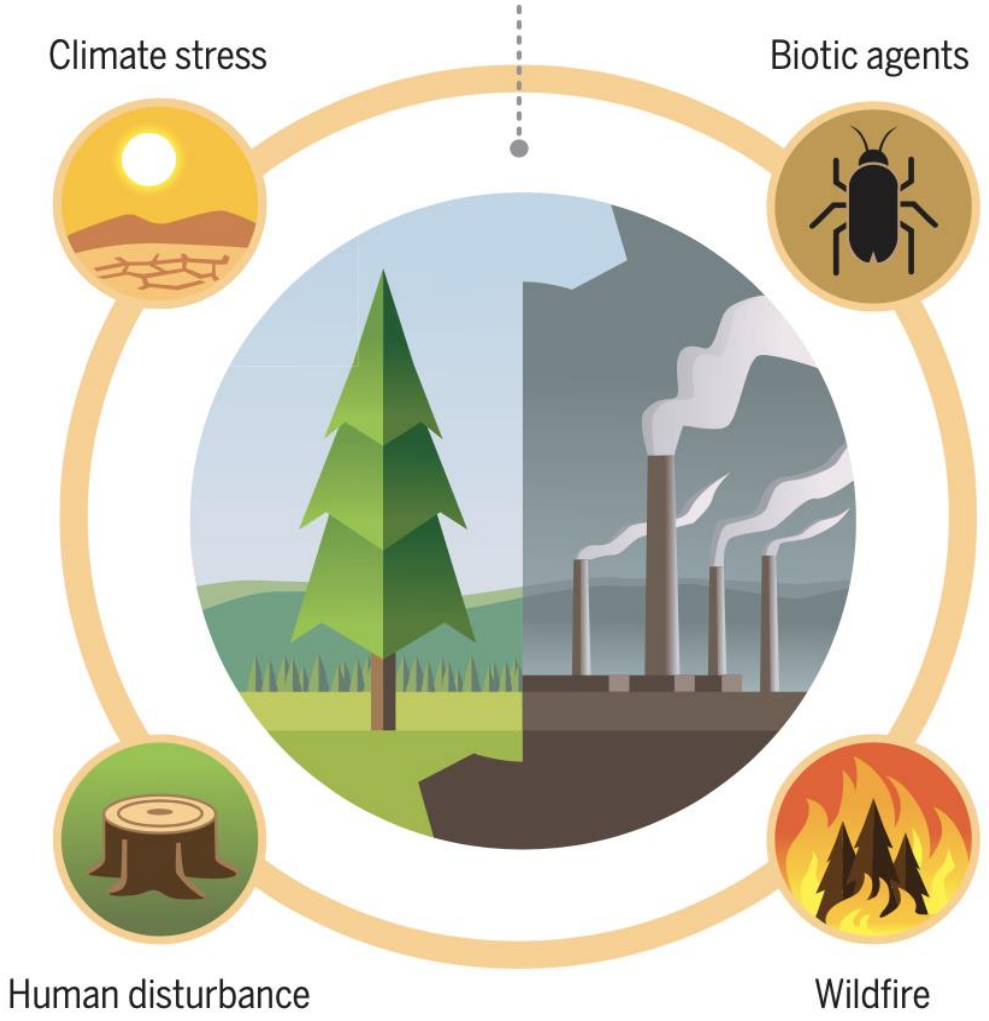


Brancalion et al. 2021

Guidance & trade-offs for successful tree planting initiatives

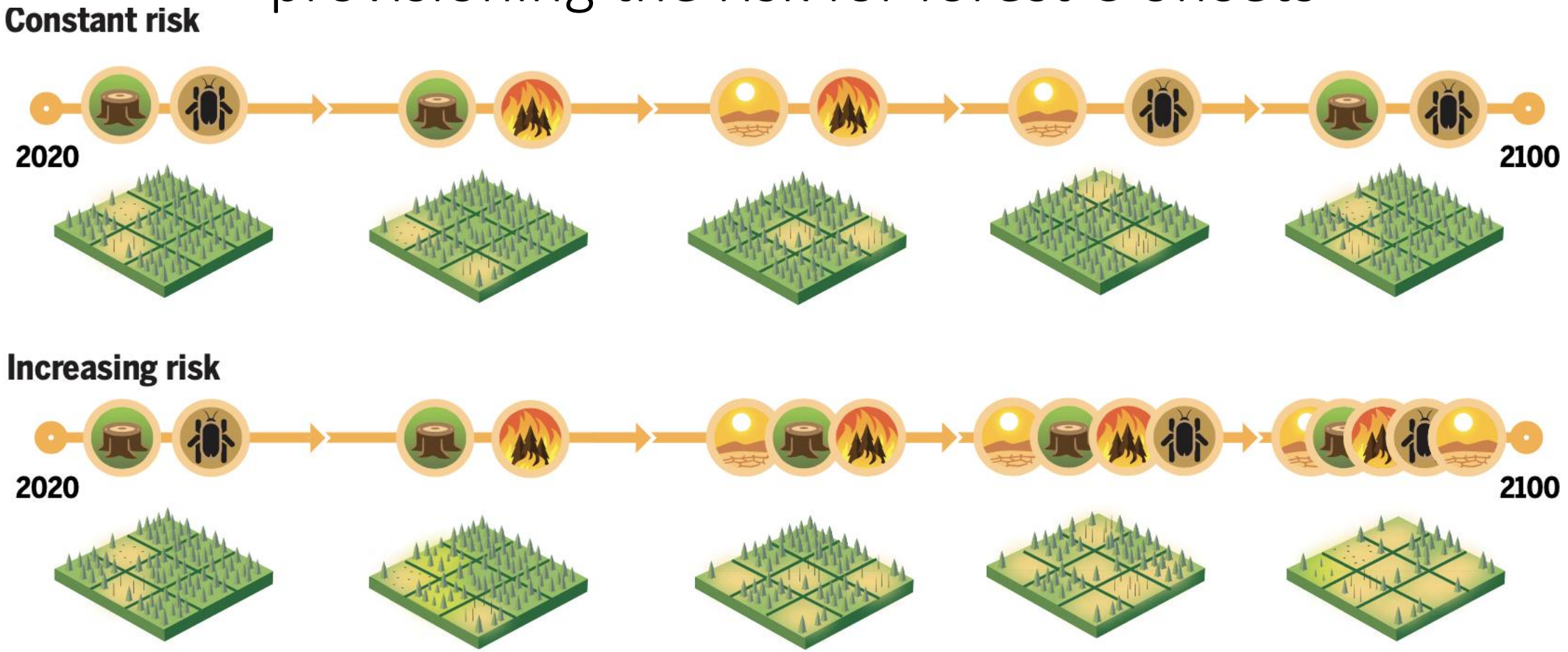
- Protect existing forests first
- Natural regeneration will store more C & maintain diversity compared to plantations
- Tree planting is a means to achieve clearly specified goals and should be considered as part of a multidisciplinary decision-making process that thoroughly evaluates trade-offs and uncertainties
- Clear decision-making process required to plan, implement, maintain and monitor projects.
    - In more arid ecosystems, extensive tree planting may increase risks of massive fires
    - Some carbon farming projects have dispossessed local people from land in several developing countries
- Host of decisions must be made about implementation from local to regional, national and global scale
- New indexes to quantify carbon potentials & monitor carbon changes with a low latency
    - ESA CCI 100 m biomass maps
    - Very high resolution Planet data (5m) made open for tropical regions by the Norwegian government for degradation
    - Vegetation Optical depth for biomass change
    - NASA GEDI global Lidar tree height products

NCS and climate risks in forests



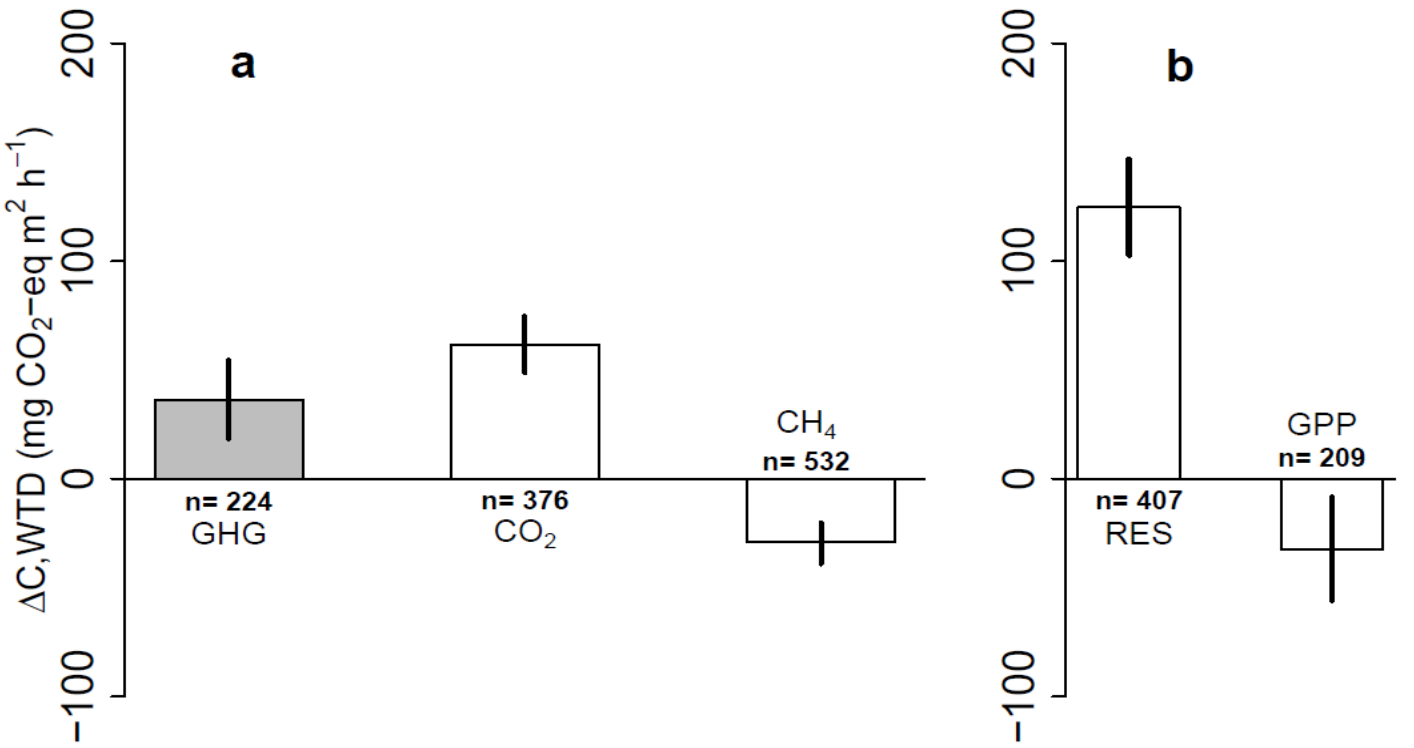
Anderegg et al. Science 2020

Non stationary climate & compound climate / anthropogenic disturbances must be accounted for in provisioning the risk for forest C offsets



Anderreg et al. Science 2020

NCS and climate risks -> wetlands & peatlands

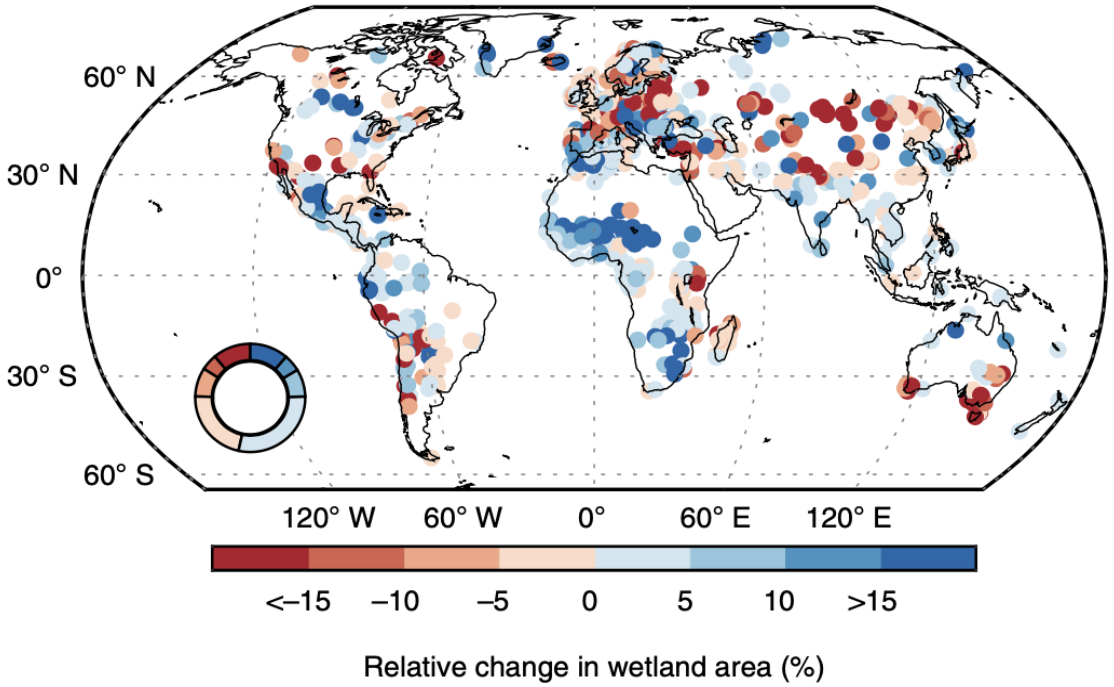


Huang et al. Nature Climate Change, In Press

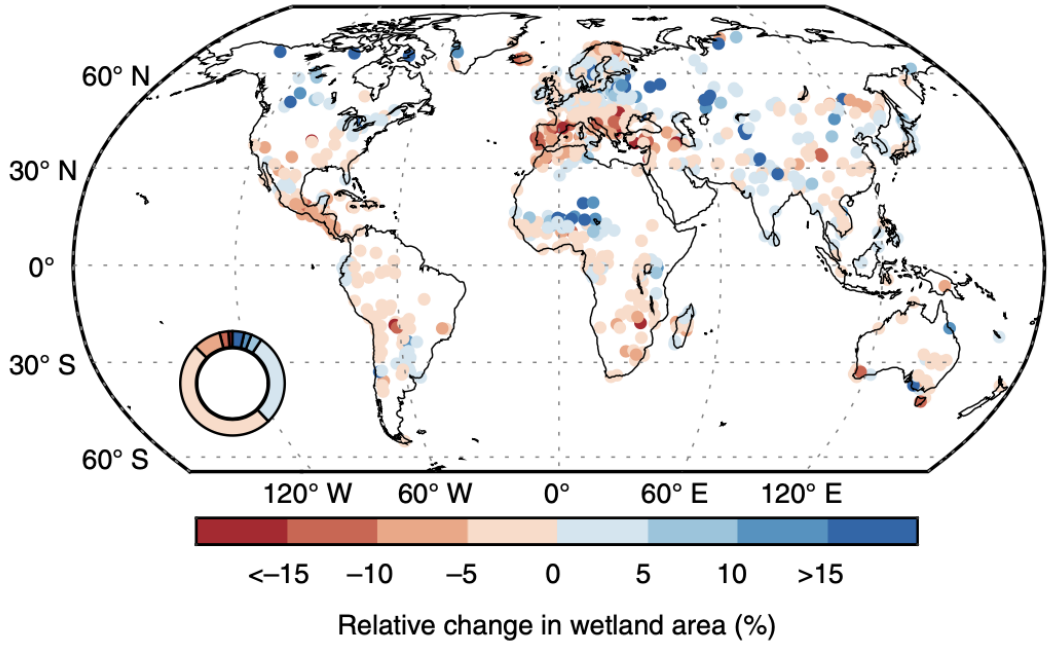
Climate induced lowering of water table decreases CH_4 but increases CO_2 emissions, turning peatlands into higher net GHG emitters

Most mid-latitudes wetlands are expected to shrink from climate-induced decrease of water table

Last 30 years



2100, RCP2.6



Xu et al. Nature Climate Change, 2021

Take Home

- People have different concepts of nature-based climate solutions
- Large uncertainties and variability in biological systems (including big emission spikes through fires/pest attacks/drought)
- Caution about interpreting global models into national / sectoral-level planning

  -> Need to integrate adaptation/mitigation/nature protection through coordinated planning from local to regional and global level
- Resilience of land systems needs to be increased – it is an adaptation and mitigation issue
- Framing the science in the conversation

  -> at local level we cannot not separate out mitigation and adaptation– local context is important
- Cannot decouple ecosystems from people

  -> Importance of restoring socio-ecological systems – without this managing ecosystems for mitigation and increasing local income (or adaptation) benefit will not work

  -> Importance of sectoral dialogues

Thank you for your attention

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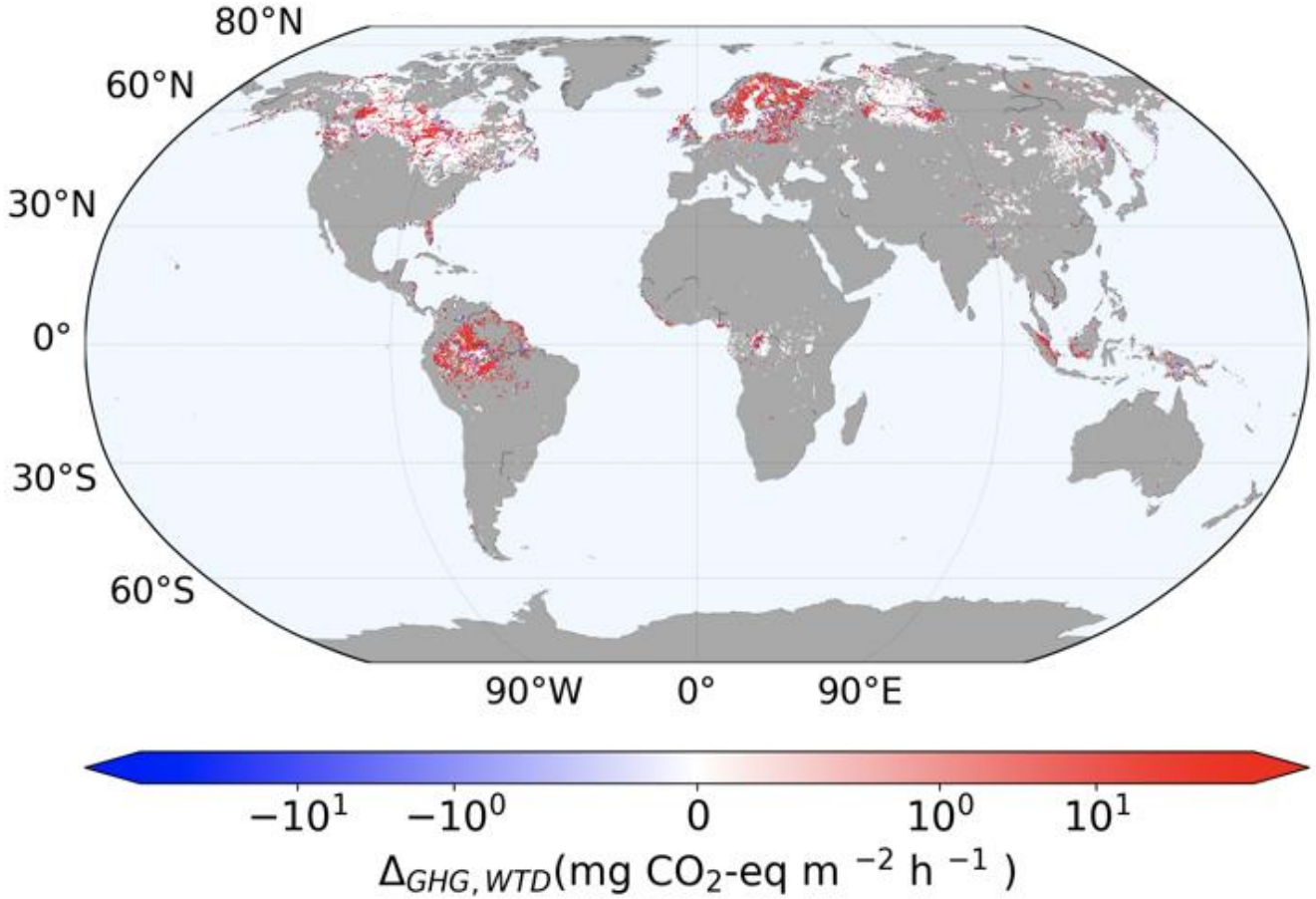
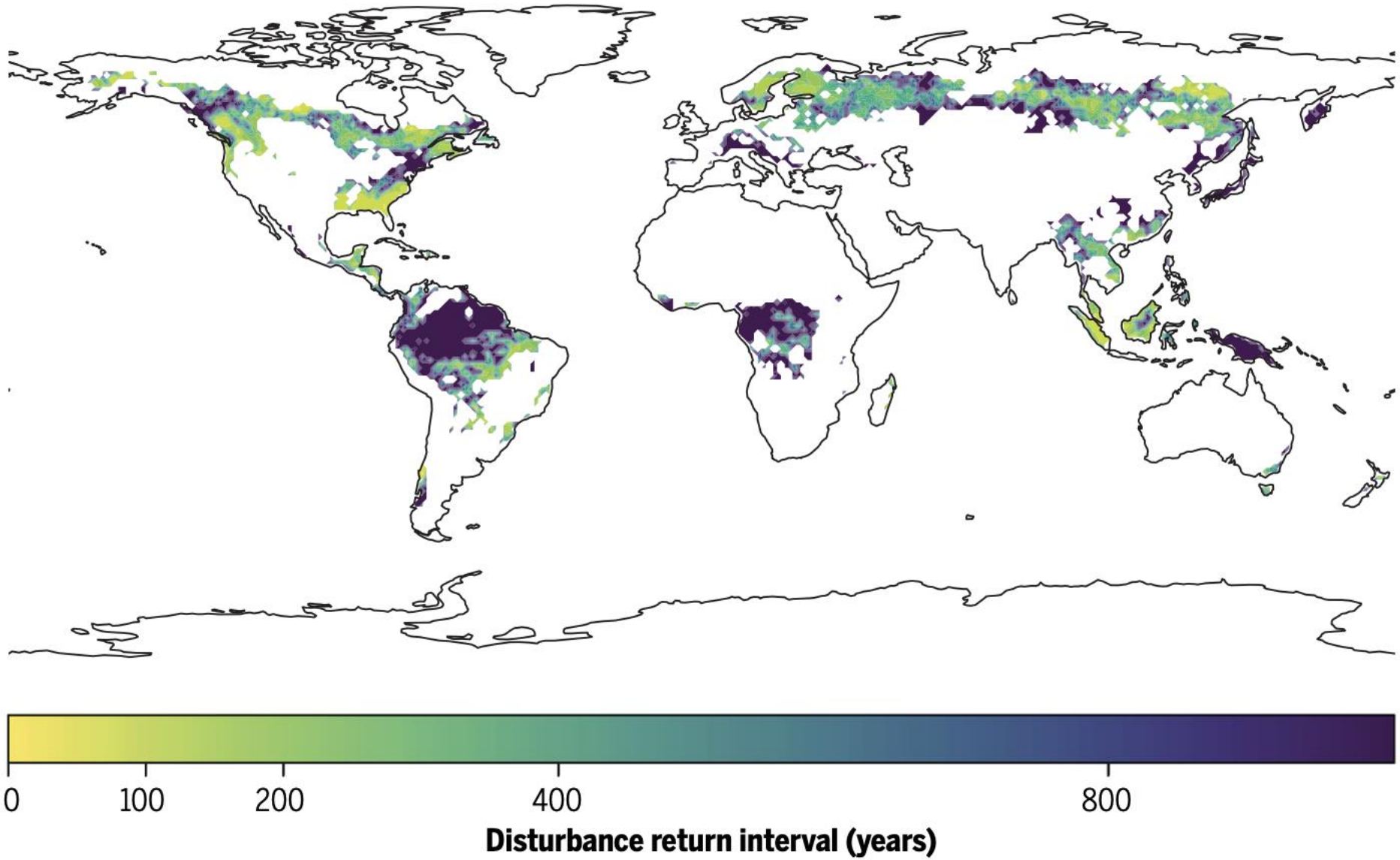
Net GHG emissions are projected to increase in response to water table reductions in peatlands

RCP2.6

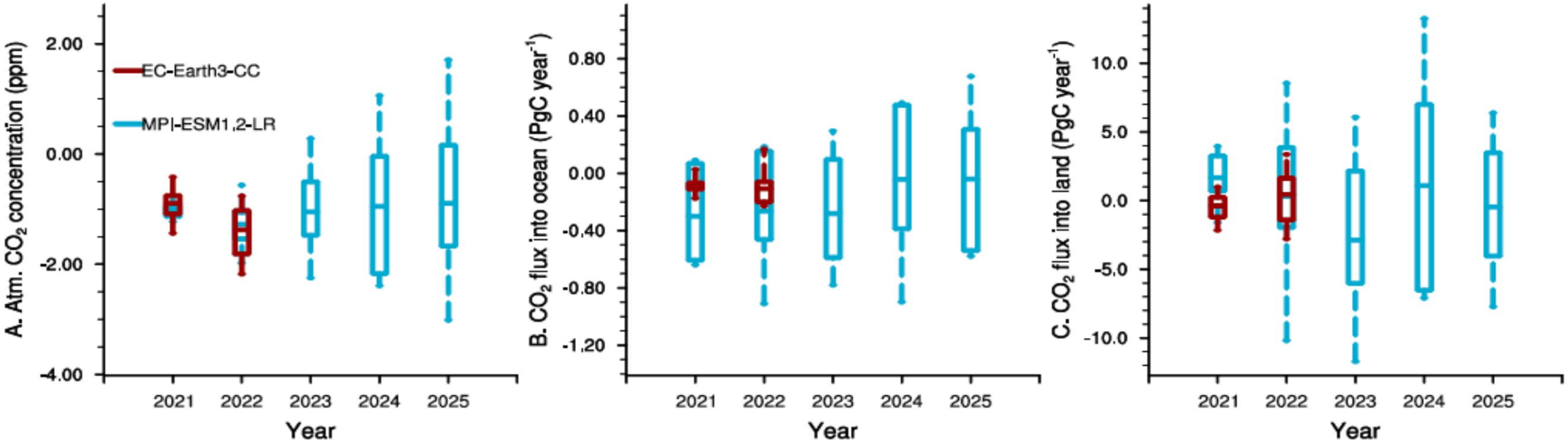


Huang et al. Nature Climate Change, In Press[24]


0
100
200
400
800
Disturbance return interval (years)

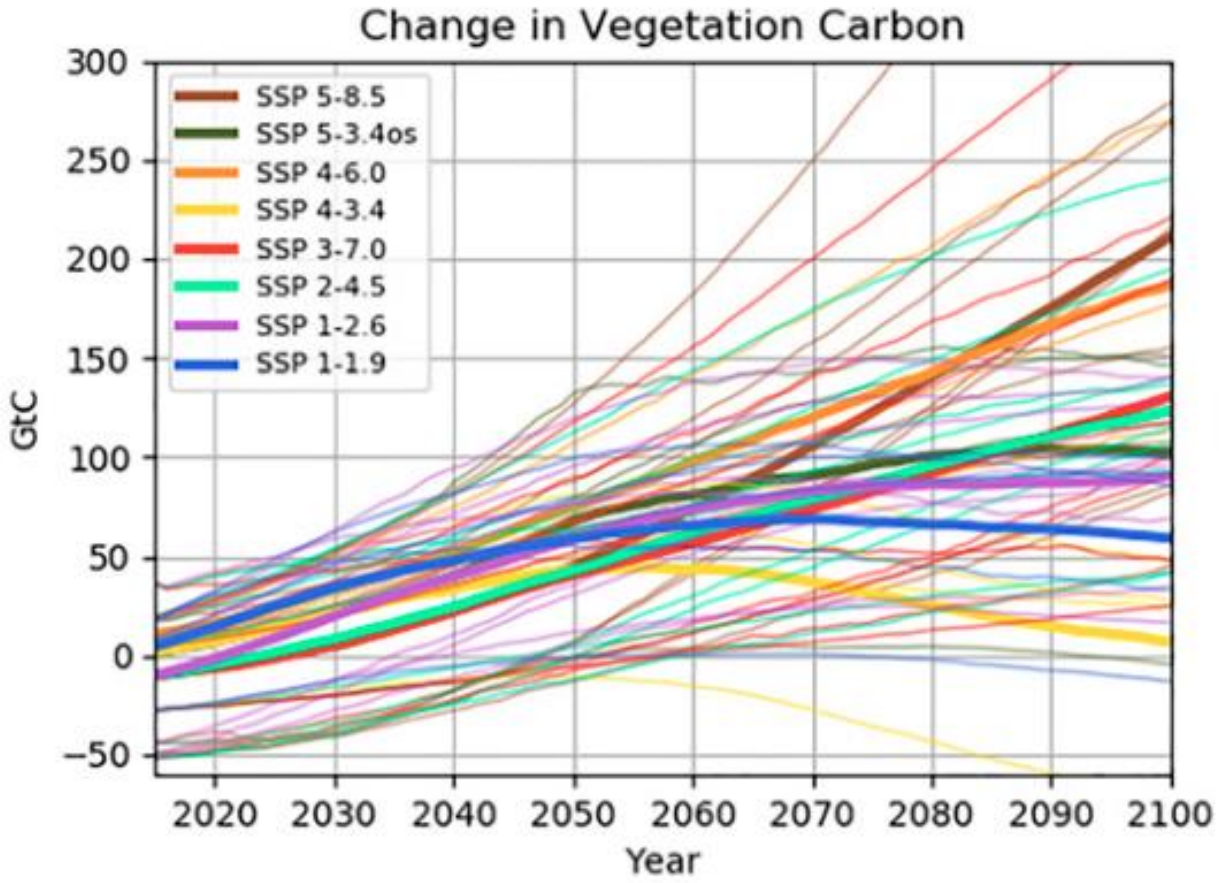
Decadal predictions of future atmospheric CO_2 over the stocktake period following future climate change scenarios

ESM SSP245 with a COVID two years blip minus baseline

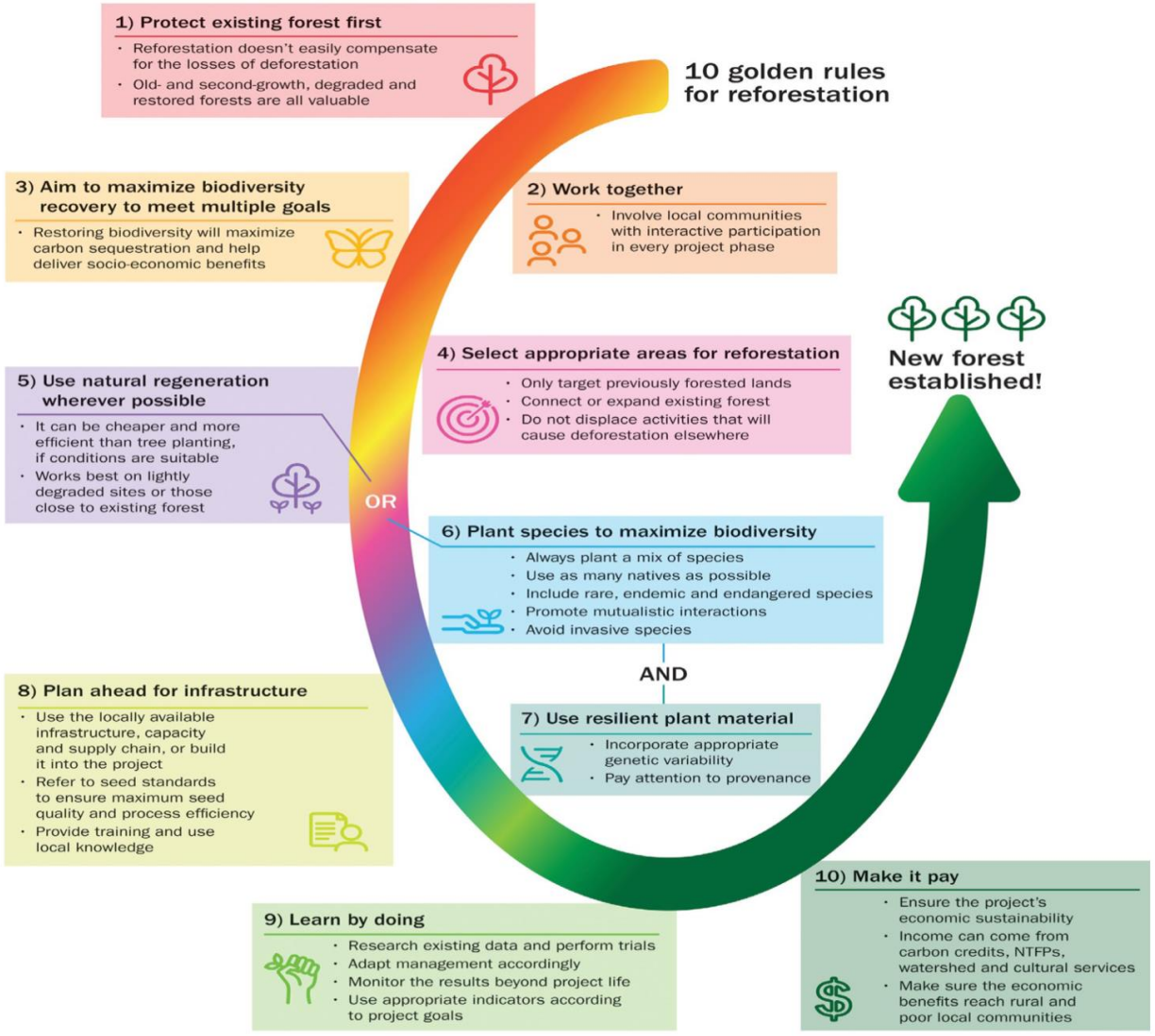


Difference between the simulations under CovidMIP two-year blip forcings and those under esm-ssp245 baseline forcings shows consistent changes in atmospheric CO_2 concentration between EC-Earth3-CC and MPI-ESM1.2-LR but with discrepancy in the CO_2 fluxes.

Still, huge uncertainties persist across land models through successive IPCC assessment reports



Reforestation to optimize carbon sequestration, biodiversity recovery and livelihood benefits



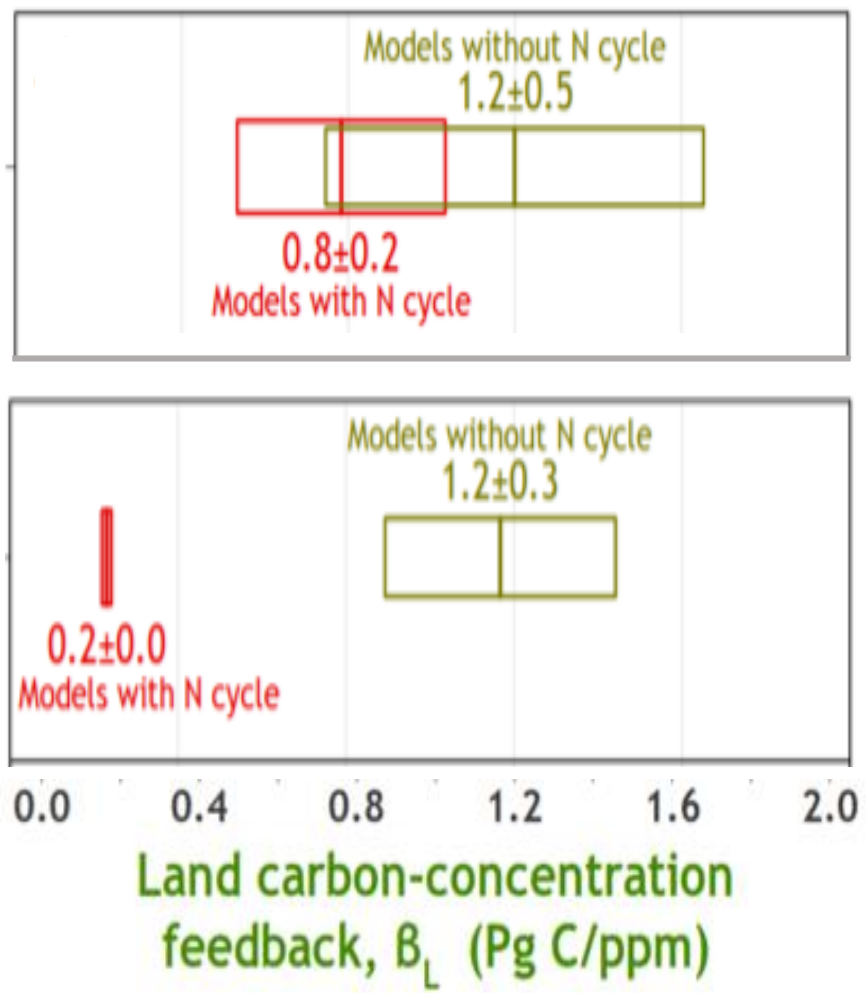
Di Sacco et al. Global Change Biology, 2021

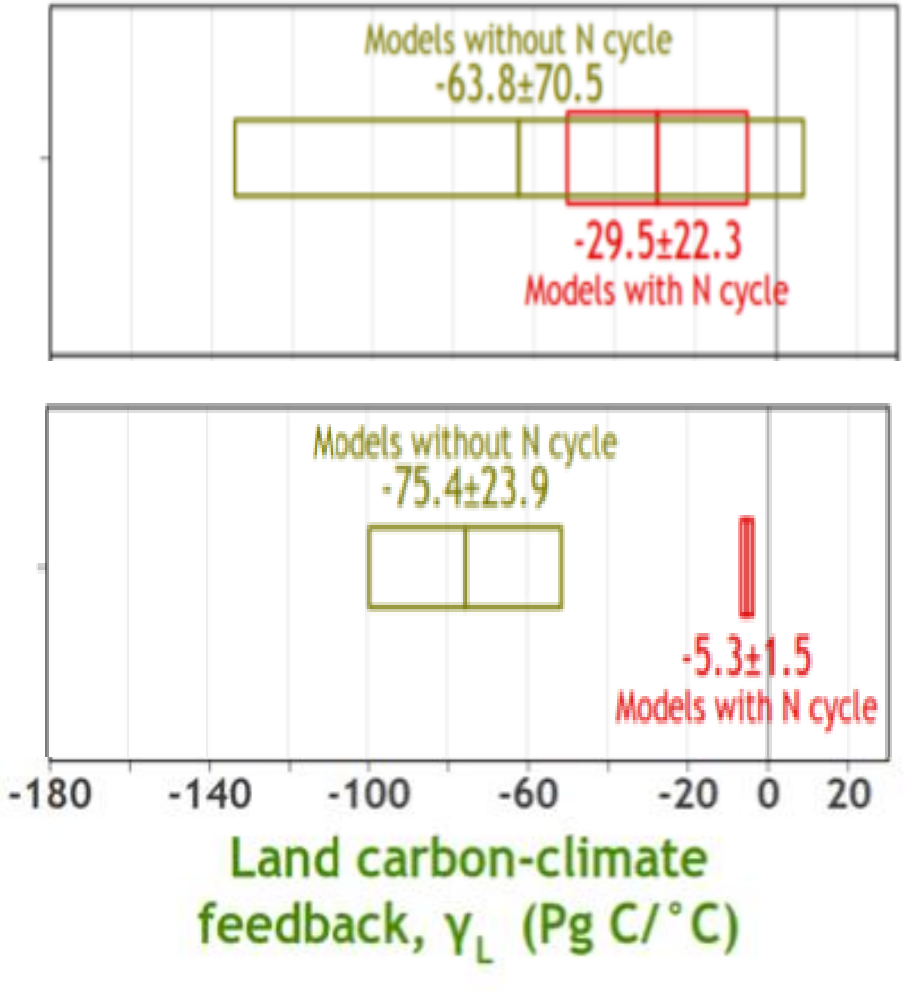
Positive CO_2 feedbacks
-> CO_2 fertilization and turnover, limitations by nitrogen availability

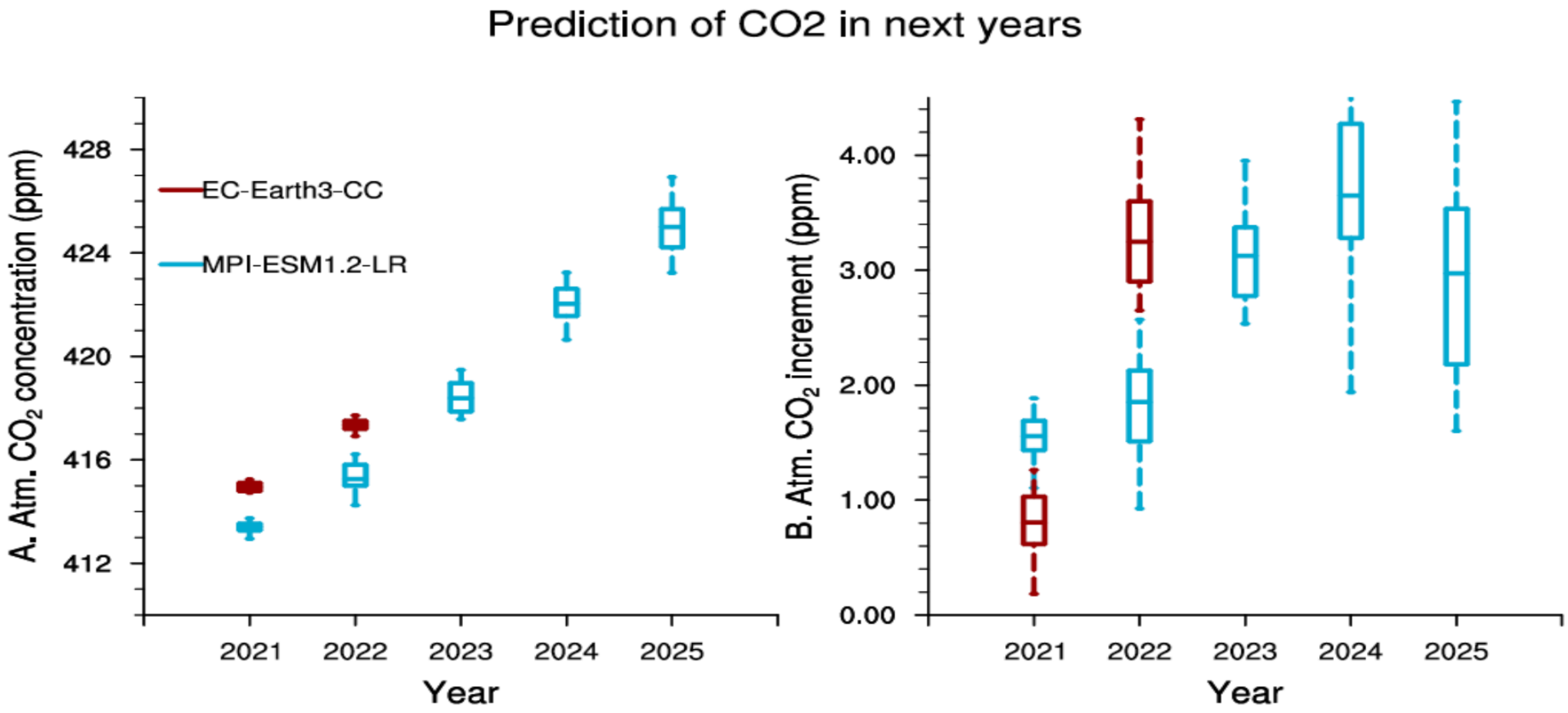
Negative Climate feedbacks
-> Warming and drying reduce productivity and increase respiration

CMIP6

CMIP5







First attempt of predicting atmospheric CO2 concentration and increment from two Earth System Models show increase of atmospheric CO2 concentration with a lower rate in the next year than normal years because of emission stabilization in the SSP245

Climate-Carbon Interactions in the Current Century