

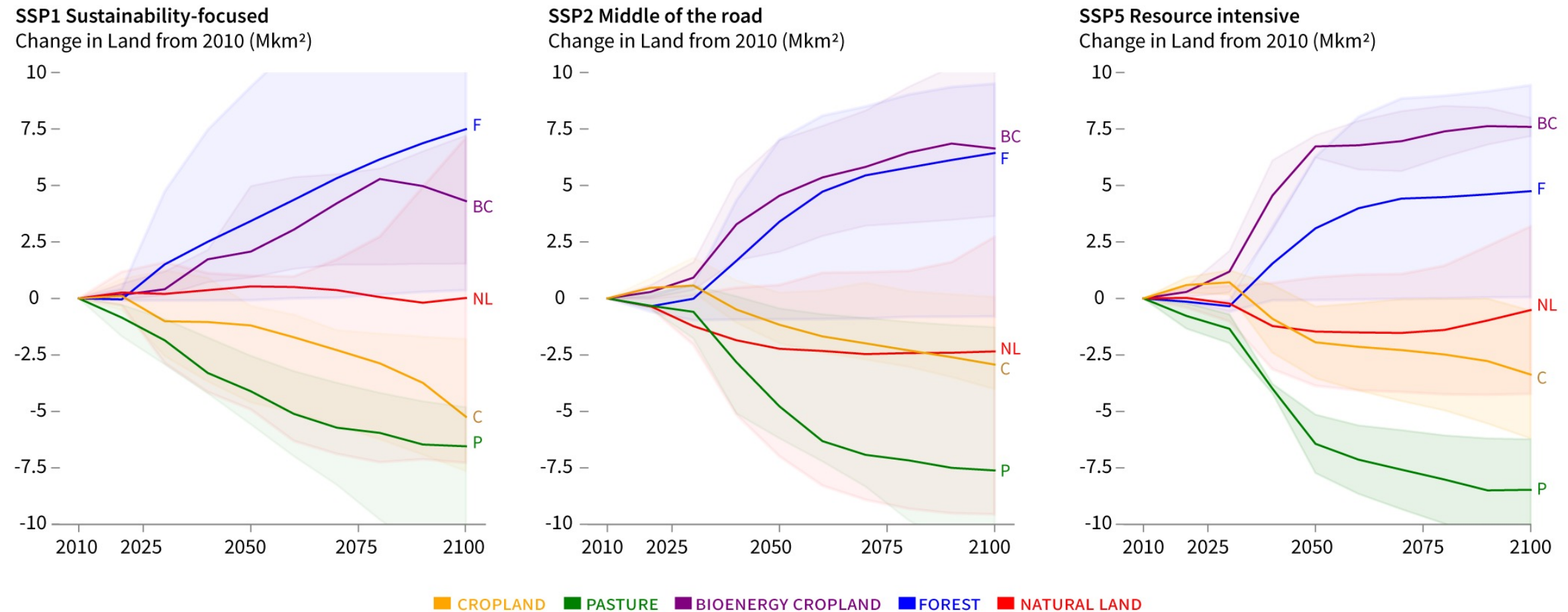
Modeled estimates of afforestation and reforestation

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Some modeled pathways include significant increases in forest cover through afforestation/reforestation



Source: IPCC SRCCL SPM Figure 4a

Criticism of modeled afforestation/reforestation

- IPCC SR1.5 SPM C3.2: “In pathways limiting global warming to 1.5°C with limited or no overshoot, BECCS deployment is projected to range from 0–1, 0–8, and 0–16 GtCO₂ yr⁻¹ in 2030, 2050, and 2100, respectively, while **agriculture, forestry and land-use (AFOLU) related CDR measures are projected to remove 0–5, 1–11, and 1–5 GtCO₂ yr⁻¹ in these years** (medium confidence). The upper end of these deployment ranges by mid-century **exceeds** the BECCS potential of up to 5 GtCO₂ yr⁻¹ and **afforestation potential of up to 3.6 GtCO₂ yr⁻¹** assessed based on recent literature (*medium confidence*).”
- Turner et al. (2018): “In some cases, mitigation scenarios include abrupt reversal of deforestation, paired with massive afforestation/reforestation.”

At the scales indicated in modeled pathways, afforestation/reforestation could have trade-offs with sustainability

Reforestation and forest restoration



High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of reforestation and forest restoration (partly overlapping with afforestation) at a scale of 10.1 GtCO₂ yr⁻¹ removal {6.3.1}. Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people; the impact of reforestation is lower {6.3.5}.



Best practice: There are co-benefits of reforestation and forest restoration in previously forested areas, assuming small scale deployment using native species and involving local stakeholders to provide a safety net for food security. Examples of sustainable implementation include, but are not limited to, reducing illegal logging and halting illegal forest loss in protected areas, reforesting and restoring forests in degraded and desertified lands {Box6.1C; Table 6.6}.

Afforestation



High level: Impacts on adaptation, desertification, land degradation and food security are maximum potential impacts assuming implementation of afforestation (partly overlapping with reforestation and forest restoration) at a scale of 8.9 GtCO₂ yr⁻¹ removal {6.3.1}. Large-scale afforestation could cause increases in food prices of 80% by 2050, and more general mitigation measures in the AFOLU sector can translate into a rise in undernourishment of 80–300 million people {6.3.5}.



Best practice: Afforestation is used to prevent desertification and to tackle land degradation. Forested land also offers benefits in terms of food supply, especially when forest is established on degraded land, mangroves, and other land that cannot be used for agriculture. For example, food from forests represents a safety-net during times of food and income insecurity {6.3.5}.

Source: IPCC SRCCL SPM Figure 3b

Questions to answer

- What do models say about the potential for afforestation and reforestation?
- How does that differ by type of model and assumptions?
- What are the limits to model-based estimates?

Modeled potential for afforestation and reforestation

Carbon Dioxide Removal

Afforestation/Reforestation (A/R)

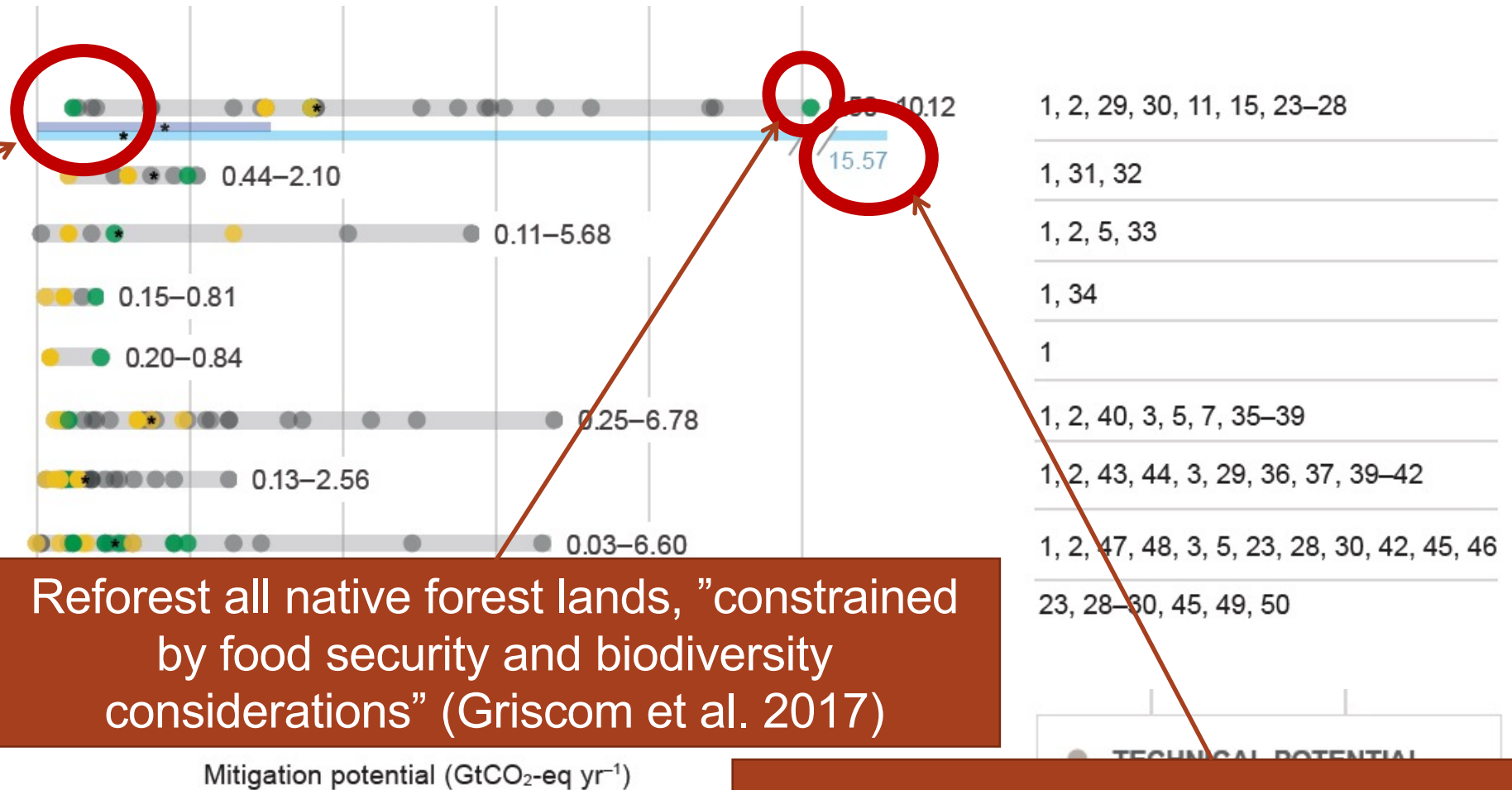
Forest management

Agroforestry

Peatland restoration

Yan et al. 2017, Fuss et al. 2018

BECCS deployment



Reforest all native forest lands, "constrained by food security and biodiversity considerations" (Griscom et al. 2017)

IAM potential can be larger

Source: IPCC SRCCL Chapter 2 Figure 2.24

Different approaches to modeling afforestation/reforestation potential

- Bookkeeping approaches
- Rule-based land use/land cover models and IAMs
- Economic land use/land cover models and IAMs
- Earth system models

Bookkeeping approaches

- Approach: Define estimates of land available / used for afforestation / reforestation and calculate carbon uptake
- Limits:
 - Not clear in practice how to incentivize and/or limit afforestation/reforestation to the areas specified
 - Type of potential depends on rules defined
 - Not always clear what factors are included in the carbon uptake

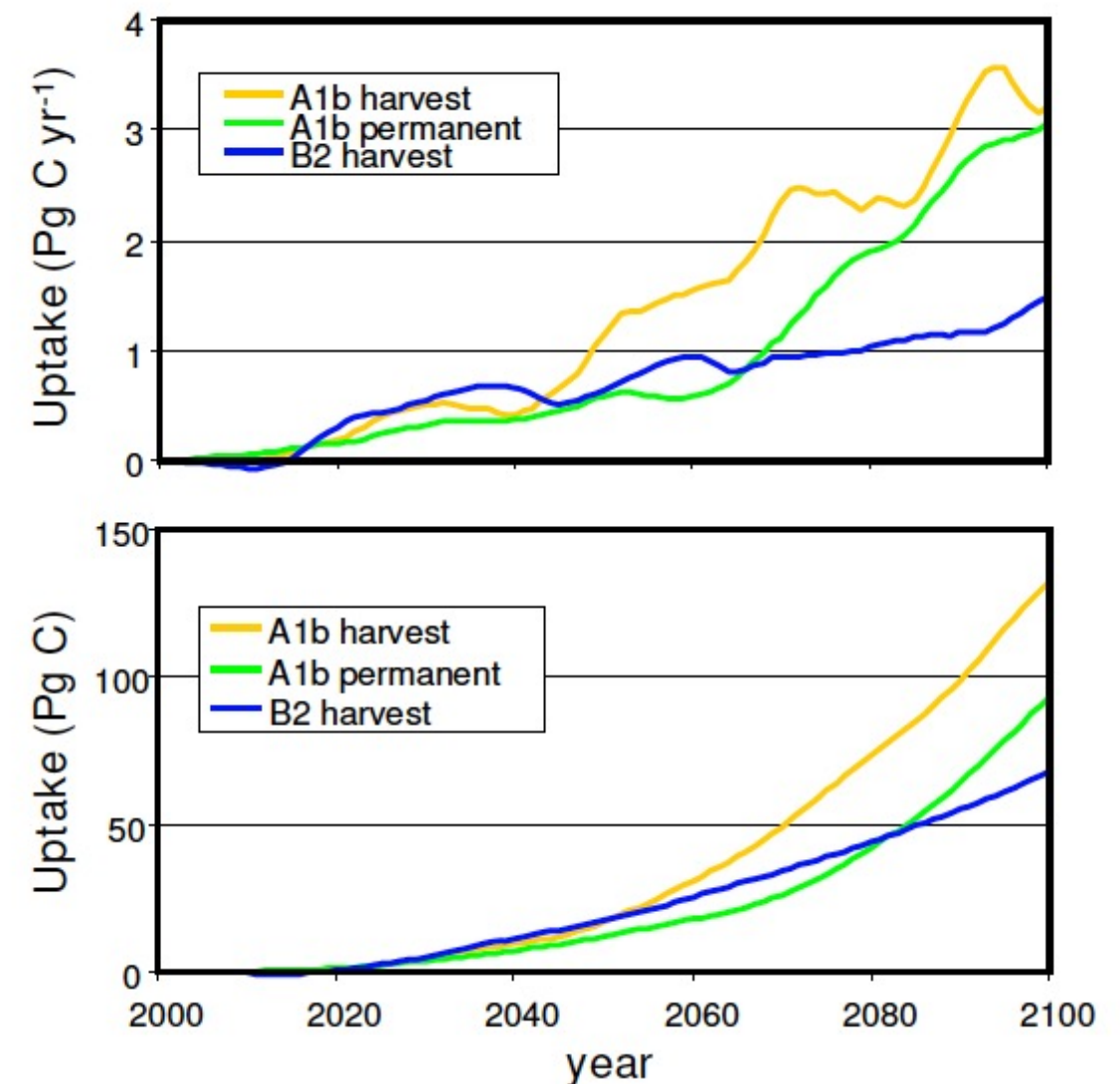
Examples from Fuss et al. (2018):

- The low end of the range is from Lenton et al. (2014) and is based on an extrapolation of current afforestation trends and an assumption about carbon uptake per Ha, resulting in 0.37-0.74 PgC/yr in 2050.
- Author's Assessment. "**Albedo effectively constrains afforestation as a mitigation strategy to the tropics**.... The estimate by Houghton et al (2015) for a total area of **500 Mha of marginal land in the tropics** is therefore a feasible, yet ambitious boundary limit for global afforestation.... **The 500 Mha constraint constitutes approximately 3.6 GtCO₂ yr⁻¹ of carbon removal by 2050**, albeit declining to 0 by the end of the century (Houghton et al 2015)."

Rule-based models

- Approach: Define rules for establishing which land can be used for afforestation, then use a land use / land cover model to determine carbon uptake
- Limits:
 - Not clear in practice how to incentivize and/or limit afforestation/reforestation to the areas specified
 - Type of potential depends on rules defined
 - Not all models include effects of climate change or disturbances on carbon uptake

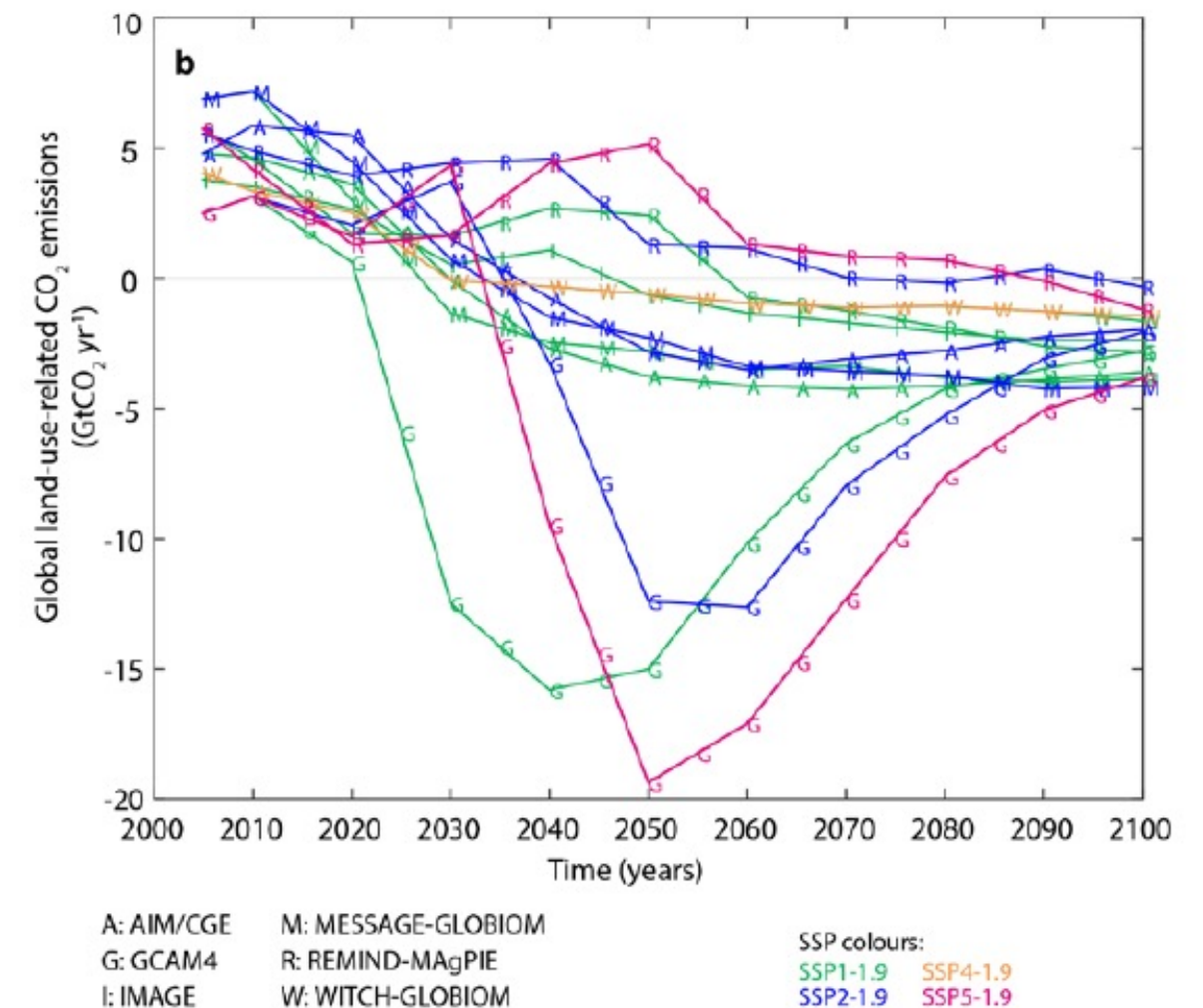
Example from van Minnen et al. (2008)



Economic models

- Approach: Profit-driven changes in land use and land cover, with explicit financial incentives for afforestation/reforestation included.
- Limits:
 - Not all incentives included in models can be implemented in the real world
 - Type of potential depends on constraints imposed
 - Land use decision making, and its uncertainties, not always well represented
 - Not all models include effects of climate change or disturbances on carbon uptake

Example from Rogelj et al. (2018)



Earth System Models

- Approach: Implement simulations with and without increases in forest cover to calculate effects on carbon storage; forest cover estimates typically come from IAMs

Earth System Models

B. C. O'Neill et al.: The Scenario Model Intercomparison Project (ScenarioMIP) for CMIP6

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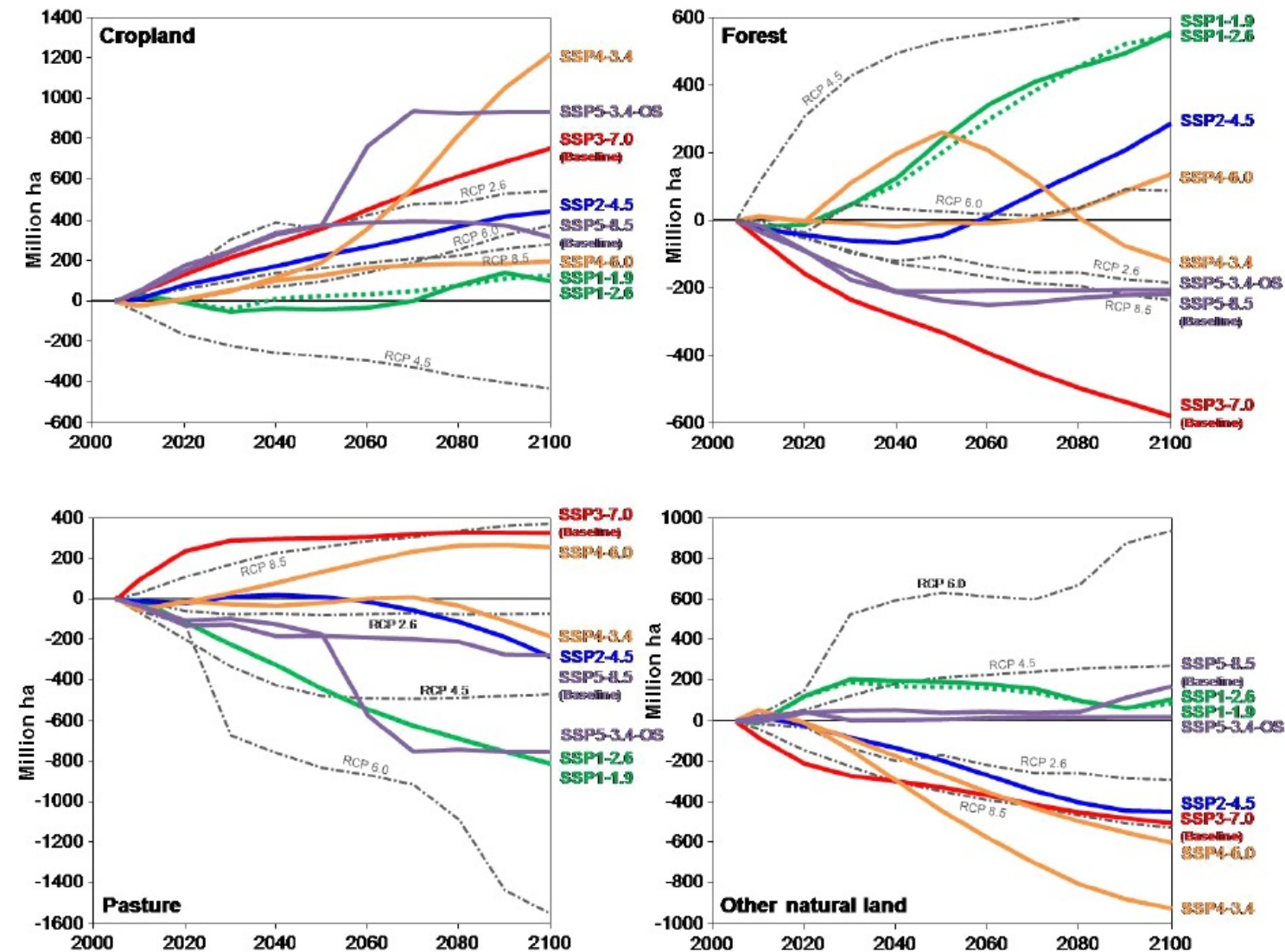


Figure 4. Changes in cropland (a), forest (b), pasture (c), and other natural land (d) for the 21st century scenarios in the ScenarioMIP design, from the same IAM runs used to produce Fig. 3. Land use change for the RCPs (van Vuuren et al., 2011b) is shown for comparison.

Earth System Models

biomass (“cVeg”) in the four scenarios

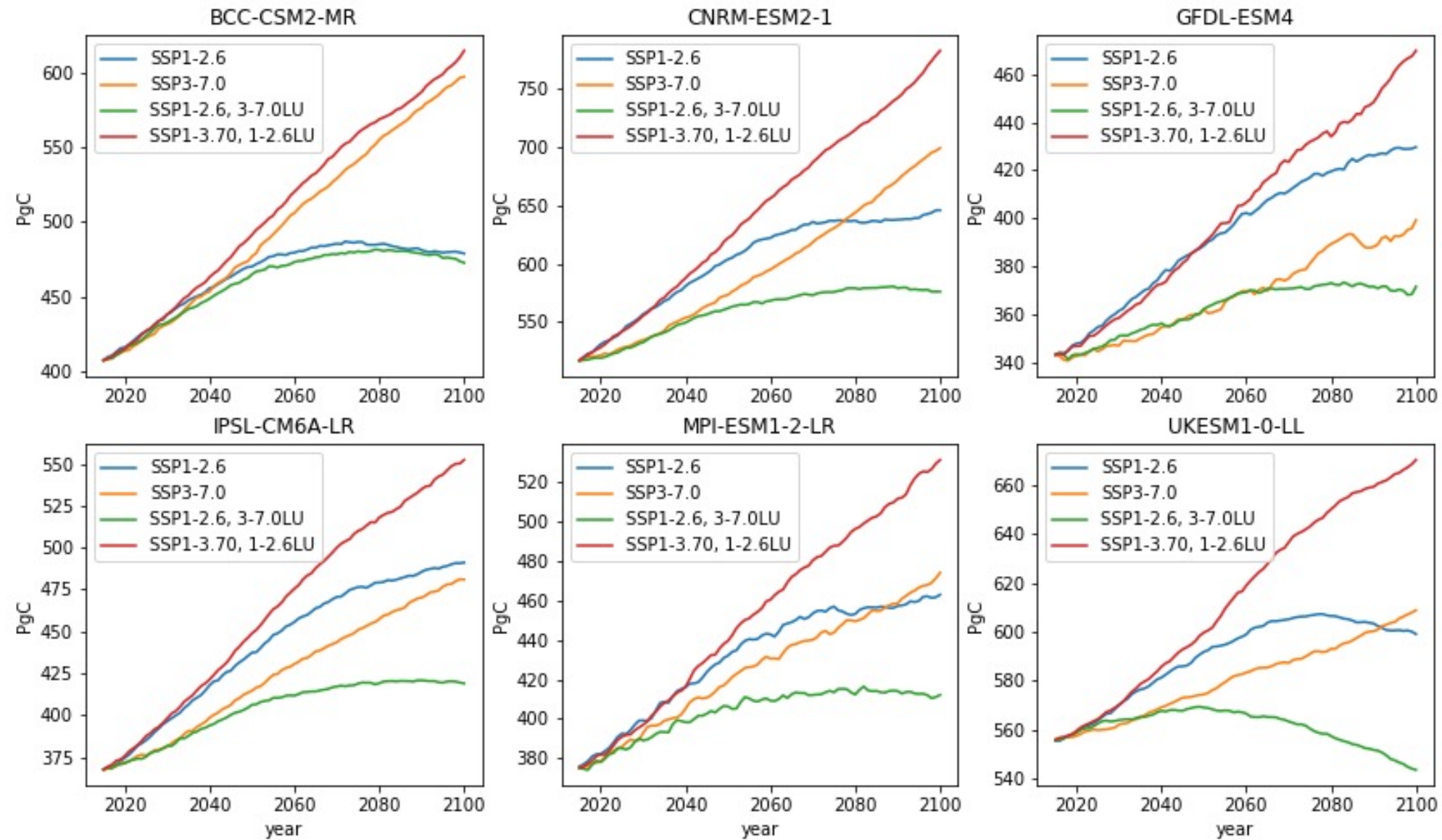


Figure from Chris Jones

Earth System Models

Difference biomass (“cVeg”) with ssp126 climate

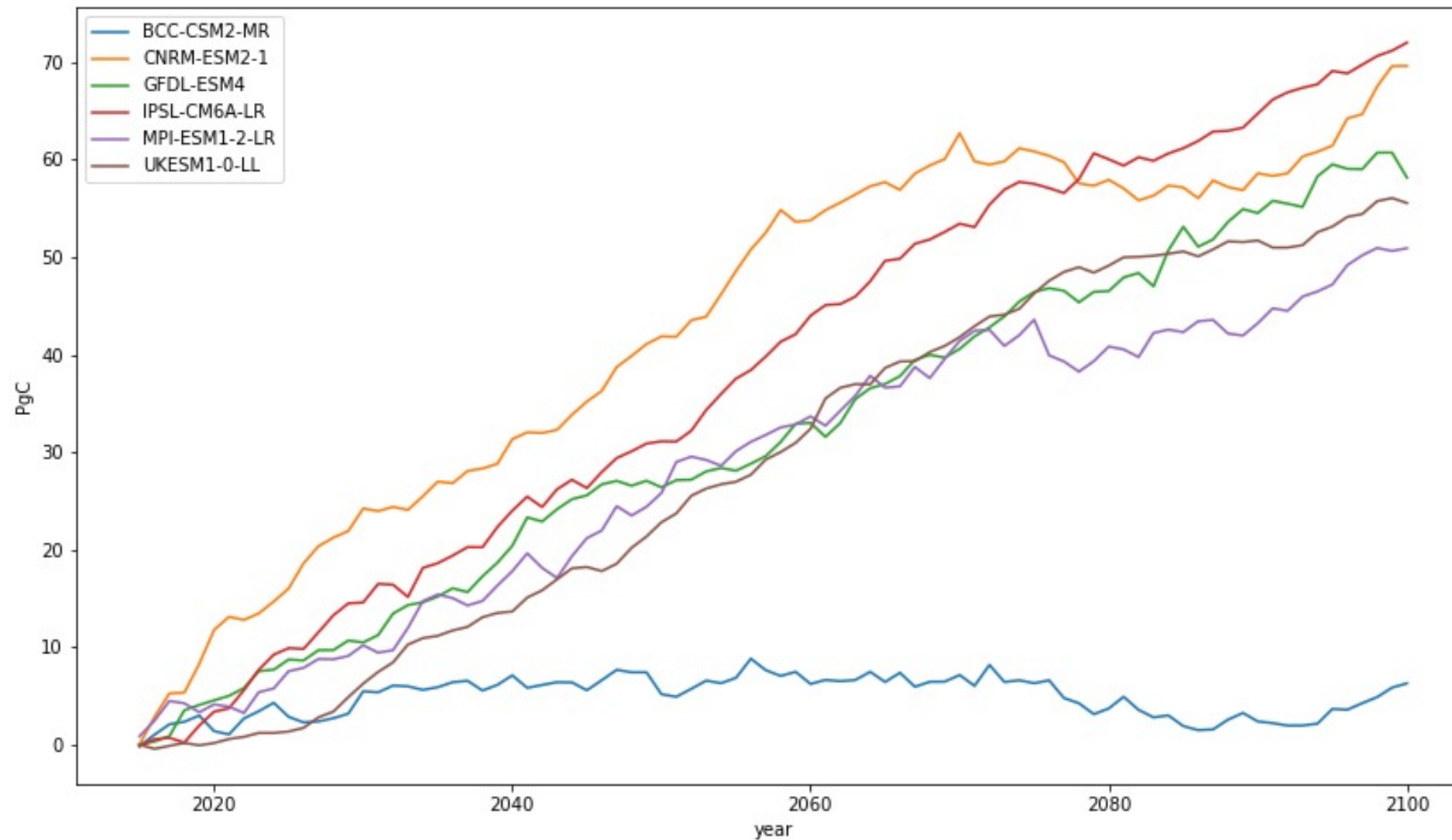


Figure from Chris Jones

Earth System Models

- Approach: Implement simulations with and without increases in forest cover to calculate effects on carbon storage; forest cover estimates typically come from IAMs
- Limits:
 - Potential depends on the forest cover estimates provided to the ESMs and may not represent total potential (or economic/sustainability constraints)
 - Implemented differently in different ESMs in part due to translation issues between IAMs and ESMs

Difference biomass (“cVeg”) with ssp126 climate

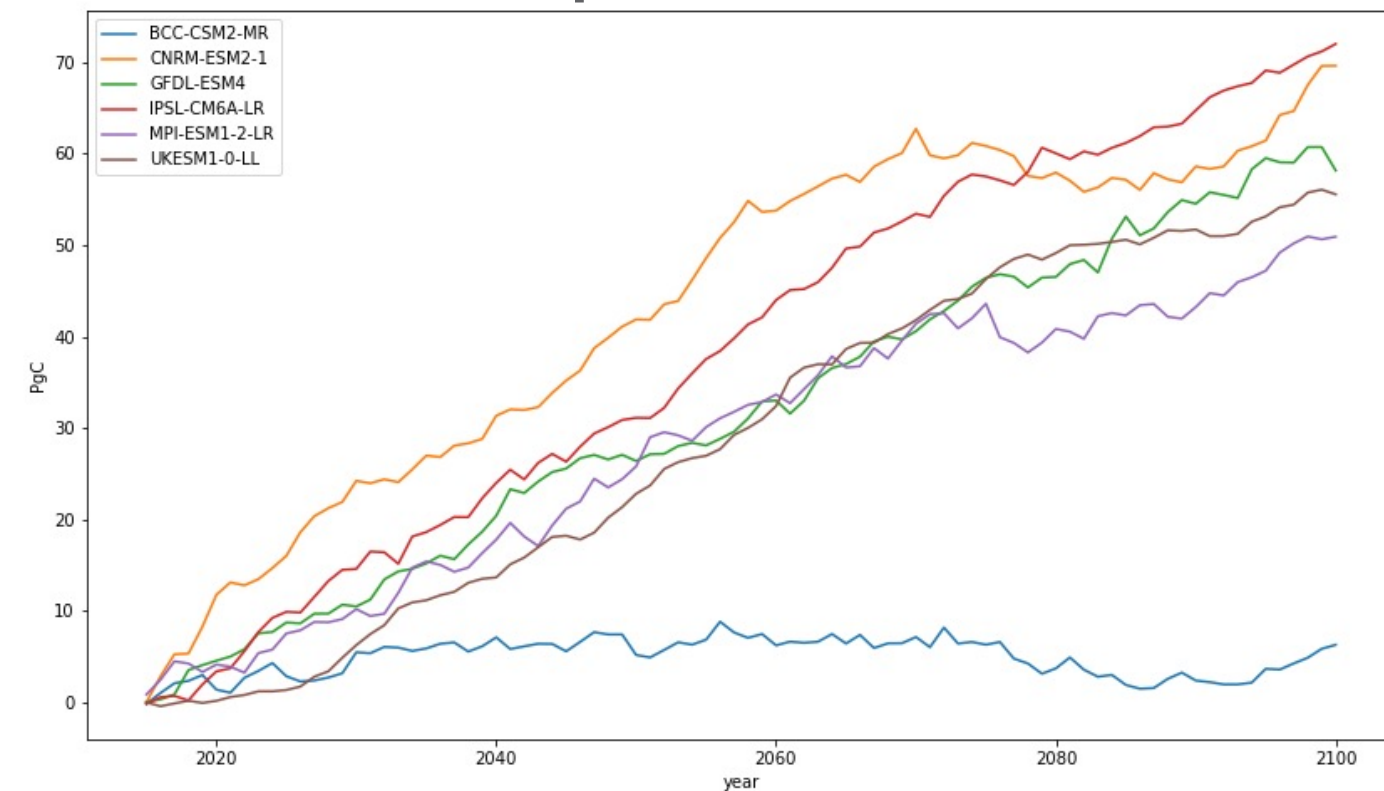


Figure from Chris Jones

Summary

- There are many different types of potential (e.g., technical, economic, sustainable).
- There are many different methods of estimating potential in models. Each approach provides different information with different limitations. Approaches vary in whether they:
 - Capture how afforestation/reforestation would be implemented/incentivized
 - Reflect economic or sustainability constraints
 - Consider climate impacts and disturbances

Thank you

