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Policy implications from aligning IPCC scenarios to national land emissions inventories

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Taking stock of global progress towards achieving the Paris Agreement requires measuring aggregate national action against modelled mitigation pathways. A key gap exists, however, in how scientific studies and national inventories account for the role of anthropogenic land-based carbon fluxes, resulting in a 5.5-6.0 $GtCO2yr^{-1}$ difference between the respective present-day land-use estimates. Modelled pathways mainly include direct human-induced fluxes, while inventories submitted by countries to the UNFCCC (NGHGIs) generally include a wider definition of managed land area as well as the indirect removals on that land caused by environmental changes (e.g., the CO2 fertilization effect). This difference hinders comparability between targets set by countries and scientific benchmarks.

Scenarios assessed in AR6 show that a combination of deep near-term gross emissions reductions and medium-term carbon removal from the atmosphere are needed to reach net-zero and eventually net-negative CO2 emissions to limit warming in line with the Paris Agreement temperature goal. However, scenarios lacked key information needed to estimate land-based removals and to align their LULUCF projections with NGHGIs. Here, we estimate the land-based removals consistent with NGHGIs using a reduced complexity climate model with explicit treatment of the land-use sector, OSCAR, one of the models used by the Global Carbon Project. Of the 1202 pathways that passed IPCC vetting, 914 provide sufficient land-use change data to allow us to fill this information gap and enable alignment between pathways and inventories.

Across both 1.5°C and 2°C scenarios, pathways aligned with NGHGIs show a strong increase in the total land sink until around mid-century. However, the 'NGHGI alignment gap' decreases over this period, converging in the 2050-2060s for 1.5°C scenarios and 2070s-2080s for 2°C scenarios. These

dynamics lead to land-based emissions reversing their downward trend in most NGHGI-aligned scenarios by mid-century, and result in the LULUCF sector becoming a net-source of emissions by 2100 in about 25% of deep mitigation scenarios.

Our results do not change any climate outcome or mitigation benchmark produced by the IPCC, but rather provide a translational lens to view those outcomes. We find that net-zero timings on average advance by around 5 years; however, this does not imply that 5 years have been lost in the race to net-zero, but rather that following the reporting conventions for natural sinks results in net-zero being reached 5 years earlier. Understanding how these different accounting frameworks can be mutually interpreted is a fundamental challenge for evaluating progress towards the Paris Agreement, given the reality that direct and indirect carbon removals cannot be estimated separately with direct observations.

We propose three primary ways to address this science-policy gap. First, targets can be formulated separately for gross emission reductions, land-based removals, and technical carbon removals, allowing for nations to clearly define their expected contributions and to measure progress in each domain separately. Second, nations can clarify the nature of their deforestation pledges. Third, modelling teams can provide their assumptions for the NGHGI correction as part of their standard output which future IPCC assessments can use to vet scenarios.