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COMMENT

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Reporting carbon fluxes from unmanaged forest

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Unmanaged land areas are not included in current national reports on greenhouse gas emissions for the Paris Agreement. Here, we argue that carbon dioxide fluxes from all forest land need to be recorded in order to help tracking progress towards global climate targets.

Under the Kyoto Protocol, countries agreed that greenhouse emissions and removals from land activities should count towards their climate targets only if arising from direct human-induced effects. However, the Intergovernmental Panel on Climate Change (IPCC) noted that direct human-induced effects on land are deeply intertwined with changing environmental drivers such as increased atmospheric carbon dioxide (CO_2) concentration (indirect effects) and that they cannot be separated through the methods used in national greenhouse gas inventories. Therefore, to facilitate national greenhouse gas inventory reporting, the IPCC Guidelines[1] adopted the concept of 'managed land'—land where countries decide that human interventions and practices have been applied to perform production, ecological or social functions—as a pragmatic proxy for anthropogenic effects. Greenhouse gas fluxes are thus defined as *all* those occurring on managed land, whether they stem from either direct human-induced effects or from changing environmental drivers.

Countries thus only need to estimate and report to the United Nations Framework Convention on Climate Change (UNFCCC) the greenhouse gas fluxes on managed land. While it is good practice to report the area of unmanaged lands in the greenhouse gas inventory, there is no obligation to report greenhouse gas fluxes from these lands. In other words, countries have so far assumed that they have no control over, and are therefore not liable for the greenhouse gas fluxes on unmanaged lands. The current separation, in which only part of the land is reported, makes it impossible to establish a direct link between the fluxes reported to UNFCCC and the observed growth rates of greenhouse gases in the atmosphere. This narrow focus on managed land also contributes to the discrepancy between national greenhouse gas inventories and the estimates for the global net terrestrial carbon flux established by the scientific community (Fig. 1). To a large degree, the mind-boggling range in estimates shown in Fig. 1 results from different ways to define the term 'anthropogenic'. In addition, managed and unmanaged land is delineated in diverse ways, depending whether the delineation is performed by land use researchers, as part of countries' greenhouse gas reporting[2], through remote sensing approaches or via atmospheric inversion approaches. Furthermore, the definition of managed land as a proxy for anthropogenic emissions and removals is not homogeneous across countries. At present, large areas of unmanaged forest are reported by Brazil, Canada and Russia, while for most developing countries it is often unclear if they consider all forest as managed or not[3]. Even less information is available for unmanaged non-forest area, which might include grassland and wetlands.

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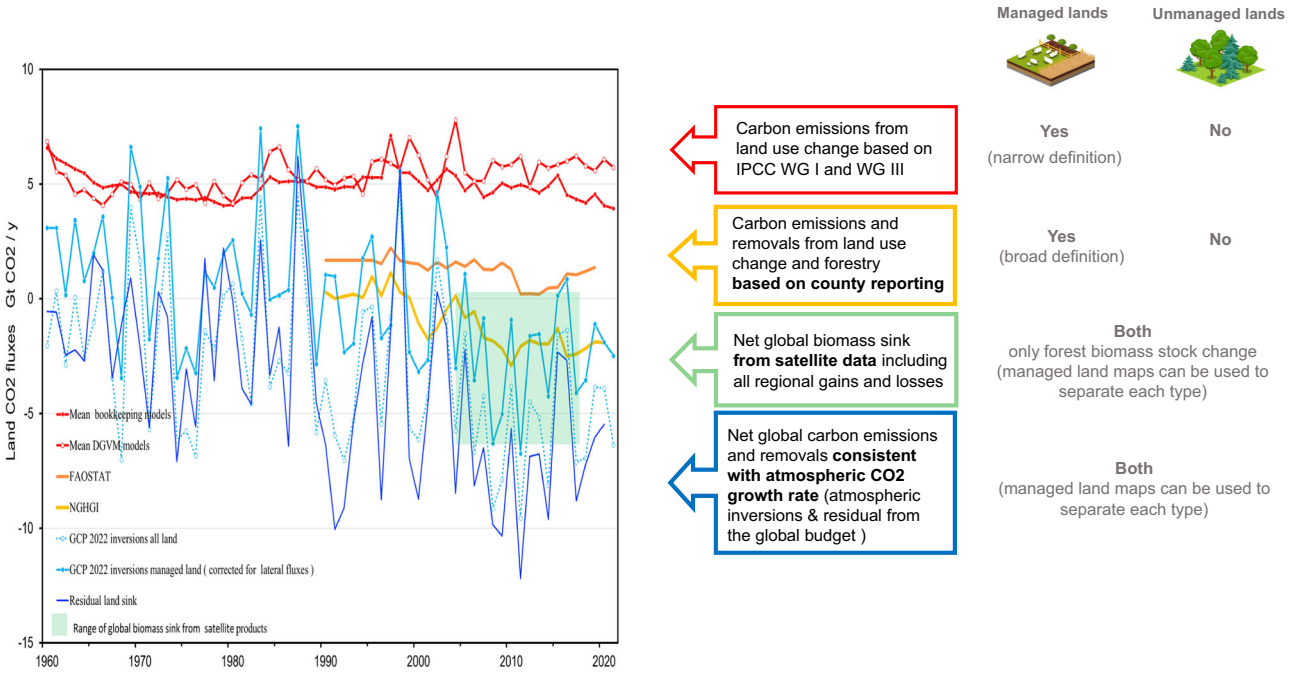

Fig. 1 Global net land CO_2 flux for 1960–2021. Despite improved data acquisition a mind-boggling large variation and uncertainty in estimates of CO2 land emissions and sinks remains. The mean of the bookkeeping models originates from three bookkeeping models[5–7]. Mean of the Digital Global Vegetation Models (DGVMs) originate from 8,9. National Greenhouse Gas Inventories (NGHGI) are estimates for the managed lands only, according to their definitions[3,11]. FAOSTAT estimates are estimates for all forests[10]. The satellite products[12,13] represent all forest lands. While the Global Carbon Project (GCP 2022) inversions[9] and its residual land sink[9] are portrayed both for all land area and for managed land. Estimates from the satellite products in the range of the green shaded area are for all forest lands. Ref. [3] reconciled some of the differences and brought bookkeeping and NGHI reporting closer together delineating the managed lands and their C fluxes in a more harmonised way. Figure adapted after 4. The middle panel with the arrows groups the estimates in left hand panel by main approach. The right-hand panel states whether the approach considers managed lands, unmanaged lands, or both.

Differences in the results of global models with greenhouse gas inventories have been explained and largely reconciled. But the atmospheric build-up of greenhouse gases still does not match with the cumulated impact of national reporting[3].

The range in estimates of land-based carbon fluxes that arise from different definitions (Fig. 1) cannot be reduced by simply improving each method separately. Here, we argue that a more comprehensive total land approach in the greenhouse gas inventories is needed to fill a knowledge gap and to better track the progress towards global climate targets. Given the predominant role of forest in the land CO_2 fluxes, we propose that such more comprehensive approach starts by including the CO_2 fluxes from all forests. A possible future use of this information in the accounting towards climate targets would also help incentivize additional CO_2 removals by the sector of agriculture, forestry and other land use fluxes, to achieve its own greenhouse gas neutrality by 2035, as portrayed by the IPCC[4]. If such an accounting towards climate targets will occur, additional aspects will need to be considered. First, an adjustment of the global remaining carbon budget will be needed[2] to avoid double counting with the definition of anthropogenic CO_2 sink used so far in the IPCC assessment reports. Second, to avoid the possibility that an extra sink from unmanaged forest dilutes mitigation efforts in other sectors, countries shall accordingly and transparently adjust their climate pledges.

Towards rethinking the approach on managed land

A lot of progress has been made by the scientific community in quantifying and understanding the land fluxes in the last two decades[4–13]. This is a solid basis for policy makers to rethink the approach of separating managed and unmanaged land. The IPCC's Working Group III report made a step towards integrating these two types of land in the Sixth Assessment Report. The residual sink (the residual of fossil, cement production, and land-use change emissions minus the oceanic sink and the atmospheric CO_2 growth) for the whole land biosphere is portrayed now in the mitigation assessment. The contemporary net land balance, consisting of anthropogenic land use, land-use change and forestry plus natural fluxes across the entire land surface, was estimated as a sink of—6.6 gigatonnes CO_2-equivalent per year[4]. Furthermore, the reconciliation between global models and National Greenhouse Gas Inventories[3,4] has shifted over half of the natural land sink of about 11 gigatonnes CO_2-equivalent per year into the anthropogenic component.

By 2050, the land use sector is expected to remove up to 8–14 gigatonnes CO_2-equivalent additionally per year from the atmosphere[4]. Such a large sink needs reliable estimation certainly when counting towards the goals of the Paris Agreement. We propose a more complete, less complex, more consistent approach to forest carbon reporting; greenhouse gas fluxes over unmanaged land can be reported using best available scientific knowledge and inventory methods recommended by the IPCC. In countries with sparse sampling, these methods can be enhanced with the help of advances in remote sensing and modelling, especially for monitoring biomass changes. If implemented for all countries in a transparent and verifiable way, such as under the UNFCCC reporting system subject to an independent review, this approach will make it possible to establish a more direct link between fluxes reported to UNFCCC and the observed growth rates of greenhouse gas in the atmosphere.

Reporting of all land use emissions and removals

There are no quick fixes to the challenges of land use reporting. Nevertheless we believe that a few important steps can be made

now. Countries can include best available estimates of emissions and removals from unmanaged lands in their reporting. This is difficult, but could be achieved by taking advantage of open-access ground-based data and monitoring opportunities now offered by earth observation and modelling. Initially, greenhouse gas flux estimates for unmanaged land could be included on a voluntary basis for information purposes in country reporting, and in a second step, they could be considered in the official accounting towards the climate targets. Such an approach would provide a better incentive to include, for example, carbon-rich unmanaged forests that are vulnerable to climate change and human actions. On the other hand, accounting CO_2 fluxes from all forests towards the climate targets requires adjusting the global carbon budget and national climate pledges accordingly[2].

The process could start in the following manner: in the context of the Enhanced Transparency Framework of the Paris Agreement, all countries that refer to forest carbon in their Nationally Determined Commitments should be on a pathway to reach coverage of more than 70% of their forest area reported with at least IPCC tier 2 (i.e. using country-specific data e.g. on forest growth) by 2035 and more than 90% by 2050. In addition, we recommend to concentrate on improvement of monitoring and reporting for the top 30 countries with more than 20 million hectares of forests. This would cover practically all unmanaged forests.

Countries' biennial transparency reports should provide clear documentation of the methods used and the timing of their implementation. Entities in countries, or countries, should only be allowed to transfer carbon emission reductions or sequestration to entities in other countries where the same, or better reporting standards have been met. Through a full inclusion for unmanaged as well as managed forest land the scientific community could also engage more directly in the review and support of National Greenhouse Gas Inventories, because coverage will better align with the scientific estimates on forest lands. The scientific community can and should also become more closely associated to the UNFCCC reporting process.

In summary, we propose a gradual transition along the following lines:

1. Report greenhouse gas emissions and sinks on all forest lands. The aim would be that all parties to the Paris Agreement agree to move towards more than 70% of all forest land included in reporting of forest sources and sinks with at least IPCC Tier 2 by 2035 and more than 90% by 2050. This expansion could start with the 30 largest forest countries by area, bringing large additional forest land areas into the reporting architecture, for example, much of Amazonia, remote Canada, Congo Basin, central Siberia. Annual fluctuations could be larger, but they will align better to what the atmosphere sees;
2. Include the carbon greenhouse gas fluxes on unmanaged forests, which is currently not included in countries' reports, with the aim of covering all natural and anthropogenic effects on all forest lands. The system would annually provide per country the net greenhouse gas balance and should aim to capture the effect of land use management changes. It would rely more on near real time assessments, which continue to become more feasible over time as more sophisticated remote sensing products are developed;
3. Revise estimates from 1990 or 2000 forward, depending on data availability, in order to use a long-term record as part of the transparency reports. Such a re-calibration could be part of the global stocktake, from which new targets and timetables are expected;
4. Start the transition in 2–3 years' time, by using the existing IPCC Guidelines. Another decade or so might be required for countries to achieve the first goal of 70% coverage with at least IPCC Tier 2 level reporting in 2035. The transition starts for all forest lands, in parallel with the improvement in accuracy and completeness already expected under the Enhanced Transparency Framework. The move to 'all lands' approach can be decided later.

Our proposal may raise concerns about the lack of clarity in reporting during the transition period and on the need of adequate financial support for developing countries. Nevertheless, we are convinced this transition is needed, and it is better to start now. The proposed approach recalibrates and provides an on-ramp for all countries to implement full reporting of carbon in all forests, whether managed or unmanaged. It will require from countries without sufficient data to start improving and producing their own estimates in combination with the latest remote sensing and other models and techniques which we deem feasible now. We argue that the transition to a more complete carbon reporting system needs to start now, if we want to increase the credibility of the land-use sector in the coming decades.

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Author contributions

G.J.N.: conceived idea and wrote the text. P.C.: conceived idea and wrote the text. G.G.: conceived idea and wrote the text. R.A.H.: co-wrote the text. B.S.: co-wrote the text.

Competing interests

The authors declare no competing interests.

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