WORKING PAPER

Forest Mitigation: A Permanent Contribution to the Paris Agreement?

Sandro Federici, Donna Lee, Martin Herold

October 2017

This report has been funded primarily by the Norwegian International Climate and Forest Initiative, with support from the Climate and Land Use Alliance. The authors are solely responsible for its content.

Executive Summary

The Paris Agreement set forth new global goals on mitigation. Recent studies[1], as well as the Intergovernmental Panel on Climate Change (IPCC), in its most recent Assessment Report[2], suggest that such goals cannot be met without a significant contribution from forests. Halting conversion of forest into other land uses, ending forest degradation, and restoring peatlands would avoid accumulation in the atmosphere of around 30% of global anthropogenic CO_2 emissions[3]. Additionally, expanding forests is critical to reaching carbon balance and providing the negative emissions needed to reach the 1.5°C global set out by the Paris Agreement.

However, forest contributions have sometimes been 'discounted' by policy makers, climate negotiators, and groups that claim forest mitigation is not permanent and therefore should not be considered on par with emission reductions in, for example, the energy sector. This report suggests otherwise, for the following reasons:

1. Forests have been sequestering carbon for thousands of millennia and have been a permanent feature of the terrestrial biosphere. Currently, forests sequester around 30% of human-caused emissions[4] and represent the only carbon capture and storage approach that has proven to work at scale and at reasonable cost[5]. There is 40% more carbon stored in forests than in fossil fuel deposits[6].
2. Because human activities impact C stocks on land, and because mitigation actions may incentivize the substitution of fossil fuels and other energy-intensive material with wood, the inclusion of forests in accounting frameworks is a precondition to ensure that accounted results in the energy sector correspond to what is actually "seen" by the atmosphere.
3. To the atmosphere, avoiding emissions from deforestation and forest degradation is no different than avoiding emissions from fossil fuels—the atmosphere sees the same thing.
4. Furthermore, the land sector is unique in that it is 'self-correcting'; emissions caused by natural disturbances normally result, over time, in the recovery of carbon stocks, returning lost carbon back to the land (e.g. through forest regrowth). This is not true for any other sector.
5. While natural ecosystems experience inter-annual variability, they have an average long-term C stock (with exception of peatlands), and only changes to this long-term average permanently impact atmospheric CO_2 concentrations.

---

[1] Rockström, J. et al (2017). A roadmap for rapid decarbonization. *Science 355* (6331); Roe, S. et al (2017). How Improved Land Use Can Contribute to the 1.5°C Goal of the Paris Agreement (Working Paper).
[2] IPCC AR5 – Mitigation of climate change (http://www.ipcc.ch/report/ar5/wg3/).
[3] This figure has been calculated by summing up CO_2 emissions from gross deforestation, i.e. 2.8 Gt C yr^{-1}, estimated by Goodman R.C. and Herold M. (2014) Why Maintaining Tropical Forests Is Essential and Urgent for a Stable Climate - CGD Climate and Forest Paper Series #11 (figure 6.b https://www.cgdev.org/sites/default/files/CGD-Climate-Forest-Paper-Series-11-Goodman-Herold-Maintaining-Tropical-Forests.pdf), from forest degradation, i.e. 0.5 Gt C yr^{-1}, estimated from FAO FRA 2015 data (Federici, in elaboration), from peatland drainage, i.e. 0.5 Gt C yr^{-1}, estimated by Wetlands International (2009) in The Global Peatland CO_2 Picture (https://www.wetlands.org/publications/the-global-peatland-co2-picture/); from all other sectors as estimated by Le Quéré, C. et al (2016), Global Carbon Budget, (Earth Systems Science Data 8, 605-649, http://www.globalcarbonproject.org/).
[4] Le Quéré, C. et al (2016). Global Carbon Budget. *Earth Systems Science Data 8*, 605-649 - http://www.globalcarbonproject.org/
[5] Wolosin, M. (2017). Large-scale Forestation for Climate Mitigation: Lessons from South Korea, China and India.
[6] Scharlemann, J. et al (2014). Global soil carbon: understanding and managing the largest terrestrial carbon pool, Carbon Management, 5:1, 81-91, DOI: 10.4155/cmt.13.77 --- McGlade, C. and Ekins, P. (2015). The geographical distribution of fossil fuels unused when limiting global warming to 2 °C. Nature, 517 (7533) pp. 187-190.

6. Primary forests have the highest long-term average carbon stocks—and therefore their protection must be a priority.
7. To the extent there are risks of 'reversals' of a particular mitigation action, these risks exist in the energy (and other) sectors as well as for land use and forests. All sectors have drivers of emissions that can be reversed. Therefore, it is critical that all mitigation actions are 'transformational'[7].
8. In the land use sector, transformational actions that reduce emissions also tend to increase removals. And, in addition, the protected sink may persist for decades, contributing to long-term increases in C stocks. There is also a gain in delaying land use conversion—which is not true of fossil fuels—since forests, while they are kept standing, will remove carbon[8].
9. The Paris Agreement and recent COP decisions that require all countries to submit national GHG inventories (NGHGIs) and be accountable for significant categories of CO_2 fluxes within their NDCs (and continue to be accountable for them, once a source, sink, or activity is counted) is critical for the issue of permanence. Reversals at the national level are now 'covered' through the long-term responsibility of signatories to the Paris Agreement.
10. Accounting frameworks that operate on a shorter-term basis (e.g. crediting or trading mechanisms) have developed tools to manage risks of reversals from credited removals or emission reductions. Examples include insurance mechanisms (pooled buffer or reserve accounts), monitoring obligations beyond the accounting period, program design requirements (to ensure long term storage of carbon stocks), and liability provisions. Furthermore, permanence of accounted results may be ensured if liability is transferred, after the project ends, to national reporting and accounting of a nationally determined contribution (NDC), since the latter is a long-term commitment under Paris Agreement.

Currently, a majority of countries have made commitments to reduce emissions (or increase removals) in the land use and forest sector through submitted NDCs under the Paris Agreement. Several donor governments have pledged to support developing countries, in particular, with such efforts. In addition, many large multi-national companies have pledged to take deforestation out of their supply chains. While such transformation change is difficult to achieve, once it is in place, it can also be difficult to reverse. In Europe[9], there are 30% more forests since 1900 despite a significant increase in agriculture production. Reversing forest loss conserves biodiversity, protects watersheds and ecosystem services, regulates local climate critical for sustained rural development, and provides livelihoods for forest-dependent communities. Science tells us that we cannot delay action if we are to avoid dangerous climate change—and forests can contribute, in permanent ways, to meeting such a goal.

---

[7] Transformational changes remove the driver(s) of emissions such that emissions would not occur after the end of the period of activity (further discussed in Section 4).

[8] According to Le Quéré, C. et al (2016) - Global Carbon Budget. Earth Systems Science Data 8, 605-649 – there is a large residual sink on land that offset almost one third of anthropogenic emissions. This sink is mainly located in forest land (Schimel D. et al (2014) Effect of increasing CO_2 on the terrestrial carbon cycle, http://www.pnas.org/content/112/2/436.full, Keenan T.F. et al (2016) Recent pause in the growth rate of atmospheric CO_2 due to enhanced terrestrial carbon uptake, https://www.nature.com/articles/ncomms13428).

[9] Fuchs, R. (2015). Gross changes in reconstructions of historic land cover/use for Europe between 1900 and 2010. Global Change Biology 21 (1)

Contents

1. Preface

The term “non-permanence” is generally used to indicate the reversal of an achieved result, while its opposite, “permanence,” indicates the quality of a result lasting through time. While the UNFCCC does not have an official definition of permanence in its reporting and accounting framework, references to the term have implicitly suggested two aspects related to the results of mitigation actions:

- Permanence of an emission or removal, i.e. its resident time into the atmosphere;
- Permanence of the driver causing the emission and/or removal, i.e. the likelihood that after mitigation results have been accounted, the driver(s) counteracted by the mitigation action will be active again, reverting avoided CO_2 emissions or stored CO_2 removals to the atmosphere.

Non-permanence affects the integrity of any accounting mechanism for mitigation. This occurs when an accounted unit—i.e. one that does not actually correspond to either an avoided emission or an enhanced removal because of a reversal—has not been cancelled or offset/replaced by another accounting unit.

This report focuses on CO_2 fluxes caused by human activities and on their deviation from business-as-usual levels and trends, where such deviations are accounted as results from the implementation of mitigation actions. When accounting for results and assessing their permanence, CO_2 fluxes associated with natural disturbances (see Box 1, page 7), as well as those associated with activities and disturbances that occurred before the onset of the mitigation actions (i.e. the legacy effect, see Box 2, page 7), must be zeroed, since both are not directly associated with the mitigation actions.

The Paris Agreement has established a universal obligation to regularly publish a national greenhouse gas inventory report (NGHGI), following IPCC guidance. All countries are expected to report time series of estimates of anthropogenic greenhouse gas (GHG) emissions and removals—including in the land sector. Furthermore, all countries that ratify the Agreement must submit nationally determined contributions (NDCs) that include all significant emissions and removals. These provisions should, in principle, guarantee that any reversal is not only reported (at the time in which it occurs), but also that the country is held liable for such reversals through accounting for its NDC.

Carbon stored in forest land represents 60% of total C stock contained in terrestrial C pools and exceeds by 40% the total C stored in fossil deposits and by 450% the total amount of C that can be added to the atmospheric CO_2 concentration without exceeding the 2°C goal of the Paris Agreement (see Box 3, page 8). Forests currently remove almost one-third of anthropogenic CO_2 emissions, and new afforestation activities may significantly increase this mitigation effect.

However, human activities impact lands by using them for production of food and feed, biomaterials,[10] and biofuels at large scales,[11] resulting in deep alteration of resident C stocks[12] and their dynamics. An accurate estimate of anthropogenic CO_2 fluxes cannot overlook such changes. Current modeling suggests that pathways to limit temperature increases to 2°C likely require increasing use of biomaterials and

---

[10] According with data reported in FAOSTAT database (http://www.fao.org/faostat/en/#data/FO), around 1 Pg C yr^{-1} of wood has been harvested in 2016, that where not serving from a sustainable management of forest may determine a net decrease in the long-term C stocks of forest land and consequently a net accumulation of carbon into the atmosphere.

[11] Currently, human activities are consuming around 40% of the global net primary production (www.nature.com/nature/journal/v429/n6994/pdf/nature02619.pdf); the forecasted increase of human population and of its consumption of biomaterials, including biofuels, and the contemporary decrease in primary production due to deforestation and land degradation, including forest degradation, and negative impacts of climate change may likely increase such quota over 50% by 2030.

[12] Deforestation only has been estimated to have transferred around 150 Pg C (1870-2016) just in the period 1870-2016.

bioenergy. However, if these are not sustainably produced, it would result in a significant displacement of emissions[13] from energy-related sources to lands, especially to forest land. For these reasons, it is critical to include forests in any accounting framework.

The Paris Agreement invites Parties to take action to conserve and enhance terrestrial sinks and reservoirs of GHG. Nevertheless, since the advent of the Kyoto Protocol, the liability of countries and local actors for emissions and removals from terrestrial C pools and their inclusion within market mechanisms have been contentious within UNFCCC negotiations. Critiques have pointed to

I. the concurrence of natural factors in determining emissions and removals from the terrestrial C pools;
II. the temporary nature of mitigation actions and consequently of their achieved results.

This report provides an analysis of the nature of CO_2 emissions and removals from managed terrestrial C pools, hereafter also referred as the land use sector[14], and of the nature of results achieved by mitigation actions in the land use sector. Although the analysis focuses its discussion on the permanence of climate results achieved through mitigation activities that affect forest land, i.e. activities for reducing C stock losses and enhancing C stocks of forests, the content of this report may be applied to all other terrestrial ecosystems (although for peatlands, see Box 4 on page 8, such general considerations may not apply).

---

[13] Where CO_2 emissions from bioenergy are not accounted for in the land sector, bioenergy cannot be assumed to be carbon neutral since the production and use of biofuels may determine a decrease in the long-term average C stocks of land (see figure in section 3). For instance, according to global data on fuelwood production (http://www.fao.org/faostat/en/#data/FO), almost 2 Gt CO_2 yr^{-1} are currently emitted by its use although not accounted for since deemed to be at equilibrium with atmospheric CO_2 concentration (i.e. the CO_2 emissions will be taken back by the subsequent regrowth of forest)
[14] Sector of a NGHGI

Box 1. Natural Disturbances

The annual GHG net flux[15] of a managed land is the result of multiple causes/drivers that can be aggregated within three groups: (a) those directly attributed to human activities (e.g. harvesting, planting); (b) those indirectly attributed to human activities (mainly N and CO_2 fertilization, climate change); and (c) natural disturbances (mainly fires, drought, pests).

Although it is possible to list these causes/drivers of emissions and removals, it is not possible to separate their contribution to the total GHG net flux by cause, occurrence, or specific land area. For example, it is difficult, if not impossible, to separate out the causes of GHG emissions and subsequent removals from forest fires. Fires have affected forest ecosystems since before the appearance of human beings. They may be the intentional or unintentional consequence of human activities, and their frequency and intensity is directly impacted by climate change (and the indirect consequence of human activities). Consequently, the total emissions and removals associated with forest fires is the result of a range of causes—anthropogenic, direct and indirect, and natural—that influence each other and cannot be separated. Consider, for instance, a country in which all forest fires are anthropogenic and the number of fires is the same in three consecutive years, but where summer weather conditions vary, so the first year is wet and mild, the second dry and warm, and the third dry, hot, and windy. This variability in weather condition is natural but also, because of climate change, indirectly-human induced. In terms of the impacts of the forest fires, GHG fluxes associated with fires occurring in the first year will be an order of magnitude smaller than those associated with fires occurring in the second year and much smaller than those in the third year. So, although all fires are anthropogenic, and the frequency of occurrence is the same, the results are different because the impact of natural variability *and* because of human-induced climate change. But it is possible to statistically identify when natural causes are predominant over human causes in impacting annual net GHG fluxes since, in such cases, the net GHG flux would exceed (i.e. be statistical outliers) the typical range of observed variability of natural disturbances over a period of years.

Box 2. Legacy of C pool disturbances

C stocks in C pools tend naturally towards an equilibrium where C stock gains are equivalent to C stock losses. This means that, when in one year a disturbance (natural or human-induced) alters one of the two terms of the equilibrium, the C pool reacts in subsequent years. This can either (a) determine a net C accumulation, i.e. annual C gains larger than annual C losses when the disturbance initially caused annual losses larger than annual gains (e.g. harvesting/fires impacts on biomass pool), or (b) determine a net C decay, i.e. the case when the disturbance initially caused annual gains larger than annual losses (e.g. harvesting or fire impacts on dead organic matter pool). Consequently:

- A CO_2 emission associated with a C stock loss can revert from the atmosphere because of the subsequent vegetation regrowth;
- A CO_2 removal associated with a C stock gain may revert to the atmosphere because of a subsequent disturbance (human or natural).

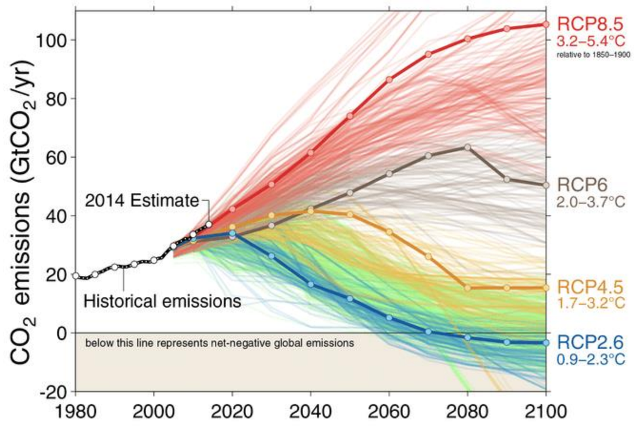
Consequently, “net emission reductions” as well as “net removal enhancements” may over-account what is actually seen by the atmosphere across a time period longer than the time period of accounting for mitigation results. Similarly, “net emission increases” as well as “net removal decreases” may be over-accounted if the legacy effect is not zeroed.

[15] and the associated long-term average C stock

Box 3. Representative Concentration Pathways

Representative Concentration Pathways (RCPs) are GHG concentration (not emissions) trajectories adopted by the IPCC for its AR5. They describe four climate futures, all of which are considered possible depending on GHG emissions in the years to come. The RCPs (RCP2.6, RCP4.5, RCP6.0, and RCP8.5) are named after a possible range of radiative forcing values in the year 2100 relative to pre-industrial values (+2.6, +4.5, +6.0, and +8.5 W/m^2, respectively).

AR5 global warming increase (°C) projections		
time period	2046-2065	2081-2011
Scenario	Mean and likely range	
RCP2.6	1.0 (0.4 to 1.6)	1.0 (0.3 to 1.7)
RCP4.5	1.4 (0.9 to 2.0)	1.8 (1.1 to 2.6)
RCP6.0	1.3 (0.8 to 1.8)	2.2 (1.4 to 3.1)
RCP8.5	2.0 (1.4 to 2.6)	3.7 (2.6 to 4.8)



Box 4. Peatlands

Peatlands are a part of the terrestrial carbon pool. However, unlike forests that (if left undisturbed) have a long-term average C stock, the C stored in peatlands does not tend toward an equilibrium. Peat can sequester an unlimited amount of C if pedoclimatic conditions (i.e. soil temperature, water, aeration) allow.

Without human intervention, most of the C stored in peatlands would not react with the atmosphere. Consequently, peat may be considered a fossil C stock that would not be emitted to the atmosphere without human action and, accordingly, any avoided emission is a permanent reduction of emissions.

However, if drivers of peat degradation have not been permanently removed—which means that peat may be disturbed in the future—the original action to avoid peat emissions is no different, and no less permanent, than an avoided fossil fuel emission.

2. The role of terrestrial C pools for mitigation of climate change

Terrestrial C pools contain the stocks of living organic matter (biomass) and dead organic matter (dead wood, litter, soil organic C, and harvested wood products) associated with vegetation. Such biomass pools remove CO_2 from the atmosphere (i.e. they are a carbon sink) because of net photosynthesis, and emit CO_2, CH_4 and N_2O from redox[16]of organic matter associated with continuous processes such as decay[17] or sudden events such as wildfires.

Terrestrial C pools store around 1.9 Eg[18] of C (~1.4 in soils and ~0.5 in phytomass)[19], mainly in forests[20] (1.1 Eg C), and peatlands[21] (0.6 Eg C). The total is a quantity larger than the C stored in fossil fuels reserves (~0.8 Eg C)[22], and more than the carbon already added to the atmosphere as a consequence of human activities since 1870 (~0.6 Eg C)[23]. This stored quantity also exceeds the quota of emissions that can be added to the atmosphere in order to keep the increase in average global temperature below 2 °C (0.2 Eg C)[23].

Until 1950, CO_2 emissions from terrestrial C pools were the main flux of CO_2 emissions caused by human activities. Around one-quarter of total anthropogenic CO_2 emissions since 1870 have been sourced from terrestrial C pools[23]. In recent years, largely due to the growth of fossil fuel emissions, net land use change (largely deforestation) has declined to around 10%[24] of total global anthropogenic CO_2 emissions—but more importantly, the land sector (largely forests) remove from the atmosphere 30% of total anthropogenic CO_2 emissions[23]. If only anthropogenic emissions (and not removals) are considered, gross deforestation, forest degradation, and peatlands drainage would together comprise around 30% of global total CO_2 emissions[3].

Due to their dual role as both a source and sink in the global C budget, terrestrial C pools have been recognized as key actors to achieve stabilization of atmospheric concentration of GHG at a level that does not seriously harm human, socio-economic, and natural systems. Indeed, halting the conversion of forest land and peatlands into agricultural or other lands and preserving the current land sink[25] would avoid accumulation in the atmosphere of more than one-third of global anthropogenic emissions[26]. In other words, failing to protect and sustainably manage forests and peatlands will accelerate by almost one-third the current pace of C accumulation into the atmosphere.

On the other hand, enhancing the current sink, especially through afforestation and rewetting of drained peatlands, would further increase the mitigation potential of terrestrial C pools. The IPCC, in its latest

---

[16] Redox reactions include all chemical reactions that involve the transfer of electrons between chemical species. The chemical species from which the electron is lost is said to have been oxidized (gain of oxygen), while the chemical species to which the electron is added is said to have been reduced (loss of oxygen). Oxidation is generally associated with oxygen availability (oxic conditions) while reduction with anoxic conditions.
[17] Decay processes determine a chain of organic compounds with a continuous loss of weight, also caused by CO_2 emissions, from biomass to dead wood and litter to soil organic matter and its subsequent respiration to CO_2 emissions.
[18] An Exagram corresponds to 10^{18} grams or a thousand Gt, e.g. 1.9 Eg C corresponds to 1,900 GtC.
[19] Scharlemann, J. et al (2014). Global soil carbon: understanding and managing the largest terrestrial carbon pool, Carbon Management, 5:1, 81-91, DOI: 10.4155/cmt.13.77
[20] 2000 IPCC special report on Land Use, Land-Use Change and Forestry
[21] Note that some forests occur on peatlands
[22] McGlade, C. and Ekins, P. (2015). The geographical distribution of fossil fuels unused when limiting global warming to 2 °C. Nature, 517 (7533) pp. 187-190.
[23] Le Quéré, C. et al (2016). Global Carbon Budget. *Earth Systems Science Data 8*, 605-649 - http://www.globalcarbonproject.org/
[24] Net deforestation from Le Quéré, C. et al (2016). Global Carbon Budget. *Earth Systems Science Data 8*, 605-649 - http://www.globalcarbonproject.org//
[25] Including by avoiding forest degradation
[26] Around 11.6 Gt CO_2 yr^{-1}

assessment report[27], considers the role of terrestrial C pools, particularly large-scale afforestation, critical to avoiding global warming above 2 °C[28]. Such mitigation potential is reflected in NDCs under the Paris Agreement, where the management of terrestrial C pools, especially forests, constitutes one-quarter of the collective commitment[29]. A failure to achieve this mitigation would double the gap[30] between current NDCs and a global net emission benchmark consistent with a pathway[31] to keep global warming below 2°C.

Further, forests are the habitat of around 80% of terrestrial biodiversity and provide indispensable and irreplaceable services beyond C sequestration and storage. Forests regulate local climate, enhance air quality, prevent soil erosion, improve soil fertility, and increase water availability and quality—leading to more reliable food production and advancing other societal goals.

Summary: The role of terrestrial C pools for mitigation of climate change

- Forest land stores 60% of the total C stock contained in terrestrial C pools.
- Forest land contains 40% more C than that contained in fossil fuels deposits.
- Forest land contains almost five times more C than can be added to the atmosphere without exceeding the 2 °C goal.
- The *net* CO_2 balance of land use change (largely deforestation) is currently responsible for around 10% of global anthropogenic CO_2 emissions; while *gross* deforestation, forest degradation and peatlands drainage are collectively responsible for around 30% of the global total. But forests also remove almost one-third of total emissions due to forest management, including natural forest expansion, and the indirect effects of human activities. New afforestation activities may significantly increase this mitigation effect.
- Failing to protect and expand the carbon stored in forests will make it impossible to achieve Paris Agreement goals.

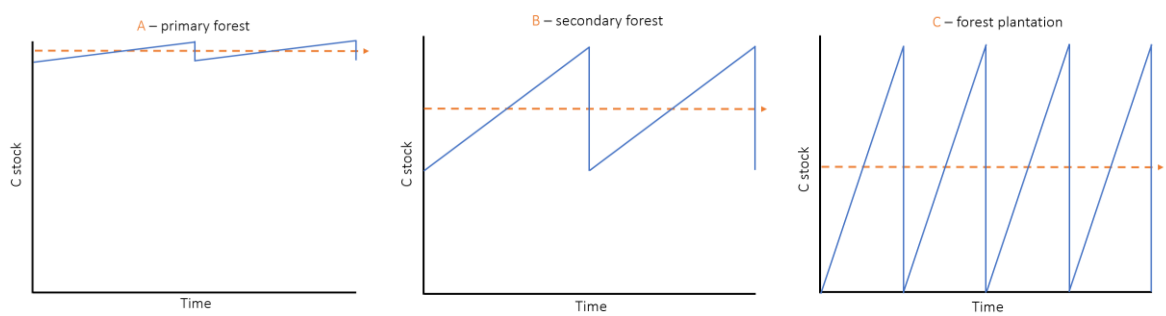
[27] https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf
[28] According to the mitigation scenarios and associated RCP2.6, failure in achieving net emissions at scale by 2050 will lock societies in a high temperature future.
[29] Grassi G. et al (2017). The key role of forests in meeting climate targets requires science for credible mitigation. Nature Climate Change, doi:10.1038/nclimate3227
[30] http://climateactiontracker.org/global/173/CAT-Emissions-Gaps.html (~14.5 Gt CO_2eq yr^{-1})
[31] RCP2.6

3. The nature of CO_2 emissions and removals from the land use sector

Before discussing the nature of CO_2 fluxes from land, it is worth briefly discussing the nature of CO_2 emissions generated by the use of fossil fuels, since they are the largest share[32] of anthropogenic CO_2 emissions and the core of any accounting framework for mitigation. Carbon contained in fossil fuels is stored in geological deposits confined from the atmosphere. Because of human activities that extract and oxidize it, fossil C is added to the atmosphere, or more precisely to the atmosphere-land-ocean system[33]. These emissions are permanent, because the carbon does not revert to the geological deposits[34].

The organic carbon contained in terrestrial C pools is in dynamic equilibrium with the atmosphere, subject to natural and human-induced processes of accumulation from the atmosphere into the C pools and of subsequent decay to the atmosphere[35]. This equilibrium can be quantified as a long-term average C stock stored in each terrestrial C pool[36]. The long-term average C stock takes into consideration the resident time of C within the C pools (see Box 5 below) and is determined by the ecological conditions, the system of management practices (i.e. land use) and the associated regime of natural and anthropogenic disturbances. A change in any of these factors can result in a change in the long-term average C stock.

Box 5. Long-term average C stock of various forest types



In the three graphs, the blue lines represent the C stock level across time, with C stock losses followed by equivalent C stock gains. Although in all three forests types there are CO_2 emissions and removals across time, it is possible to calculate a long-term net impact on the atmospheric CO_2 concentration for each of them i.e. their long-term average C stock (the dotted lines). Although the three forest types have almost equivalent peaks of C stock, the different resident time of carbon in C pools makes each forest's contribution to the atmospheric CO_2 concentration significantly different. As illustrated in the graphs, compared to primary forests, the long-term average C stock of secondary forests is 25% lower and forest plantations is 50% lower.

Consequently, the conversion of a primary forest to a secondary forest or to a forest plantation results in a permanent loss of C stock and therefore a permanent increase in the atmospheric CO_2 concentration. Alternately, the conversion of a forest plantation to a secondary forest or of a non-forest land to a forest land is a permanent C stock gain and therefore a permanent decrease in the atmospheric CO_2 concentration.

---

[32] 72% of total CO_2 emissions since 1870 have originated from fossil fuels.

[33] According to the globacarbonproject.org, 26% of CO_2 emitted to the atmosphere since 1870 has been absorbed by oceans, 31% has been absorbed by land, and the remaining 44% has accumulated in the atmosphere.

[34] Ignoring extremely long-term geological processes.

[35] Peatlands are an exception, since they act as an almost unlimited C sink (Box 4).

[36] The long-term average C stock at equilibrium in a land use and management system of practices is the average C stock stored in the land across one or several cultural cycles—allowing C pools to achieve their equilibrium status.

The long-term average C stock of a land represents what the atmosphere sees as the land's overall contribution to the atmospheric CO_2 concentration, although annually CO_2 emissions may not be equivalent to CO_2 removals. Consequently, any net change in the long-term average C stocks caused by a change in activities (e.g. a change in land use or management) results in a total permanent net impact[37] on the atmosphere.

The reporting instrument under the Paris Agreement, the NGHGI, is a permanent obligation that requires all countries to submit regular (at least every two years) time series of estimates of annual anthropogenic CO_2 emissions and removals. All annual CO_2 emissions and removals are reported within NGHGIs, and their net impact on the atmosphere should be estimated. Within the cultural cycle (e.g. harvest and regrowth), CO_2 emissions in one year may be offset by CO_2 removals in subsequent years, and vice versa. Consequently, over time, NGHGIs should capture any changes in long-term average C stocks as the net permanent effect of time series of annual emissions and removals. In other words, the sum of annual CO_2 fluxes across the conversion period[38] should reflect the total net change in the long-term average C stock[39] and therefore the net impact on atmospheric CO_2 concentration (see Box 6 on next page).

As noted in Box 4 (page 8), peatlands do not have a long-term average C stock level, since they tend to accumulate carbon indefinitely if the pedoclimatic conditions allow. Human activities, however, may turn the indefinite CO_2 sink into a CO_2 source. These fluxes are permanent, since stored CO_2 is not emitted in absence of a human intervention and no CO_2 is sequestered back into the land unless an additional and opposite human intervention occurs.

Summary: Nature of CO_2 emissions and removals from the land use sector

- CO_2 emissions from fossil fuels are a permanent addition to the atmosphere, although a portion of these emissions is annually removed by the land and ocean.
- CO_2 emissions from land may have a limited resident time in the atmosphere; the long-term average C stock of the land represents the permanent impact of land on atmospheric CO_2 concentration.
- Changes in the long-term average C stock from land use are long-term permanent CO_2 addition to, or subtraction from, the atmosphere and therefore comparable with net changes in CO_2 emissions from fossil fuels.
- Changes in the long-term average C stocks of a land are reported, when they occur, within a NGHGI as annual CO_2 emissions and removals, whose sum across a time series (covering the full conversion period) quantifies the permanent net flux.

[37] The IPCC's basic assumption is that the impact of changes in human activities stands for 20 years (i.e. transition period); after such period a new equilibrium is achieved and the impact of the change may be assumed completely counted.
[38] i.e. the time need to C stocks to move from the long-term equilibrium of the previous use and/or management system to the new one.
[39]Indeed, counting the annual losses and gains of C in a conversion from e.g. a primary forest to a secondary forest would ultimately count for the net difference between the two long-term average C stocks (see Box 5).

Box 6. Impact on atmospheric CO_2 of a forest management change, from clearcut to selective logging

For any year of a time series, the sum of CO_2 emissions and removals may be calculated to reflect the impact on atmosphereic CO_2 concentration *in that year* from a management change. The total net impact of the management change, however, would be the change in the sum of annual fluxes across complete management cycles. In the figure below, for example, it would mean comparing the time series of annual CO_2 emissions and removals during the management cycles of clear-cut harvesting (e.g. time a. to time just before c.) to the annual CO_2 emissions and removals during management cycles of selective logging (from c. to the end of cycle d.). In this case, the comparison of total net CO_2 emission/removal across the management cycles gives the long-term average C stocks increase (as demonstrated in Figure B) caused by the the conversion from clearcut to the selective logging system.

Figure A: Annual C stock changes (CO_2 emissions and removals) reported in the NGHGI

Note: Green bars are negative values representing forest growth (CO_2 removals); red bars represemt forest harvesting (CO_2 emissions)

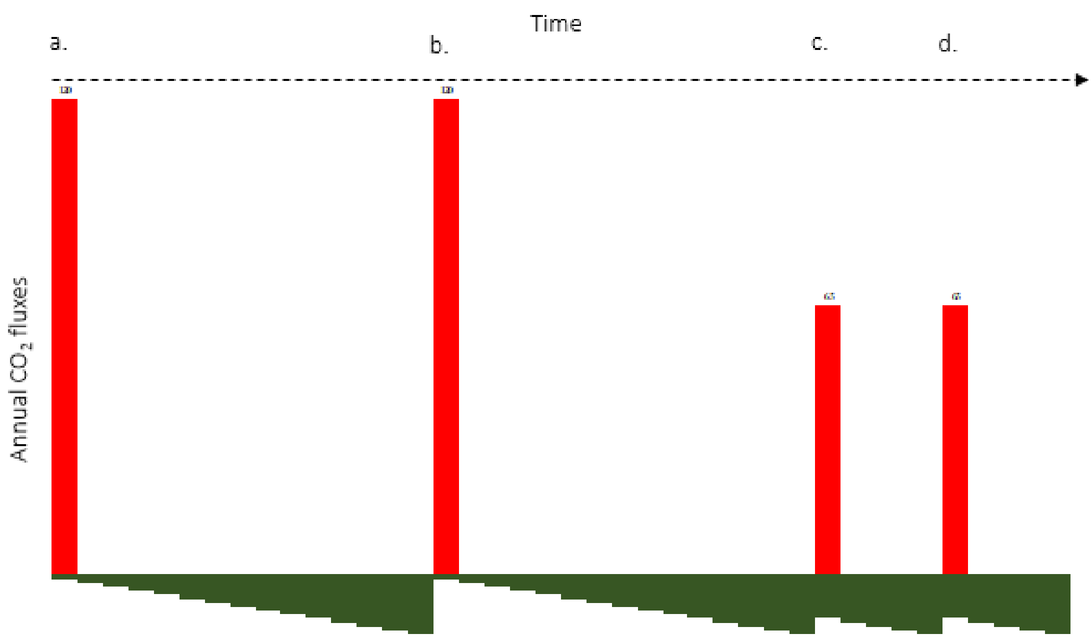
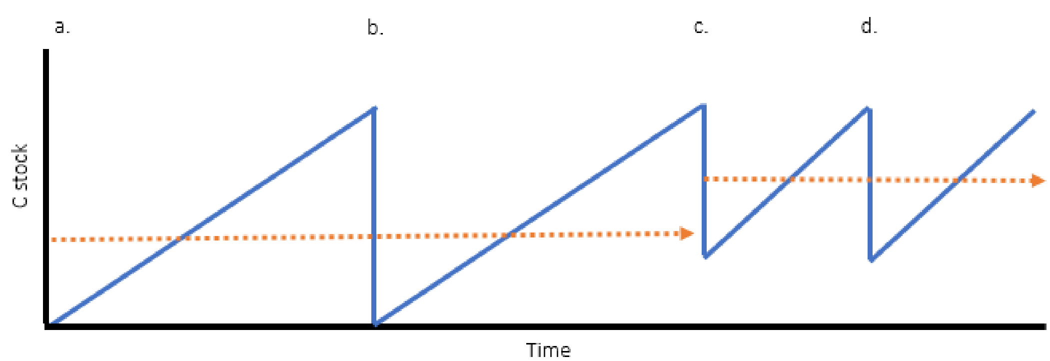


Figure B: C stocks dynamic in forest land

Note: The blue lines represent C stocks and the orange lines represent long-term average C stocks



4. Drivers of CO_2 emissions and removals in the land use sector

As noted in the Preface, under the UNFCCC reporting and accounting framework the term "permanence" refers to two aspects of the results of mitigation actions[40]:

A. Permanence of an emission or removal, i.e. its resident time within the atmosphere;

B. Permanence of the driver causing the emission and/or removal, i.e. the likelihood that, after mitigation results have been accounted for, the driver(s) that was counteracted by the mitigation action will be active again, resulting in the accounted emission reduction or removal to be then emitted.

Regarding A, the previous section of this report concluded that because both CO_2 emissions and removals from terrestrial C pools may be part of a unique activity, e.g. forest harvesting and subsequent forest regrowth, the CO_2 resident time of an emission (into the atmosphere) or a removal (into the C pools) in the land use sector may be shorter than that of an emission from a fossil fuel. But, the long-term average C stock that establishes full comparability among CO_2 fluxes generated by the land use sector and those from other sectors of the NGHGI.

This section focuses on the second aspect of permanence: the drivers of CO_2 emissions and removals. Drivers determine whether an achieved result, i.e. an avoided emission or enhanced removal, may be reversed in the future. In case a mitigation action does not remove the drivers permanently, it may again cause CO_2 emissions after the action ends. For example, a hectare of forest saved this year from conversion because of specific enforcement activities may be converted in a following year if such enforcement is halted; similarly, an amount of fossil fuel not used in a particular year because of an incentive related to public transport may be emitted in a following year if the incentive is not renewed.

Consequently, within a project- or program-based accounting framework, only projects or programs[41] that implement transformational changes may ensure permanence of achieved results, because they remove the driver(s) of emissions such that emissions would not occur after the end of the period of activity. For instance, shifting to a vegetarian diet would permanently reduce one's carbon footprint, or the designation of a forested national park would preserve all achieved C stock gains and would avoid further C stock loss. Similarly, phasing out internal combustion engines and replacing them with electric engines coupled with the use of renewable energy can permanently reduce the carbon footprint of the transportation sector.

On the other hand, within a NGHGI-based accounting framework as the Paris Agreement, no emissions will be unaccounted after the end of the mitigation actions since NDCs and the underlying NGHGI are a permanent obligation of each country. Consequently, the permanence (or non-permanence) of drivers should not impact the accounted quantities over time, since any emission that occurs after the end of the mitigation action should be reported and accounted.

Considering first fossil fuels emissions, the only driver is human activity. Human activities cause fossil fuel redox and associated GHG emissions, such that an increase[42] in activities drive a rise of GHG emissions (although additional emissions may be avoided through energy efficiency and renewable energy). Consequently, any variation in the amount and trend of GHG emissions from fossil fuels occurring in any year across a time series is an indicator of a change, occurring in that year, of the unique driver. While

[40] i.e. reduced emission or enhanced removal
[41] Without distinction among sectors of the NGHGI targeted by the project
[42] Associated with human population growth and with intensification of activities

replacing fossil fuels with renewable power may be considered as transformational change, other instruments used as incentives to reducing using fossil fuels, or fiscal measures to make their use more onerous, may exhaust their impact once they are halted or they may be neutralized by the market, with a consequent reversion to fossil fuel use and associated GHG emissions.

In the land use sector, the annual C stock balance of a managed land is determined by the concurrent impacts of human activities and natural variables[43]. The impact of natural variables may materialize as disturbances[44] that, in extraordinary cases, may be predominant over human activities in determining CO_2 emissions and removals from land. However, while human activities result in a permanent net change in the long-term average C stock of a land, a natural disturbance only causes temporary C stock losses. Indeed, after a disturbance, forest regrowth accumulates C stocks to their pre-disturbance levels (see figure in Section 3 box) particularly in primary forests, where decreases in C stocks are exclusively caused by natural disturbances. Therefore, although natural disturbances may impact the annual CO_2 flux of an area of land, their occurrence does not impact the long-term net flux, since associated emissions and removals balance out across time.

Drivers of CO_2 emissions and removals in the land use sector have another significant characteristic: they impact CO_2 emissions and removals in the year of occurrence but also in subsequent time periods. Indeed, both human activities and disturbances result in processes of C accumulation—e.g. forest regrowth after harvesting or decay— that remain active well beyond the year of occurrence. This characteristic is generally referred to as 'legacy effect'. This means that the positive impact of a mitigation action usually lasts, or sometimes even increases, in years subsequent to implementation of a mitigation action; for example, the revegetation or afforestation of degraded land may continue to accumulate carbon for centuries after the initial establishment.

Transformational changes in the land use sector are usually associated with legislation or policies, e.g. the designation of a national park or changes that clarify land tenure or increase land security for local communities. Other actions may also result in permanent changes to drivers, such as the establishment of rules and guidance for the sustainable management of degraded land.

Summary: Drivers of CO_2 emissions and removals, including in the land use sector

- Without distinction among sectors (applies to both fossil fuels and land use):
  - human activities that drive emissions may return as soon as a mitigation action ends or loses its effectiveness; transformational changes address drivers far beyond the end of the initial mitigation action;
  - any reversal of accounted avoided emissions/enhanced removals should be eventually reported within repeated NGHGIs; due to their long-time horizon, NGHGIs quantify the impact of recurrent drivers that reverse previously accounted quantities.
- In the land use sector:
  - addressing drivers of emissions often also results in additional CO_2 removals; a failure to recognize such CO_2 removals would bias the accounted results.

[43] Most relevant are the temperature and humidity regimes.
[44] E.g. forest fires, which were an important ecological factor also before the appearance of the human beings (natural disturbance). Noting however, that from the appearance of humans, forest fires are also a consequence, direct and indirect, of human activities (anthropogenic disturbance).

5. Nature of results accounted for by mitigation actions in the land use sector

The goal of mitigation actions, for any sector, is to reduce atmospheric concentration of GHG or to avoid further increases. Mitigation results (AQ_{MR}) are therefore accounted as the achieved deviation from the GHG fluxes that would occur in absence of the action i.e. the counterfactual value[45]. Mitigation results (AQ_{MR}) are thus accounted by subtracting expected GHG fluxes ($GHG_{EXPECTED}$) from actual GHG fluxes (GHG_{ACTUAL}): $AQ_{MR} = GHG_{ACTUAL} - GHG_{EXPECTED}$.

As discussed in the previous section, when accounting for mitigation results in the land use sector, legacy effects of activities and disturbances that occurred before the onset of the mitigation action, as well as the impact of ongoing natural disturbances, may impact annual GHG fluxes—i.e. annual GHG fluxes may include emissions or removals not associated with the specific mitigation actions taken within the reporting year. Because fluxes average out across long time periods (e.g. the time needed to forest biomass to regrow after a disturbance, or the time period for dead organic matter originating from a disturbance to oxidize), the results accounted across a limited time period may not reflect what is actually seen by the atmosphere as a consequence of the mitigation action. For such reason, when accounting for results of mitigation actions in the land use sector, emissions and removals due to the legacy of previous human activities, as well as those associated with natural disturbances, should be separated out from the GHG balance of each land area. In practice, what is needed is to identify and measure the signal (the mitigation results from actions taken) separate from the noise (the legacy effects and natural disturbances).

To manage legacy effects, two conditions should be satisfied in the accounting:

A. legacy emissions/removals from activities and disturbances that occurred before the onset of the mitigation action should be accounted as zero (while no anthropogenic flux should be excluded);

B. mitigation results are accounted across a time period equal to the period needed to exhaust the legacy effect caused by the mitigation action.

Such conditions may be satisfied by the following two approaches that may be implemented to deal with the legacy effect on accounting for mitigation results:

Approach I reflects what is currently done under the Kyoto Protocol accounting, where:

- *to comply with A*: the legacy emissions and removals associated with activities and disturbances that occurred before the onset of the mitigation action are projected, quantified, and included within the counterfactual (baseline) value, and
- *to comply with B*: an indefinite time series of annual GHG inventories is accounted for.

Approach II reflects what is currently implemented under REDD-*plus* accounting[46][47], where:

- *to comply with A*: it is implicitly assumed that C stocks on the land are at their long-term average C stock, and

[45]This is usually referred as base year, reference level, or baseline.

[46]This is the approach applied in the Method & Guidance Documentation of the Global Forest Observation Initiative (MDG-GFOI at http://www.gfoi.org/methods-guidance/) for REDD-plus activities

[47]This approach also corresponds to the IPCC default Tier 1 methodological approach to estimate net C stock changes in the soil organic matter of mineral soils as consequence of changes in the land use and/or in the land management system of practices. This methodological approach uses the two values of long term average SOC at equilibrium associated with use and management of the land before and after the change to estimate the net C stock change across a transition period.

- *to comply with B*: the overall impact of the mitigation action on the so-called long-term average C stock of the land is reflected by the quantified changes during the monitoring period.

To deal with natural disturbances, the condition to be satisfied to ensure that non-anthropogenic emissions and removals are accounted for as zero, and that no anthropogenic emissions and removals are excluded from accounting:

- the amount of CO_2 emissions[48] (CO_2E_{ND}) and CO_2 removals (CO_2R_{ND}) reported as associated with natural disturbances must average out[49] across time ($CO_2E_{ND} = CO_2R_{ND}$).

Within an accounting framework like the Kyoto Protocol, such condition is satisfied through accounting as zero the GHG emissions associated with a natural disturbance, but also counting as zero all subsequent CO_2 removals until the C stocks on the same land achieve pre-disturbance levels. Although the lag in the residence time of C stocks has a temporary[50] impact on atmospheric CO_2 concentration, the approach excludes from accounting such temporary impact, since it is neither caused nor materially influenced from the mitigation action to be accounted for (see also Box 1, page 7).

Summary: Nature of results accounted for by mitigation actions in the land use sector

- Mitigation results (AQ_{MR}) are deviations associated with actions aimed at reducing the atmospheric concentration of GHG or avoiding further increases. Thus, they are accounted by subtracting the expected GHG fluxes ($GHG_{EXPECTED}$), i.e. the counterfactual (baseline) value, from actual GHG fluxes (GHG_{ACTUAL}), i.e. what the atmosphere has seen, $AQ_{MR} = GHG_{ACTUAL} – GHG_{EXPECTED}$.
- In the land use sector, the contribution of legacy emissions and removals, as well as emissions and removals from natural disturbances, should be accounted as zero, since they are not associated with the implemented mitigation actions.
- To zero the contribution of legacy emissions and removals associated with activities and disturbances that occurred before implementation of the mitigation actions and to count all legacy effects of the implemented mitigation actions:
  - either legacy emissions/removals are included in the counterfactual (baseline) value and mitigation results are accounted through an indefinite time series of GHG inventories, or
  - C stocks are assumed to be at their long-term equilibrium and the entire difference in long-term C stocks caused by mitigation actions is accounted for.
- To zero the contribution of natural disturbances, the amounts of CO_2 emissions and removals associated with natural disturbances and accounted for should balance out.

[48] The other 2 GHG, CH_4 and N_2O, decay in the atmosphere to other compounds so that their emissions balance always to zeros across the 100-year time frame of GWP's.
[49] This is the approach implemented in the 2013 IPCC KP Supplement (http://www.ipcc-nggip.iges.or.jp/public/kpsg/index.html)
[50] This means that the C stocks of the land remain within the long-term average C stock at equilibrium.

Summary of Sections 1 to 5

In the previous sections, the nature of CO_2 emissions and of removals, as well as the drivers of such emissions and removals have been discussed, with the following conclusions:

- Any CO_2 emission from fossil fuels, including peat[51], is a net addition to the atmosphere-land-ocean (biosphere) system and results in a proportional[52] increase of atmospheric CO_2 concentration;
- CO_2 emissions from terrestrial C pools (i.e. land use sector) may be either:
  - A *temporary* increase in atmospheric CO_2 concentration if the long-term average C stock of the land of origin does not change. This is the case if the emission is a consequence of a natural disturbance (e.g. wildfire) or a management practices where the CO_2 emitted will be balanced out across time by subsequent CO_2 removals from the land; or
  - A *permanent* increase in the atmospheric CO_2 concentration. This is the case if the emission is consequence of a change in the land use and/or management system that determines a decrease of the long-term average C stock, since the CO_2 emitted is not expected to be balanced out by subsequent CO_2 removals from the land.
- Similarly, CO_2 removals from terrestrial C pools may cause either a permanent or a temporary decrease of the atmospheric CO_2 concentration, depending on whether they are associated with an increase of the long-term average C stock or not.
- Whether from fossil fuels or terrestrial C pools, any emission avoided within a time frame can subsequently occur—resulting in a reversal—if its drivers have not been permanently addressed.
- Similarly, any CO_2 removal associated with an increase of the long-term average C stock may be subsequently reversed if the drivers that previously impeded such increase have not been addressed permanently.
- NGHGIs include a time series of all national GHG emissions and removals. They aim to include only those caused by the national socio-economic system (i.e. anthropogenic fluxes) and reflect the impact of such systems on the atmospheric GHG concentration. Within the time series the temporality/permanency of GHG fluxes is properly reflected such that the sum of the time series corresponds to the actual net impact in the atmospheric GHG concentration caused by the country, from the first year till the last year of the time series.
- Changes in the NGHGI trend provide information on achieved reduction of emissions and/or enhancement of removals.

[51] See Box 4, page 8 for details on peat as a fossil C stock
[52] According to Le Quéré, C. et al (2016). Global Carbon Budget. *Earth Systems Science Data 8*, 605-649 - http://www.globalcarbonproject.org/, 44% of the annual CO_2 emissions accumulate into the atmosphere, 31% are sequestered by terrestrial C pools (mainly forests) and 25% by oceans.

6. Permanence of accounted quantities

In this section the permanence of accounted quantities is analyzed. Accounted quantities are the reduced emissions, or the enhanced removals, achieved and measured during an accounting period against a counterfactual[53] baseline level.

There is no official definition of permanence under the UNFCCC. However, within the UNFCCC, permanence was first discussed within the CDM, in relation to net C stock accumulation accounted in project activities related to afforestation and reforestation (AR-CDM). Because project activities have a limited timeline, there is no certainty that achieved results will persist after the end of the project activity. Such uncertainty stems from the lack of knowledge about the future use of the land, i.e. whether the drivers (e.g. alternative use of forest land) have been addressed by the project activity temporarily or permanently. For such reason accounted units expire at the end of the monitoring period[54].

Subsequently, permanence was discussed again under the CDM in relation to avoided emissions from Carbon Capture and Storage (CCS) project activities. Avoided emissions by CCS are considered to have been permanently achieved 20 years[55] after the end of the crediting period (i.e. from 20 to 41 years after the emissions has been avoided). This means that it is assumed, after 20 years, that the likelihood of a reversal of results (e.g. emissions' leakage from geological deposits) is zero—i.e. all the CO_2 is assumed to have moved from the system atmosphere-land-ocean to the geological deposit. Thus, because the CO_2 is no longer considered part of the atmosphere-land-ocean system, the accounted units do not expire and are considered permanent.

Permanence of mitigation results is therefore an issue that stems from the limited time scale of mitigation activities compared with the time frame of the UNFCCC's objective to stabilize atmospheric GHG concentration at a level that does not seriously harm human socio-economic systems as well as natural ecosystems. It is an issue relevant for any accounting system, in particular when project or program proponents that generate emission reductions are not liable for reversals of accounted results that occur beyond the monitoring period. In other words, when a non-permanent unit is accounted, it does not correspond to actual mitigation, and consequently undermines the integrity of the accounting framework.

Thus, when discussing permanence of mitigation results, the time frame of the accounting mechanism determines whether there is a gap in the liability for any subsequent reversal of accounted results. The UNFCCC[56] and its associated Kyoto Protocol[57] and Paris agreement[58] all reference long-term achievement of results. The IPCC, in its AR5[59] and in the special report on CCS[60], uses the word "long-term"[61] to indicate the time period needed to achieve stabilization of atmospheric CO_2 concentration at a safe level[62], and establishes that a long-term result is one achieved up to the end of this century.

---

[53] The GHG emissions and removals that would occur in absence of mitigation.
[54] See section F. for a description of the provisions implemented under AR-CMD to address non-permanence of accounted units
[55] See UNFCCC decision 10/CMP.7
[56] "...modifying long term trends in anthropogenic GHG [net] emission…"
[57] "...long term benefits related to mitigation…"
[58] "…long term temperature goal…" and "…long term low GHG [net] emission development strategies…"
[59] 2013, IPCC 5th Assessment report. Working Group 1: The physical Science Basis (http://www.ipcc.ch/report/ar5/wg1/)
[60] 2005 IPCC Special Report on Carbon Dioxide Capture and Storage (http://www.ipcc.ch/report/srccs/)
[61] The very long-term objective is to further reduce it towards pre-industrial levels.
[62]This level is currently established around 450 ppm of CO_2 atmospheric concentration (IPCC AR5, 2014 - https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf)

For NGHGIs, the IPCC has implicitly established a 100-year time frame by calculating the global warming potential (GWP) of each GHG as the average[63] warming effect caused across a century. So, consistent with the UNFCCC's objective, NGHGIs report levels and trends of anthropogenic GHG emissions and removals, with the aim to assess:

- the contribution of human activities to the (increasing) concentration of GHG into the atmosphere, and
- the results of implemented mitigation policies and measures.

Further, in its special report[64] on Land Use, Land-Use Change, and Forestry, the IPCC defines Permanence as: "The longevity of a carbon pool and the stability of its stocks, given the management and disturbance environment in which it occurs"[65]. The "long-term average C stock at equilibrium," as defined in the previous section of this report, fully corresponds to such description. The long-term average C stock measures the "permanent" negative[66] (or positive) contribution of the land to the atmospheric CO_2 concentration, taking into consideration the impact of the management system of practices and of the natural disturbances regime.

Thus, consistent with the IPCC and UNFCCC reporting framework, those results that stand for a century are permanent. This means that:

- the avoidance of GHG emissions from fossil fuels, including peat, is permanent if the driver of such emissions is permanently addressed by the project (i.e. transformational changes);
- the avoidance of CO_2 emissions from fossil fuel combustion through CCS is considered permanent after 20 years have passed, i.e. the C is considered to be permanently injected in the geological deposit;
- the avoidance of CO_2, and non-CO_2, emissions from land is permanent so far as the long-term average C stock of the land does not change, i.e. if the use and/or management system of practices of the land does not change;
- the sequestration of CO_2 removals is permanent so far as it is associated with an increase of the long-term average C stock; considering that per IPCC default assumption such change occurs within a 20-year period, after a 20-year period the CO_2 removals can be considered permanent.

When accounting for mitigation results, the length of the monitoring period therefore determines whether achieved results are permanent, i.e. whether they stand for a century, or not.

Since project activities are always implemented for a shorter time period than a century, their mitigation results may not be considered permanent, with the exception of CCS whose CO_2 has been sequestered apart from the atmosphere-land-ocean system, unless the liability for potential reversal beyond the end of the monitoring period of the project activity is addressed.

---

[63] GWPs are calculated in function of the GHG's resident time in the atmosphere

[64] 2000 IPCC Special Report on Land Use, Land-Use Change, and Forestry (available at www.ipcc.ch/ipccreports/sres/land_use/index.php?idp=0)

[65]It further discusses: "Enhancement of C stocks resulting from land use, land-use change, and forestry activities is potentially reversible through human activities, disturbances, or environmental change, including climate change. This potential reversibility is a characteristic feature of LULUCF activities in contrast to activities in other sectors. This potential reversibility and non-permanence of C stocks may require attention with respect to accounting, for example, by ensuring that any credit for enhanced C stocks is balanced by accounting for any subsequent reductions in those C stocks, regardless of the cause"

[66] i.e. the amount of CO_2 subtracted permanently from the atmosphere,

On the other hand, if project activities occur within the scope of coverage of a long-term national commitment, e.g. as strata/subdivisions of the NGHGI's categories, permanence may be considered addressed—i.e. since liability would reside with the project implementers until the end of the monitoring period, and then transfer to the country thereafter.

Summary: Permanence of accounted quantities

• There is no official definition of Permanence under the UNFCCC, although it has been discussed in relation to liability for reversal of accounted mitigation results (e.g. within the CDM, for Afforestation/Reforestation and Carbon Capture and Storage project activities).
• With the exception of net emission reductions achieved through CCS, any mitigation result may be reverted if the drivers of emissions are not permanently addressed by the mitigation action.
• Under the UNFCCC and IPCC reporting framework the timeline for long-term (permanent) results is the century. Accordingly:
  o Project activities may not account for permanent results, unless liability of potential reversal beyond the monitoring period is addressed (CCS is an exception);
  o Results accounted through NGHGIs are always permanent, since the time frame of NGHGIs ensures that any reversal that occurred within the century would be accounted.
• If the scope of project activities falls within national accounting for an NDC (e.g. a forest carbon project occurs on land within a country that accounts in its NDC for the same forest land), permanence is addressed by shifting liability from the short-term project to the long-term national commitments of the country in which the project resides.

7. Addressing the risk of non-permanence under the UNFCCC

Under the UNFCCC the risk of non-permanence of accounted results has been so far recognized for Kyoto Protocol-LULUCF activities and for AR and CCS project activities under the CDM. For other CDM activities, non-permanence has not been considered an issue. This is because either the project activity is assumed to permanently addresses the drivers of emissions, e.g. when a renewable energy power plant is built, or because it has been implicitly assumed that emissions occurring after the end of the project implementation are not associated with the project itself, e.g. when a bioenergy power plant drives in a region the overexploitation of biomass stocks.

UNFCCC provisions are aimed at addressing the risk of non-permanence, instead of just minimizing, its impact on accounting. Thus, for Kyoto Protocol accounting, the risk of non-permanence has been fully addressed by:

- ensuring that once a land is accounted for it must stay within the accounting forever[67], and reported within the NGHGI. This means that any reversal is reported in the NGHGI and accounted for in the year(s) in which it occurs;

[67] This ensures that any reversal is timely reported and accounted for.

- requiring countries that experience natural disturbances in a given year—and that take out of the accounting emissions from such a disturbance event—to also take out of the accounting in subsequent years the regrowth that occurs up to the same amount;
- issuing temporary credits for AR-CDM project activities that expire at the end of the monitoring period (although they can be renewed for subsequent crediting periods[68]). This means that any future reversal is pre-emptively accounted for at the end of the monitoring period. It is worth noting that: (a) such a solution likely leaves a portion of mitigation results unaccounted for, since C stocks may need a period longer than the established monitoring period to fully account for the increase in the long-term average C stock and (b) although based on the net increases of long-term average C stocks, mitigation results are accounted for as temporary because of the precautionary principle;
- ensuring the monitoring of CCS-CDM project sites for the 20-year period subsequent to the end of the crediting period (after which the risk of reversal is assumed to be zero)[69]. CCS-CDM project activities also minimize the risk of non-permanence between the end of the project accounting period and the end of the monitoring period through reserving 5% of accounted quantities to offset any leaked emission. This, however, leaves unaddressed the risk of non-permanence of leaked emissions beyond the 5% threshold.

Within the Paris Agreement, non-permanence has been fully addressed by requiring that "Parties strive to include all categories of anthropogenic emissions or removals in their nationally determined contributions and, once a source, sink or activity is included, continue to include it"[70]. In other words, any subsequent reversal of results should be reported and accounted for (in the year in which it occurs).

Summary: Addressing the risk of non-permanence under the UNFCCC

- Under the UNFCCC, the risk of non-permanence is fully addressed in accounting frameworks through an assumption that reporting (through the NGHGI) and accounting (e.g. through the Paris Agreement) will occur indefinitely;
- For the land use sector, such a risk is further addressed by:
    - ensuring that once a land/pools/activity is accounted, it must remain within the accounting in perpetuity; and
    - issuing temporary mitigation units that may be renewed so far as GHG emissions and removals from accounted land/pools are monitored.
- Under the Paris Agreement, permanence is addressed so long as land/pools/activities accounted for in any NDC are accounted for in all subsequent NDCs.

[68] The crediting period is the period during which achieved mitigation results are accounted and, if verified emission reductions have occurred, mitigation units are issued.

[69] However, it is recognized that, in the very long term, CO_2 stored in deposits under oceans may have an impact on atmospheric CO_2 by first saturating sea water.

[70] Decision 1/CP.21, para 31c. Considering that both land and C pools may be either a source or a sink, it may be implied that once a land or a C pool is included in the NDC accounting it must be accounted forever.

8. Addressing the risk of non-permanence under other accounting frameworks

There are a number of other accounting frameworks, outside the UNFCCC, that have adopted approaches to deal with the risk of non-permanence. The development of such approaches is necessary because of the mismatch between the (short) timeframe of projects or programs seeking crediting and the (longer) time horizon across which permanence of accounted results need to be ensured. Such approaches vary, but are usually a combination of measures that:

- Aim to reduce the *risks* of non-permanence when accounting over shorter time-frames:
  - Program design requirements (e.g. to demonstrate transformational change)
  - Insurance mechanisms (e.g. buffer accounts or pooled reserve)
- Address non-permanence, such as:
  - Requirements for monitoring for long periods
  - Liability for reversal

Many programs include requirements related to program design, i.e. demonstration that the underlying project or program that is generating emission reductions or removals has been designed to ensure long term storage of C stocks. For example, the Forest Carbon Partnership Facility's Carbon Fund requires countries to demonstrate "how effective Emission Reduction Program design and implementation will mitigate significant risks of reversals … and will address the sustainability of Emission Reductions." The Verified Carbon Standard also requires such 'sustainable' program design through the required application of a "non-permanence risk tool" which scores a program based on a range of risk types and does not allow high risk projects to proceed. In addition, the ratio of units required to be placed in the buffer pool (see paragraph below) is determined by the project's scoring on permanence risk, which incentivizes the mitigation of reversal risks through good project design.

Most crediting or payment mechanisms (e.g. the Verified Carbon Standard, Forest Carbon Partnership Facility's Carbon Fund, California's cap-and-trade system) require projects or programs seeking to issue emission reductions (or credits) to establish a reserve of accounted units to be used to offset any reversal. These are often pooled into a 'buffer' reserve or account which may then be used in the instance of a reversal. Some accounting frameworks only allow the buffer to be used in the case of a natural disturbance, or force majeure, event (while placing liability for 'intentional' reversals on the project proponent or land owner). The number of units required to be placed in the reserve is estimated based on an analysis of the likelihood of a reversal. For example, a risk analysis may be based on: lack of broad and sustained stakeholder support, lack of institutional capacities and/or ineffective vertical/cross sectorial coordination, lack of long-term effectiveness in addressing underlying drivers, the lack of unambiguous assignment of carbon rights, the exposure and vulnerability to natural disturbances (although the latter is not a cause of non-permanence so far as the disturbed forest is allowed to grow again till its pre-disturbance status). Finally, a reserve account reduces the risk of reversals, but only ensures permanence of units equivalent to the quantity of reserved units it contains since all reversals exceeding such amount would not be offset—although such risks can be mitigated through a pool of credits drawn from a diversified set of projects.

A few systems have more stringent rules to address permanence, through legal liabilities placed on project proponents and/or land owners. California's cap-and-trade system defines permanence as lasting for 100 years. A forest carbon project must monitor, verify, and report offset project data for 100 years following any year a credit is generated and issued. For example, if a credit is issued in year 25 of a project, monitoring and verification would have to last for a total of at least 125 years. Furthermore, there is a regulatory obligation[71] for *all* intentional reversals (e.g. from land conversion, over-harvesting or other negligence) to be compensated through retirement of other compliance instruments[72]. Similarly, the Australian Emissions Reduction Fund requires any carbon uptake underlying issued credits to be stored for at least 100 years—or 25 years with a 20% discount on credits. A land owner may choose to cancel a project at any time but, in doing so, is required to relinquish all credits as well as use credits from another project or purchase an equivalent amount at market price, to replace any credits already sold. In both instances (California and Australia), these provisions are in addition to participating in a buffer pool, i.e. projects are also required to place a percentage of emission reductions achieved into a reserve, which is used only for 'unintentional reversals', primarily natural disturbances, while the project proponent or land owner is fully liable for any intentional reversal.

Summary: Addressing the risk of non-permanence under other accounting frameworks

Other accounting frameworks have developed systems and tools to manage the risk of reversals:

- Requiring projects or program to contribute to a buffer reserve account (a kind of pooled insurance mechanism), particularly for use in 'unintended reversals' (force majeure events, e.g. natural disturbances); such a mechanism only ensures permanence up to the number of units in the reserve;
- Requiring specific elements to be included in the project/program activity and/or design that minimize the risk for reversals;

Or to address non-permanence:

- Monitoring and verification for a long-term period considered to ensure permanence, e.g. up to 100 years;
- Providing clear liability for 'replacement' of accounted units for any instance in which a reversal occurs.

[71] Regulation for the California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms https://www.arb.ca.gov/cc/capandtrade/capandtrade/unofficial_ct_100217.pdf

[72] If the forest owner does not provide offset credits for retirement equal to the reversal amount, then California's Air Resources Board retires the difference and the forest owner is considered in Violation of the regulation and subject to enforcement action.