Cover sheet

Deforestation – a call for consistent carbon accounting

Gerard Wedderburn-Bisshop[1]

[1] World Preservation Foundation; Unit 43 Newhaven Enterprise Centre, Denton Island, Newhaven BN9 9BA, United Kingdom

E-mail: gerard.bisshop@worldpreservationfoundation.org

This is a non-peer reviewed preprint of a Perspective submitted to *Environmental Research Letters.*

Deforestation – a call for consistent carbon accounting

Gerard Wedderburn-Bisshop[1]

[1] World Preservation Foundation; Unit 43 Newhaven Enterprise Centre, Denton Island, Newhaven BN9 9BA, United Kingdom

E-mail: gerard.bisshop@worldpreservationfoundation.org

Keywords: carbon accounting; LULUCF; FOLU; deforestation emissions; avoided deforestation; emission sectors.

Carbon accounting conventions treat emissions differently depending on their source. Fossil fuel carbon emissions are assessed as gross, whereas anthropogenic land carbon emissions are assessed as net. Despite calls for consistent gross accounting, accounting guidelines remain unchanged. Here we consolidate arguments for consistent accounting and explore implications for national inventories, sector contributions, carbon markets and programs aimed at reducing deforestation and supporting forest protection.

There is growing support for consistent gross accounting of carbon emissions and sinks (1–3). These authors argue that net accounting distorts mitigation strategies; that gross accounting is needed to fully describe carbon stocks and flows, which they see as critical to meeting Paris Agreement temperature goals; and that IPCC integrated assessment models of future warming suffer a fundamental data and knowledge gap because they do not use gross emissions and removals. They find that gross accounting more accurately represents the effect of reduced deforestation because models using net accounting undervalue vegetation carbon removal, and net reporting makes the task of identifying sectors responsible for deforestation difficult, if not impossible. FAO now use gross agrifood systems land use emissions targets for their global roadmap mitigation plans and the 2023 EU regulation on deforestation-free products requires gross accounting of deforestation emissions. Carbon drawdown and carbon markets also require gross accounting. Net accounting is believed to understate LULUCF emissions by a factor of three or four and to conceal the enormity of biosphere sinks (4).

Recently the value of forest carbon offsets has been questioned (5) and studies have shown regional forest sinks to be faltering or even becoming sources (6), leading to a loss of confidence in forest carbon drawdown. Although half the trees on Earth have been lost to deforestation (7), forests still hold 90% of the world's standing plant biomass carbon (8), and are a large and increasing carbon sink (9).

Arguments supporting consistent accounting

The inventory category Land Use/Land Use Change and Forestry (LULUCF) reports net emissions and sinks on 'managed' land (10). LULUCF CO_2 emissions come from deforestation (77%), degradation, including timber harvest and wood fuel (10%) and anthropogenic fire (13%) (11). LULUCF CO_2 reporting is the only net assessment of any greenhouse emission, CO_2 or otherwise, an apparent inconsistency. This was first noticed by the author when examining Australia's national greenhouse accounts (12). Australia has high rates of deforestation, but sectors driving deforestation enjoy carbon credits from vegetation regrowth sinks on other land, in accordance with IPCC convention. In contrast, fossil fuels are not gifted any credits, even though fossil CO_2 is absorbed by growing vegetation in precisely the same manner as deforestation carbon.

The reasoning for applying net accounting to LULUCF CO_2 was that emissions and drawdown on managed land were seen as part of a closed system (the biosphere carbon pool), and flux between the land surface and the atmosphere was viewed as a change in C stocks within this pool, so that only the net amount remaining in the atmosphere affected climate (13). Although arguable, this is inconsistent with gross accounting of fossil fuel CO_2, where all emissions are fully counted, even though CO_2 emissions from all sources are sequestered equally by growing vegetation. Accounting for 100% of fossil fuel CO_2 (gross) emissions and a third of LULUCF CO_2 emissions (net) implies that when emitted, different proportions of each remain in the atmosphere, which is untrue.

Despite criticism, conventional net accounting has consensus support, with researchers reasoning that fossil fuel carbon is 'truly new carbon', additional to the biosphere carbon cycle (14). In response, we see the three trillion trees removed through deforestation (15) to be no different to 'truly new' fossil carbon, and that all carbon, once emitted, becomes part of biosphere and ocean stocks. Further, all atmospheric CO_2 is rapidly mixed, cycling through vegetation every 1.5 years (16). Vegetation growth therefore sequesters a mix of original biosphere carbon and fossil carbon. Isotope studies find that the present-day atmosphere contains about 70% fossil CO_2 (17), which is consistent with CO_2 emission proportions over the decade 2012-2021 corrected for gross LULUCF. Therefore, clearing of recent regrowth is re-emitting mostly fossil carbon. Biosphere carbon storage has almost doubled due to CO_2 fertilisation (18), hence the two stocks have intermingled to create a new, growing, 'stock' where sources cannot be separated.

Additionally, we argue that drawdown by growing vegetation is a distinctly separate natural process that cannot be claimed as human caused (other than plantings). Deforestation is certainly anthropogenic, but regrowth occurs *despite* human intervention; it takes place on other land; and it would continue if deforestation were to cease. Also, knowledge of carbon flows supporting gross accounting is rapidly improving (9). We believe that no arguments offer strong reason to deny consistent full CO_2 accounting, and that emissions and drawdown are more completely and transparently described with gross accounting.

Applying consistent accounting

We compare conventional carbon accounting timeseries data from the Global Carbon Project (19) with the addition of net LULUCF data from Houghton and Castanho 2023 (Fig 1), with Fig 2 showing the same data except with gross data from Houghton and Castanho (1). Gross LULUCF values are believed to be conservative due to the use of net FAO deforestation data, and forest loss from finer-grained studies indicating higher emissions (20). Note that these data include carbon flows on both managed and intact land, as per the Global Carbon Budget.

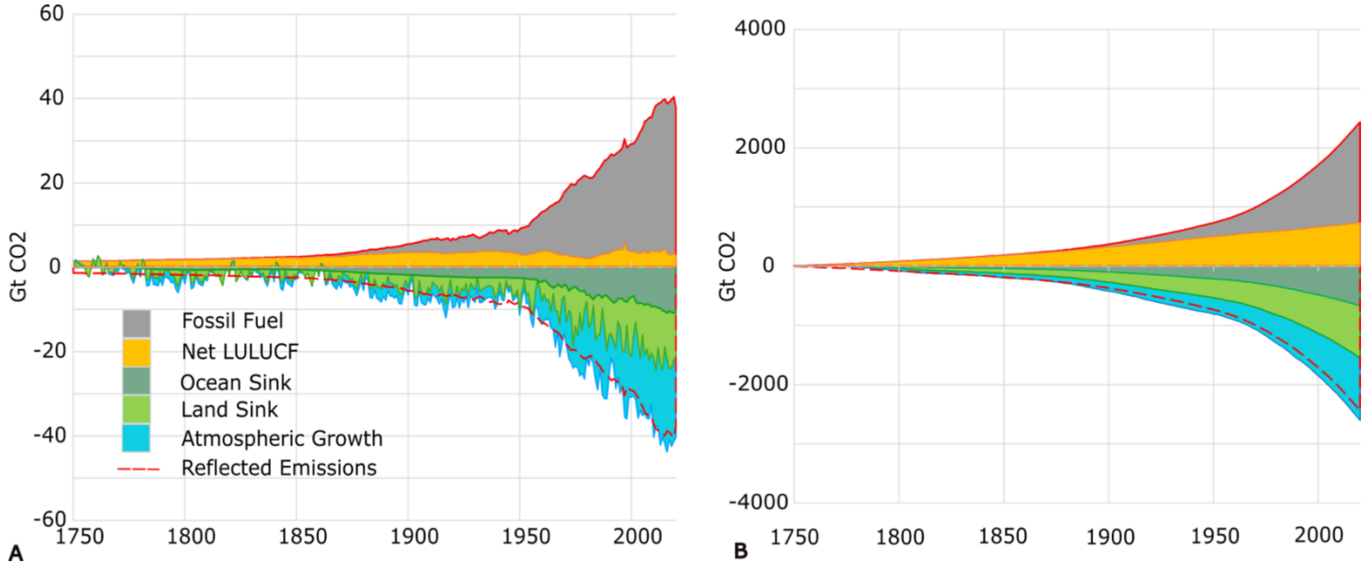

Fig 1: (A) Conventional but inconsistent fossil fuel (gross accounting) and LULUCF (net accounting) of CO_2 emissions and sinks of yearly and (B) cumulative, from 1750-2020. Data from (1,19)

Gross accounting in Fig 2 shows how growth in atmospheric CO_2 coincided with the rapid rise of fossil fuel emissions, but in reality was driven by a combination of growing LULUCF and steeply growing fossil fuel emissions, with LULUCF responsible for 56% of cumulative CO_2 emissions 1750-2020. Yearly fossil fuel CO_2 overtook LULUCF in the mid 1960's, but by 2020 cumulative LULUCF CO_2 emissions were still 20% greater than cumulative fossil fuel carbon. Net accounting understates cumulative LULUCF carbon by a factor of 2.8.

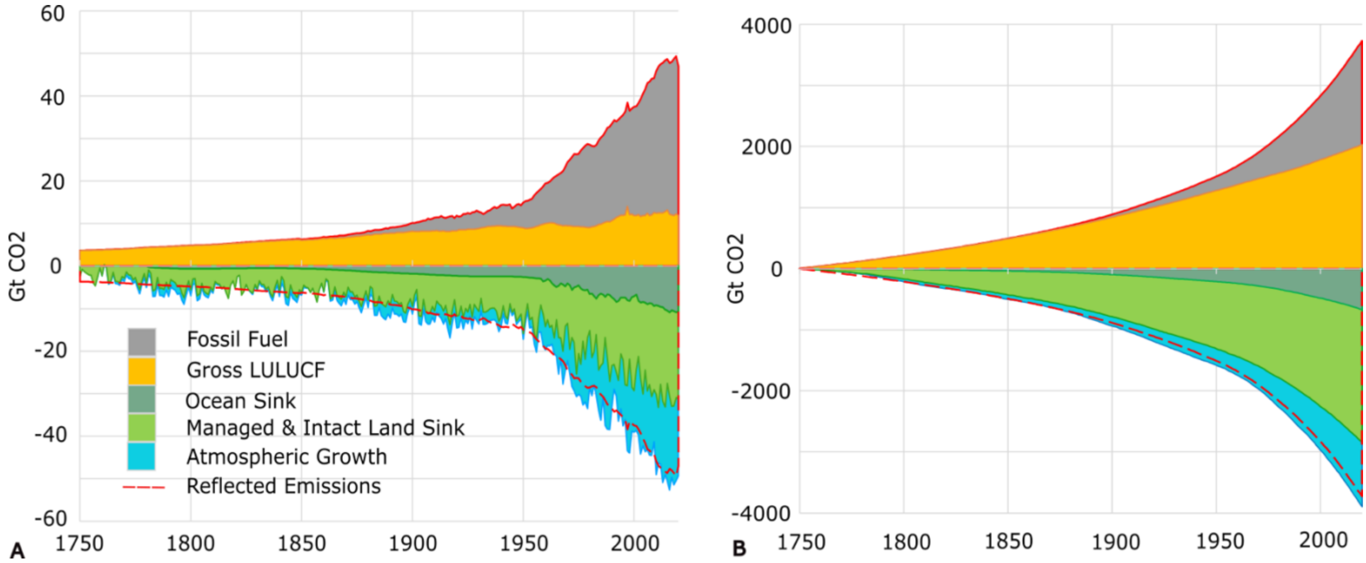

Fig 2: (A) Consistent gross accounting of fossil fuel and LULUCF yearly CO_2 emissions and sinks and (B) cumulative gross CO_2 emissions and sinks, from 1750-2020. Data from (1,19)

Fig 2 also highlights the unexpectedly large scale of biosphere drawdown. From 1750 to 2020 the biosphere and oceans have drawn down 2,842Gt CO_2, 83% greater than the drawdown of intact land only, absorbing 76% of total carbon emissions from all sources. Biosphere vegetation drawdown contributed most of this (2,170Gt CO_2), with cumulative vegetation drawdown doubling from 1880 to 1950, then doubling again from 1950 to 2020, due to CO_2 fertilisation. Over the decade to 2020, total ocean and biosphere drawdown has been 31Gt CO_2/year, or 65% of carbon emissions from all sources.

Discussion and policy implications

Consistent carbon accounting identifies LULUCF (yellow in Fig 2) as the main source of CO_2 emissions, and green segments show biosphere drawdown as the greatest sink, therefore the biosphere (forests in particular) plays a defining role in both disturbing and moderating Earth's climate. Nature has been balancing atmospheric carbon for 10,000 years, re-absorbing all emissions until just 270 years ago. Forests are therefore our formidable ally in this climate fight, also because the biosphere sink is growing, and likely to continue growing (21). Protecting and reclaiming forests could be seen as equally important as quitting fossil fuels, particularly since LULUCF emissions of recent vegetation growth is re-emitting mostly fossil carbon. Destroying forests of any age can therefore be seen in the same way as burning coal, and former forest land that is now bare could be viewed with the same distaste as coal mines.

Normalising and adopting gross emissions accounting may usefully support policies aimed at reducing deforestation and preserving forests. Gross accounting impacts carbon markets, revaluing avoided deforestation and LULUCF emissions by a factor of 2.8, strengthening support for programs such as REDD+. Sectors that have contributed to LULUCF emissions, particularly deforestation, will be seen as more important mitigation targets. We believe that gross accounting renews trust in our formidable ally, vegetation drawdown, in the face of recent doubts. Forest restoration, the most effective, lowest cost natural mitigation option, may also benefit from policies informed by a new value on historic deforestation. Carbon markets and offset programs will also benefit from consistent accounting. We believe that consistent emissions accounting will usefully lead to better informed mitigation actions and assist our transition to the age of drawdown.

Acknowledgements

Author Contributions: Conceptualization, methodology, analysis, writing—original draft preparation, and editing, G.W.-B.; internal review. ORCID ID https://orcid.org/0009-0009-6848-4156.

Funding: This research received no external funding. Early concepts were developed when co-authoring the Beyond Zero Emissions (Australia) Land Use Discussion Paper, funded by Beyond Zero Emissions.

Conflicts of Interest: The author is biased against industrial scale deforestation, having witnessed first-hand the destruction of 11 square km of forest and woodland each day while monitoring deforestation for the Queensland government. This did influence the study topic, however every effort was made to make sure my personal judgement was unbiased.

References

1. Houghton RA, Castanho A. Annual emissions of carbon from land use, land-use change, and forestry from 1850 to 2020. Earth System Science Data. 2023 May 23;15(5):2025–54.

2. Keith H, Vardon M, Obst C, Young V, Houghton R, Mackey B. Evaluating nature-based solutions for climate mitigation and conservation requires comprehensive carbon accounting. Science of The Total Environment. 2021 Jan 20;769:144341.

3. Mackey B, Moomaw W, Lindenmayer D, Keith H. Net carbon accounting and reporting are a barrier to understanding the mitigation value of forest protection in developed countries. Environ Res Lett. 2022 Apr;17(5):054028.

4. Arneth A, Sitch S, Pongratz J, Stocker BD, Ciais P, Poulter B, et al. Historical carbon dioxide emissions caused by land-use changes are possibly larger than assumed. Nature Geosci. 2017 Feb;10(2):79–84.

5. West TAP, Börner J, Sills EO, Kontoleon A. Overstated carbon emission reductions from voluntary REDD+ projects in the Brazilian Amazon. Proceedings of the National Academy of Sciences. 2020 Sep 29;117(39):24188–94.

6. Flores BM, Montoya E, Sakschewski B, Nascimento N, Staal A, Betts RA, et al. Critical transitions in the Amazon forest system. Nature. 2024 Feb;626(7999):555–64.

7. Crowther TW, Glick H, Maynard D, Ashley-Cantello W, Evans T, Routh D. Predicting Global Forest Reforestation Potential. bioRxiv. 2017 Nov 7;210062.

8. Smil V. Harvesting the Biosphere: What We Have Taken from Nature [Internet]. MIT Press; 2013. 317 p. Available from: https://mitpress.mit.edu/9780262528276/harvesting-the-biosphere/

9. Gasser T, Crepin L, Quilcaille Y, Houghton RA, Ciais P, Obersteiner M. Historical CO emissions from land use and land cover change and their uncertainty. Biogeosciences. 2020 Aug 13;17(15):4075–101.

10. Houghton J, Meira Filho L, Lim B, Treanton K, Mamaty I, Bonduki Y, et al. Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories [Internet]. IPCC, UK Meteorological Office; 1996. Available from: https://www.ipcc.ch/report/revised-1996-ipcc-guidelines-for-national-greenhouse-gas-inventories/

11. Houghton RA, Nassikas AA. Negative emissions from stopping deforestation and forest degradation, globally. Global Change Biology. 2018;24(1):350–9.

12. Longmire A, Taylor C, Wedderburn-Bisshop G. Land Use: Agriculture and Forestry Discussion Paper [Internet]. Melbourne, Vic: Beyond Zero Emissions; Melbourne Sustainable Society Institute; 2014 Oct. Available from: http://bze.org.au/land-use-agriculture-and-forestry/

13. IPCC. 2006 IPCC Guidelines for National Greenhouse Gas Inventories [Internet]. Hayama, Japan: The Intergovernmental Panel on Climate Change; 2006. Available from: https://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html

14. Ballantyne AP, Alden CB, Miller JB, Tans PP, White JWC. Increase in observed net carbon dioxide uptake by land and oceans during the past 50 years. Nature. 2012 Aug 2;488(7409):70–2.

15. Crowther TW, Glick HB, Covey KR, Bettigole C, Maynard DS, Thomas SM, et al. Mapping tree density at a global scale. Nature. 2015 Sep 10;525(7568):201–5.

16. Liang MC, Mahata S, Laskar AH, Thiemens MH, Newman S. Oxygen isotope anomaly in tropospheric CO2 and implications for CO2 residence time in the atmosphere and gross primary productivity. Sci Rep. 2017 Oct 13;7:13180.

17. Graven H, Keeling RF, Rogelj J. Changes to Carbon Isotopes in Atmospheric CO2 Over the Industrial Era and Into the Future. Global Biogeochemical Cycles. 2020;34(11):e2019GB006170.

18. Haverd V, Smith B, Canadell JG, Cuntz M, Mikaloff-Fletcher S, Farquhar G, et al. Higher than expected CO2 fertilization inferred from leaf to global observations. Glob Chang Biol. 2020 Apr;26(4):2390–402.

19. Friedlingstein P, O'Sullivan M, Jones MW, Andrew RM, Bakker DCE, Hauck J, et al. Global Carbon Budget 2023. Earth System Science Data. 2023 Dec 5;15(12):5301–69.

20. Winkler K, Fuchs R, Rounsevell M, Herold M. Global land use changes are four times greater than previously estimated. Nat Commun. 2021 May 11;12(1):2501.

21. Knauer J, Cuntz M, Smith B, Canadell JG, Medlyn BE, Bennett AC, et al. Higher global gross primary productivity under future climate with more advanced representations of photosynthesis. Science Advances. 2023 Nov 17;9(46):eadh9444.