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Assessing the impact of land use on the carbon state of global vegetation

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Vegetation plays a key role in the climate system, but many issues regarding the extent of global vegetation stocks and the driving forces of their change remain unknown. Society alters many ecosystem properties, including the flow of energy and carbon, the turnover time of carbon in biomass as well as the amount of carbon stored in biomass. While the impact of human-induced land-cover changes is relatively well described, large knowledge gaps relate to the impact of land management, i.e. changes in ecosystems properties caused by land use that occur within a land cover type. Based on the integration and analysis of state-of-the-art datasets on biomass stocks, fluxes and land use, we here quantify and map (5 arc min resolution) the human impact on the global carbon state of vegetation. By comparing the amount of biomass stocks, fluxes and turnover rates of the actual vegetation with a hypothetical state assuming no land use under current climate conditions, we isolate the impact of individual land uses and the effects of land conversions and land management. We show that land use has a massive impact: it halves biomass stocks and reduces carbon fluxes by approximately 10%, resulting in a massive acceleration of turnover rates (factor 1.9 on the global average). We find large uncertainties, in particular and surprisingly related to carbon stocks, despite their pivotal role in the climate systems, and identify inconsistencies in widely used datasets. The reduction of biomass stocks results, according to our assessment, from an unexpectedly large impact of management on biomass stocks (42-47% of total reduction), comparable in magnitude to the impact of deforestation and other land-cover changes (53–58%). This impact has been largely underestimated in the literature. Contextualizing our results with accounts of the global terrestrial carbon balance suggests either that cumulative carbon emissions from land use before the industrialized period were considerable, or that the strength of the residual carbon sink might currently be underestimated, or both. Due to the large uncertainties, efforts to restore biomass stocks are currently verifiable only in temperate forests, where their potential is limited. By contrast, uncertainties hinder verification in the tropical forest, where the largest potential is located, pointing to challenges for the upcoming stocktaking exercises under the Paris agreement. Our results underpin the virulent trade-offs that exist between conserving carbon stocks on managed land and raising the contribution of biomass to raw material and energy supply for the mitigation of climate change.