Human impacts on forests and grasslands much larger and older than previously assumed

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Human biomass utilization reduces global carbon stocks in vegetation by 50%, implying that massive emissions of CO2 to the atmosphere have occurred over the past centuries and millennia. The contribution of forest management and livestock grazing on natural grasslands to global carbon losses is of similar magnitude as that of deforestation. Currently, these effects are underappreciated in existing global carbon models and

assessments of the greenhouse gas emissions (GHG) from land-based production.

Without full consideration of land management effects, global climate forecasts and calculations of the GHG effects of future bioenergy policies are error-prone, seriously jeopardizing the robust evaluation of measures that would help achieving the 1,5°C target of the Paris Agreement. These are some of the result of a study headed by Karl-Heinz Erb from the Institute of Social Ecology, published in the scientific journal *Nature*.

Carbon stocks in vegetation have a crucial role in the global climate system. And yet, essential characteristics of vegetation have received little scientific attention to date. While research has made significant progress in the recent years with regard to the quantification of the effects deforestation, the effects of land uses that are not associated with land-cover change have been largely ignored. An international research team led by Karl-Heinz Erb has published an article in *Nature* yesterday, aiming at closing this knowledge gap. Calculations based on current state-of-the art data had already revealed that the global land-ecosystems are currently storing approximately 450 billion tonnes of carbon, "However, in a hypothetical world without land use, the vegetation would store as much as 916 billion tonnes of carbon," Karl-Heinz Erb says.

Roughly 53 to 58 percent of the difference of around 466 billion tonnes of carbon can be attributed to the clearing of forests and woodlands, mostly for agricultural purposes. However, land uses that do not result in changes in land cover, for instance forest management or grazing of natural grasslands, also have a massive impact on the amount of carbon stored in vegetation globally. Their contribution is estimated at 42 to 47 percent, two-thirds of which can be ascribed to forest management, and the remaining third to grazing.

Erb summarizes the situation: "Until now, these effects have been severely underestimated, and have therefore received scant consideration in global studies and models. Our results show that the consequences of forest management and grazing are far greater than previously assumed. Managed forests store about one third less carbon than pristine, untouched forests would. This effect is not just local, but can be observed almost world-wide. What this also tells us is that although putting a stop to deforestation is absolutely essential, that alone would not be sufficient to mitigate climate change. Besides protecting forest areas, the protection of forest functions, including carbon stocks, needs to be moved into focus."

Contextualizing this finding with the current understanding of the global carbon cycle suggests that this massive effect is far older than previously hypothesized. A considerable fraction of the biomass stock reduction took place prior to 1800, that is, before the onset of industrialisation and its accompanying fossil fuel emissions. This is relevant because it clearly illustrates that turning to biomass as major part of humanity's energy supply would exert significant pressures on vegetation and its carbon balance. Most scenarios aimed at achieving low global warming targets, such as the 1.5-2.0°C goals codified in the Paris Agreement, heavily rely on assumptions on biomass energy, often coupled with carbon capture and sequestration technologies (BECCS). To the extent that these scenario studies failed to correctly acknowledge the full carbon effects of biomass utilization, they underestimate the full carbon costs of sourcing that biomass.

The new study reveals a decisive target conflict: On the one hand, biomass as a raw material and as a component of the energy supply is implemented with the goal of reducing greenhouse gas emissions. On the other hand, increasing the utilization of biomass can result in depletion of carbon stocks and thus to considerable greenhouse gas emissions from managed land areas. "Our results clearly show that it is not legitimate to

assume that the use of biomass for energy is climate-neutral if it does not contribute to deforestation. As long as models of the future carbon cycle do not explicitly and fully reflect the full effects of land management on biomass stocks, they will not be able to accurately assess the carbon cycle effects of large scale implementation of bioenergy policies. This jeopardize the formulation of robust and reliable climate protection strategies," Erb warns.

The study, co-funded by various projects including the European Research Council and the European Commission under the H2020 programme, also points to serious knowledge gaps and data uncertainties. These uncertainties have a direct relevance for the development of land use strategies designed to fight climate change: At the moment, the reliability and robustness of data allows for a verification of biomass stock increases, e.g. due to afforestation programmes, only in the temperate climate zone. In this zone, however, the potentially achievable effects are modest. In the tropical forests, in contrast, the potentials are far larger, but enormous uncertainties hamper their verification. Karl-Heinz Erb sums the situation up as follows: "Our study illustrates that land use strategies geared towards combating or mitigating climate change require a prudent and cautious approach. Strategies that are too simple in their design can backfire, or may end up causing more harm than good due to the major uncertainties involved."

More information: Karl-Heinz Erb et al. Unexpectedly large impact of forest management and grazing on global vegetation biomass, *Nature* (2017). DOI: 10.1038/nature25138

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