Comment on "The global tree restoration potential"

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Bastin et al. (Reports, 05 July 2019, p. 76) claimed that global tree restoration is the most effective climate change solution to date, with a reported carbon storage potential of 205GtC. However, this estimate and its implications for climate mitigation are inconsistent with the dynamics of the global carbon cycle and its response to anthropogenic CO_2 emissions.

In a recent article entitled "The global tree restoration potential"(*1*), Bastin et al. claimed that their study "highlights global tree restoration as our most effective climate change solution to date". The authors estimate that one could restore about 0.9 billion hectares of canopy cover which could store 205 GtC (gigatons of carbon) in areas that would naturally support woodlands and forests. The authors claim that "reaching this maximum restoration potential would reduce a considerable proportion of the global anthropogenic carbon burden (~300 GtC) to date, placing ecosystem restoration as the most effective solution at our disposal to mitigate climate change". We believe this conclusion is wrong due to the authors' misunderstanding of both carbon storage potential and the global carbon cycle response to anthropogenic emissions.

First, the authors compared their estimate of 205GtC with "the global anthropogenic carbon burden" of about 300GtC to date. The 300GtC figure seems to refer to the historical increase in atmospheric CO_2 (expressed in their paper in units of mass, GtC as opposed to the usual units of concentration, ppm), which is only about half of the historical anthropogenic emissions of about 600 GtC (*2*). Only about 45% of these emissions remain in the atmosphere, the rest has been absorbed by the ocean and land ecosystems. The ratio of atmospheric CO_2 increase to the anthropogenic CO_2 emissions, called the airborne fraction, is relatively constant over the historical record and was described more than 40 years ago (*3*). Assuming fossil fuel emissions continue at some level for the duration of a forest restoration programme as suggested by Bastin and co-authors, net anthropogenic emissions over this period will be the difference between the fossil fuel emissions and the net biospheric uptake due to forest restoration. The balance between future emissions and future uptake will be subject to the same airborne fraction of around 45% (*4, 5*). The authors should have estimated the atmospheric carbon removal from forest restoration as the potential carbon storage multiplied by the airborne fraction, reducing by about 45% the reported impact of this forest restoration option on the atmospheric CO_2 growth rate. Alternatively, the potential carbon removal from forest restoration could be directly compared to cumulative anthropogenic emissions to date (about 600GtC), but not the fraction remaining in the atmosphere.

Second, the 205GtC figure is obtained from the potential canopy cover spatial distribution (as shown on their Figure 1B and 1C) and the carbon densities across the major biomes of the world (Table S2, with distribution shown in Figure S2). From Table S2, it appears that the authors simply multiply the potential canopy cover (in Mha) by the carbon densities (in tC/ha) of the biome currently in these regions to estimate potential carbon storage. Doing so, they would, in effect, ignore the carbon that is currently stored in that region. The right approach is to estimate the carbon storage potential as the difference between carbon potentially stored by a forest minus the carbon currently stored by the existing ecosystem, for example forest versus tundra (assuming that a forest could be sustained in the Arctic climate of the tundra biome). From the carbon densities given in Table S2 for each biome, it is clear that the potential carbon storage would be significantly lower than reported. Boreal forests can only store about 15% more carbon than tundra; temperate (tropical) forests are given the same carbon density as temperate (tropical) grasslands, implying no clear carbon gain from forest restoration.

Furthermore, forests also impact climate through biophysical feedbacks, such as changes in albedo or evapotranspiration (*6*), which can counteract the cooling effect from CO_2 uptake. It is well established for instance that afforestation in snow-covered regions may lead to weak local cooling or even to warming as the positive radiative forcing induced by decreases in albedo can offset the negative radiative forcing from carbon sequestration (e.g. *7, 8*). These biophysical feedbacks have not been discussed in the article and could substantially reduce the potential of forest reforestation in some of the considered regions.

Third, regardless of the exact amount of carbon that could be stored via forest restoration, this solution can only temporarily delay future warming. The 205GtC proposed by the authors is equal to about 20 years of global anthropogenic CO_2 emissions at the current emission rate of about 10GtC/yr (*2*). Without radical reductions in fossil carbon emissions, forest restoration can only offset a share of future emissions and has limited potential. The only long-term and sustainable way to stabilize the climate at any temperature target is to reduce anthropogenic CO_2 emissions to zero (over the coming 30-50 years to meet the temperature targets of the Paris Climate Agreement) (*9*).

Furthermore, the paper does not provide any evidence that “ecosystem restoration is the most effective solution at our disposal to mitigate climate change”. Analyses showing the carbon mitigation potential of planting trees have been available for the past two decades (e.g. *10*), yet there has been very limited adoption of such a strategy due to concerns of unintended consequences (e.g. water availability) and complex land rights. In contrast, energy efficiency and deployment of non-fossil energy sources have helped reduce emissions in the past (*11*) and are key characteristics of deep mitigation pathways even when large-scale carbon dioxide removal is deployed (*12*). The literature indicates that a multitude of mitigation measures are needed (e.g. *9, 13*), and it is unlikely that any measure would be the “most effective”.

Bastin and co-authors strongly overestimates the potential of forest restoration to mitigate climate change. The claim that global tree restoration is “our most effective climate change solution to-date” is simply incorrect scientifically and dangerously misleading.

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