

Recognizing the importance of unmanaged forests to mitigate climate change

The most effective means for keeping carbon out of the atmosphere to meet climate goals is to protect primary forests (Mackey et al., 2020) and continue growing secondary forests to accumulate additional carbon (proforestation; Moomaw, Masino, & Faison, 2019) while reducing emissions from all sources including bioenergy. We find several assumptions and conclusions in the Opinion piece by Schulze et al. (2020) inaccurate or questionable.

The Opinion compares differences in carbon storage between 'unmanaged' and 'managed' European forests, and states, '(f)or unmanaged forests, the contribution to climate change mitigation through storage is very small or close to nil'. However, no evidence is cited to support this contention, which is inconsistent with several published empirical studies and theoretical analyses (Erb et al., 2017; Houghton & Nassikas, 2018; Lutz et al., 2018). In order to support effective climate policy, we are responding to identify some of the errors of omission in the Opinion.

Based on UNFCCC accounting rules, climate mitigation depends on the relative carbon stocks in the biosphere and atmosphere, not on sequestration rates as annual flows. In order to minimize the amount of carbon in the atmosphere, the cumulative carbon in trees and soils must be maximized (Mackey et al., 2020). The maximum carbon stored in forests occurs when forests are allowed to continue growing, a management practice called 'proforestation' (Moomaw et al., 2019). As the harvest rotation period is shortened, less carbon is stored in trees averaged over the harvest period intervals, leaving more in the atmosphere (Serman, Siegel, & Rooney-Varga, 2018). Each harvest also releases additional biogenic and fossil fuel carbon emissions from the harvest process (Harris et al., 2016).

Schulze et al. cite two studies from outside Europe, which found higher area-averaged stand volumes in unmanaged compared to managed forests. However, they state that this difference does not exist in the temperate zone of Central Europe without offering any data to support the claim. A number of studies confirm higher stand volumes in older

forests in Central Europe. The results from Jacob et al. (2012) show a higher standing biomass carbon pool in old-growth forest than younger developmental stages. Horváth et al. (2012) also found that old-growth forests in reserves had the highest proportion of large trees in diameter and height, and the largest volume of dead wood, meaning that total biomass carbon stock is higher compared with secondary forests that were being actively managed or recently abandoned.

Schulze et al. do not acknowledge or investigate the capacity for unmanaged forest to store more carbon than currently. The Opinion does not provide the age class distribution of the forests that were analysed, or reflect the fact that even presently unmanaged forests in Europe have likely been harvested at some time in the past. Forests in Europe do not differ from North America or Australia in terms of their ecological processes of carbon accumulation, but rather, have not yet reached their ultimate cumulative carbon capacity.

Considering *Fagus* and *Picea* as the dominant tree species in Central Europe is an over-simplification, as the European Environment Agency maps five biogeographical regions in this region: Continental, Pannonian, Alpine and to a smaller extent Atlantic and Mediterranean. While Sabatini et al. (2018) found an uneven distribution of primary forests in Europe, with concentration often in mountainous areas with *Fagus* and *Picea*, excluding the importance of oak forest habitats and soft-wood riverine forests is a major oversight.

In their conclusions about mitigation benefits of forest management, Schulze et al. use annual rates of carbon sequestration and emissions (flows) that are the incorrect metric to assess forest carbon stocks or alternative forest management on those stocks. It is also an inappropriate metric for meeting the Paris Agreement goals. The authors also greatly underestimate the carbon stock in biomass, because only stemwood is counted, and branches, bark, canopies and roots are excluded along with soil carbon that is greatest in older forests.

The importance of primary (unlogged) forests lies in the magnitude and longevity of their carbon stock. In order to reverse the decreasing forest carbon stocks in Europe (European Environmental Agency, 2019), the largest forest carbon stores must be protected and additional forests must be allowed to

This is a letter regarding Schulze et al. 12, 186–197.

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continue accumulating carbon (proforestation). Harvesting for bioenergy increases atmospheric carbon, and slows the accumulation of forest carbon (Sterman et al., 2018).

Based on the above, we disagree with the conclusions by Schulze et al. The climate change mitigation potential of unmanaged forests is significantly greater because of their greater cumulative carbon storage than for forests managed for lumber and bioenergy. Scientific findings are critically important to decision makers addressing climate change. We urge managers to disregard the erroneous carbon metrics for forest carbon accounting in the Opinion and utilize more valid sources.

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