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RESPONSE TO THE EDITOR

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Forest management contributes to climate mitigation by reducing fossil fuel consumption: A response to the letter by Welle et al.

In a letter to Global Change Biology Bioenergy, Welle et al. (2020) accuse us of severe errors in using and interpreting data in our publication on "Climate mitigation by sustainably managed forests in Central Europe."

Welle et al. (2020) also refer to earlier letters by Kun et al. (2020) and Both et al. (2020) on which we responded already (Schulze et al., 2020a). We showed that spatial and temporal scales led to misunderstandings about carbon benefits of bioenergy which we clarified. We are deeply disappointed by the fact that Welle et al. (2020) ignored our response.

Welle et al. (2020) claim that we made a mistake, when calculating the change in stocks of Hainich National Park, and this has led to false conclusions of the contribution of unmanaged forest to climate change. Here we reject this claim.

Forest inventories are made for regions that are geographically laid out before the inventory starts. In this case, it is the National Park Hainich covering an area of 7,500 ha. The Park is required to carry out periodic inventories of stocks using permanent plots along a grid-based inventory at intervals of 10 years. In Hainich National Park, a quadratic grid of 200 × 200 m is used, comprising 1,902 sample plots in total. The grid was set before the first inventory started in 2000.

During an inventory all plots with forest cover are surveyed and measured. Following the German forest law, an inventory considers all plots that have a cover by forest trees being older than 5 years from seed or have a crown cover of >50% of the plot area. This includes old stands that collapse as well as regrowth and successional stages (BMEL, 2016).

For Hainich National Park, two inventories have been carried out—the first in 2000 and the second in 2010. During the first inventory 1,200 plots were covered by forest with dbh >7 cm. During the second inventory the number of measured plots increased to 1,421 due to forest succession in parts of the National Park that were early successional stages in 2000. According to the report of the inventory results (Nationalparkverwaltung Hainich, 2012) the average standing stocks of wood (trees >7 cm diameter at breast height) were 367.5 m^3/ha in 2010 based on the 1,421 plots and 363.5 m^3/ha based on the 1,200 plots in 2000. Thus, the average standing stocks have not increased substantially. The difference is 3.97 m^3/ha over 10 years, corresponding to 0.4 m^3 ha^{-1} $year^{-1}$, the figure used in our publication.

Welle et al. (2020) claim that the evaluation of the inventory should only be based on the 1,200 plots of the first inventory. In this case, they claim that the average standing stocks are 453 m^3/ha in 2010, as also published by the National Park (Nationalparkverwaltung Hainich, 2012), with increase of about 90 m^3/ha since 2000, corresponding to 9 m^3 ha^{-1} $year^{-1}$. The National Park published selected data of the first and second inventory (including changes in the plot area) for four subareas of the National Park that differ in land use history, but these parts overlap preventing the calculation and extrapolation of a new average for the Park as a whole.

More importantly, a selection of parts of the inventory is not an acceptable scientific practice. One cannot select the plots that support the conclusions one might want to see. Depending on how you do the selection, the result will differ compared to the standing stocks for the Park as a whole. One must be true to the initial design, as defined for the study area in beforehand. Thus, basing an interpretation on a subjectively selected area is scientifically not acceptable. The plots with natural succession are part of the Park's forest area and the design, even if not measured in 2000. This point is also valid for the National Forest Inventory (BMEL, 2016), which we chose for comparison and where changes in total plot numbers also occurred between the inventories.

The acceptance of an inventory as a whole is especially important, if the numbers are used for reporting of greenhouse gas emissions. In this context it is also important to be aware that the changes in growing stock do not represent a periodic increment, because harvest has to be considered. In Hainich National Park, 30,000 m^3 coniferous wood were harvested between 1998 and 2004. There is also loss of trees due to natural mortality that

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contributes to the deadwood stocks. Due to the species composition on successional plots, with larger amounts of, for example, ash (*Fraxinus excelsior*), we might expect the National Park will have increased standing stocks in the third inventory in 2020 compared to 2010, because young ash has a relatively high annual increment. However, we also already know that abiotic and biotic factors have caused major parts of the succession to be lost: for ash because of fungal disease, and for beech due to water stress from drought. The extent to which such factors outbalance each other is thus yet to be seen, but with this, we conclude that our publication (Schulze et al., 2020b) does not contain a major error in its use of the inventory data from the Hainich National Park (Nationalparkverwaltung Hainich, 2012).

One may ask if it was wise to use the Hainich National Park as an example of a forest area without wood harvest. Our decision was based on the fact that Hainich National Park represents types of forest communities on limestone that are common in Germany, dominated by beech, a tree species that is particularly important for Nature Conservation in Germany. Also, this Park contains sufficient variation to represent typical beech forests in Germany (see Engel et al., 2016). Undoubtedly, changes in stocks would have been larger for the National Park Kellerwald, where forest structure is more homogenous. On the other hand, if we had chosen coniferous National Parks, such as Harz, the changes in stocks would have been negative, because the bark beetles eradicated most of the old spruce stands (*Picea abies*). However, for both parks no repeated inventory data are available. In conclusion, the selection of the exact conservation unit does not change the fact that managed forests have a higher growth rate than unmanaged forests, and that the use of wood for energy, preferably after a period of use as a longer lived commodity, is an additive climate change mitigation benefit of forest management and wood utilization which *avoids* fossil fuel emissions (see Churkina et al., 2020; Mund et al., 2015; Woerdehoff, 2016). Changes in stocks only *compensate* atmospheric CO_2 concentrations (see graphical abstract).

Our conclusion that "only forest management contributes to climate mitigation, by reducing fossil fuel consumption" is based on scientifically sound data use that includes all stages of stand development, also in unmanaged forests. Please let us express that we do not question the value of National Parks and other Priority Areas for conservation. These are part of a multifunctional forest management at the national level. The author team agrees to this point. One should only be aware that the different objectives of managing forests can be complementary, differing, competing, and opposing each other. An unmanaged forest that is managed to optimize biodiversity conservation is not necessarily the most beneficial for climate change mitigation.

Ernst-Detlef Schulze[1]
Carlos Sierra[1]
Vincent Egenolf[2]
Rene Woerdehoff[3]
Roland Irsinger[4]
Conrad Baldamus[5]
Inge Stupak[6]
Hermann Spellmann[3]

[1]*Max Planck Institute for Biogeochemistry, Jena, Germany*
[2]*CESR-SURF, Uni Kassel, Kassel, Germany*
[3]*Nordwestdeutsche Fortl. Versuchsanstalt, Göttingen, Germany*
[4]*Hochschule für Forstwirtschaft Rottenburg, Rottenburg am Neckar, Germany*
[5]*Stiftung August Bier, Rietz-Neuendorf, Germany*
[6]*Department of Geosciences and Natural Resource Management, University of Copenhagen, Copenhagen, Denmark*

Correspondence
Ernst-Detlef Schulze, Max Planck Institute for Biogeochemistry, Box 100164, 07701 Jena, Germany.
Email: dschulze@bgc-jena.mpg.de

ORCID

Ernst-Detlef Schulze https://orcid.org/0000-0001-6188-9219

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