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How strong can windthrow damages affect the national carbon budget?

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Natural disturbances in forests alter various elements of their functioning, one of which is the CO_2 absorption abilities. Even though wind-origin phenomena are the main type of disturbances in European countries, an issue of carbon dioxide (CO_2) dynamics following wind disturbances in forest ecosystems seems to be still insufficiently recognized. Moreover, there are only a few studies addressing this question worldwide. Thus, here we are reporting on the consequences of such stand-replacing phenomena on the net carbon production (NEP), utilizing data from 65-year-old temperate Scots pine forest (Tuczno site) and comparing them with currently replanted windthrow area (Tlen I site) in Poland.

The study period covers 6 years of continuous eddy covariance (EC) measurements at both locations, aiming at providing information on how much CO_2 was lost from the ecosystem due to wind disturbance (Tlen I site) in relation to the amount of CO_2 sequestered by the mature pine forest (Tuczo site- the closest analogue to pre-storm forest). We have found that in the first year after the damage, each hectare of windthrow area has emitted more CO_2 to the atmosphere that could be balanced by the net uptake of the mature pine forest on an annual basis. Once the reforestation procedure began, this relationship started to change and after ploughing and pine seedlings introduction net CO_2 sequestration of untouched forest clearly surpassed CO_2 losses from the disturbed site. Five years from the wind disturbance, followed by conventional reforestation, the joint CO_2 budget of these two forest areas was close to zero. Furthermore, by extending these estimations on the 40 000-ha area, designated for reforestation after being knocked down by another severe windstorm in August 2017, we have calculated that such damage can constrain national forests' CO_2 sequestration by even 19.5% in a 5 years' time. Hence, the efforts made to comply with the Paris Agreement have to be thoroughly revised in a way to include CO_2 loses from mostly wind disturbed stands, which was already accounted for in Forest Carbon Farms project launched in 2017 by the State Forests in Poland. Similar attempt to balance net CO_2 losses from windthrow areas with the net CO_2 uptake from undisturbed forest (Tuczno forest), would probably take much longer when other reforestation treatments were applied, resulting in higher overall net CO_2 emission than that from Tlen I area reported here.

This work advances our current understanding of forest ecosystem-climate interactions, with additional conclusions regarding climate changes mitigation challenges in the face of increasing frequency and intensity of extreme weather phenomena. Additionally, the question of using different forest management practices to sustain the least CO_2 losses at wind-disturbed forest is addressed here. During the presentation, short movies from all measuring sites are going to be shown.