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Temperate Scots pine forest's carbon balance following windthrow

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Since forests play a major role as terrestrial carbon sink, a lot of effort has been put to investigate their carbon (C) balance in regard to changing climatic conditions. As a consequence of these changes, the impact of disturbances has recently got more and more attention. Any rapid changes in the spatial structure of the forest (either as a result of the trees' damage or harvesting) often results in not only changing, but even inversing the C balance of the entire ecosystem. Despite the fact, that wind damages constitute the main disturbances in European forests, there were only a few studies aiming at investigating windthrow and their consequences on forest's carbon balance. In order to close this knowledge gap, we took an opportunity of a tornado event which appeared in July 2012 in Trzebciny Forest District, northwest Poland, to investigate the impact of windthrow damages on a temperate pine forest C balance.

Presented studies cover a 4-year period of continuous eddy covariance (EC) measurements of the net carbon dioxide fluxes (NEP), exchanged between the atmosphere and currently reforested post-windthrow area ("TlenI" site). They were further compared with an intact, middle-aged pine forest in Tuczno, where corresponding measurements of CO_2 fluxes has been conducted for almost 10 years, chosen as the closest analogue to the forest which had existed at TlenI area before the disturbance. Prior to the tornado, TlenI comprised a Scots pine stand at similar age as the Tuczno forest, with comparable soil, habitat and meteorological conditions.

Given the results of our research, the average value of annual NEP totals in undisturbed pine forest in Tuczno during investigated period (2013-2016) was equal to +428 gCm^{-2}, thus constituting a moderate carbon sink. At the same time, more than 440 gCm^{-2} was released to the atmosphere from windthrow area (TlenI site: 4-year average NEP total up to -442 gCm^{-2}). Additionally, it turned out that a unit area of undisturbed forest was not able to compensate carbon losses resulted from natural hazard for the first four years after its occurrence. Moreover, in our opinion, the scale of the negative impact of this extreme meteorological event on the overall forest's C balance, should be estimated in a broader view. From the perspective of a local ecosystem-atmosphere C exchange it is though necessary to sum up the actual (measured) net emissions from the windthrow area and the estimated value of the "lack" of a net absorption, which should have occurred there. For this reason, the value of annual NEP total, that could have characterized a mature pine forest at Tlen I area if not destroyed, was determined indirectly on the basis of data from Tuczno. The approximate sum of C sequestration in 2013-2016 would therefore be more than 1700 gCm^{-2}. In total, the windthrow area "lost" approximately 3500 gCm^{-2} in four years, which is over 128 t CO_2 from each hectare.