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How does wind-throw disturbance affect the carbon budget of an upland spruce forest ecosystem?

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Forests, especially in mid-latitudes are generally designated as large carbon sinks. However, stand-replacing disturbance events like fires, insect-infestations, or severe wind-storms can shift an ecosystem from carbon sink to carbon source within short time and keep it as this for a long time. In Addition, extreme weather situations which promote the occurrence of ecosystem disturbances are likely to increase in the future due to climate change. The development and competition of different vegetation types (spruce vs. grass) as well as soil organic matter (SOM), and their contribution to the net ecosystem exchange (NEE), in such disturbed forest ecosystems are largely unknown.

In a large wind-throw area (ca. 600 m diameter, due to cyclone Kyrill in January 2007) within a mature upland spruce forest, where dead-wood has not been removed, in the Bavarian Forest National Park (Lackenberg, 1308 m a.s.l., Bavaria, Germany), fluxes of CO_2, water vapor and energy have been measured with the Eddy Covariance (EC) method since 2009. Model simulations (MoBiLE) were used to estimate the GPP components from trees and grassland as well as to differentiate between soil and plant respiration, and to get an idea about the long term behavior of the ecosystems carbon exchange.

For 2009, 2010, 2011, 2012, and 2013 estimates of annual Net Ecosystem Exchange (NEE) showed that the wind-throw was a marked carbon source. However, the few remaining trees and newly emerging vegetation (grass, sparse young spruce, etc.) lead to an already strong Gross Ecosystem Production (GEP). Model simulations conformed well with the measurements.

To our knowledge, we present the worldwide first long-term measurements of NEE within a non-cleared wind-throw-disturbed forest ecosystem.