

Long-term drought effects on spruce forests in a low mountain range of Germany – crossing the tipping point

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The extreme drought years 2018 to 2020 have led to massive tree damage in Germany, especially in spruce stands, but also in other tree species. In order to investigate the effects of the widespread dieback of spruce stands, usually followed by clear-cutting, on soil processes and mass transfer with the atmosphere, we conducted a measurement campaign in a spruce forest area particularly affected by bark beetles, storm damage and clear-cutting from end of May to December 2020 in the northern Eifel, Germany. During the field campaign, soil moisture was permanently recorded using Cosmic Ray Neutron Sensing (CRNS), and the exchange of CO₂ and water vapor between the land surface and the atmosphere was quantified with the eddy covariance method. In addition, we quantified soil respiration by manual measurements with a portable chamber system at approximately weekly intervals. Surface RGB and thermal images were taken with air-borne drones, and regular surveys were made with a mobile CRNS rover over a larger area of the northern Eifel. The measurements showed that the study area was already very dry at the beginning of June 2020. Soil moisture was also unusually low in the larger study area of the northern Eifel during the same period. During the entire study period from the end of May to the end of December 2020, the clear-cut area was a permanent source of CO₂ and emitted the equivalent of about 3 t CO₂-C ha⁻¹ during this period, while during the same period the still largely intact spruce forest at the TERENO site Wüstebach, also located in the Northern Eifel, but at higher elevation, was carbon-neutral only during the driest period in midsummer and still absorbed about 1 t CO₂-C ha⁻¹ during the rest of the period. We also found that the evapotranspiration from the clear-cut area was about 164 mm (1640 m³ ha⁻¹) lower during the observation period than that from the spruce forest, while the surface temperatures of the area were drastically higher in sunny weather than in the forest.

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