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Forests on drained agricultural peatland are potentially large sources of greenhouse gases – insights from a full rotation period simulation

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The CoupModel was used to simulate a Norway Spruce forest on fertile drained peat over 60 years, from planting in 1951 until 2011, describing abiotic, biotic and greenhouse gas (GHG) emissions (CO_2 and N2O). By calibrating the model against tree ring derived biomass data and measured 6 year abiotic data we obtained a "reference" model by which we were able to describe the GHG fluxes and controlling factors over the 60 years. The GHG fluxes are composed of two important quantities, the forest carbon (C) uptake, 405 g C m$-$2 yr^{-1} and the decomposition of peat soil, 396 g C m$-$2 yr^{-1}. N2O emissions contribute to the GHG emissions by 0.5 g N m$-$2 yr^{-1}, corresponding to 56.8 g C m$-$2 yr^{-1}. The 60-year-old Spruce forest has an accumulated biomass of 164 Mg C ha^{-1}. However, over this period 208 Mg C ha^{-1} GHG has been added to the atmosphere, which means a net addition of GHG emissions. The main losses are from the peat soil and, indirectly, from forest thinning products, which we assume have a short lifetime. Model sensitivity analysis by changing initial soil C, drainage depth and initial soil C/N ratio also confirms that forests on drained agricultural peatland are a GHG source. We conclude that after harvest at an age of 80 years, most of the stored biomass carbon is liable to be released, the system having captured C only temporarily and with a cost of disappeared peat, adding both CO_2 and N2O to the atmosphere.