Geophysical Research Abstracts
Vol. 15, EGU2013-7674, 2013
EGU General Assembly 2013

Carbon balance of a Swedish forest ecosystem after stump harvest

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Stump harvest in forests may cause both reductions of ecosystem CO_2 emissions through a decrease of decomposable substrate ("direct effect") and emission increases as a consequence of deep and extensive soil disturbance ("indirect effect"). We have studied effects of stump harvest on net ecosystem CO_2 exchange (NEE) in a former Norway spruce stand in mid Sweden. CO_2 fluxes were continuously followed by eddy-covariance measurements during the first years after harvest. Differences in NEE from stump-harvested and mounded (reference) plots were determined by measurements of soil-surface respiration. Respiration from decaying stumps was estimated by a decomposition model. The fluxes indicated a direct effect (decreased emissions) during the first year after harvest, corresponding to the absence of decomposing stumps. During the following years, this emission reduction was increasingly counteracted by an indirect effect (increased emissions) of similar magnitude. This indicates that the expected emissions caused by extra soil disturbance occur with a certain delay and increase with time. Therefore the substitution efficiency of stumps as bioenergy resource is reduced. Furthermore, at a time scale of centuries, instant combustion of stumps contributes more to global warming than slow decomposition, because the stump carbon is available earlier in form of greenhouse gas. This is estimated by the time integral of emissions. Thus, despite the surprisingly low initial emissions, the overall substitution efficiency and climate benefits of stump harvest are likely to be small. The long-term consequences of stump harvest for the carbon budget are, however, still uncertain.