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Carbon balance of a forest ecosystem after stump harvest

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Stump harvest in forests can cause both reductions of CO2 emissions through a decrease of decomposable substrate (direct effect) and increases of emissions as a consequence of deep and extensive soil disturbance (indirect effect). We present the effects of stump harvest on net ecosystem CO2 exchange (NEE) in a former Norway spruce stand in mid Sweden. CO2 exchange was 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 soil-surface respiration measurements. Respiration from decaying stumps was estimated by a decomposition model. The fluxes indicated a direct effect (decreased efflux) during the first year after harvest that corresponded to the absence of decomposing stumps. During the following years, this emission reduction was increasingly counteracted by an indirect effect (increased efflux) of similar magnitude. This means that the expected emissions caused by extra soil disturbance occurred with a certain delay and seem to increase with time. By these emissions, the substitution efficiency of stumps as bioenergy is reduced. Furthermore, at a time scale of centuries, instant combustion of stumps leads to a larger contribution 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.

Keywords: Stump harvest, carbon balance, soil respiration, silviculture, bioenergy, eddy-covariance