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Effect of clear-cutting on soil carbon pool and CO2 effluxes from boreal forest soil

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Due to their large land area and large carbon pool forests play an important role in the management of soil carbon stocks. Land use, such as forest harvesting affects soil carbon pool, and it has been suggested that carbon stocks can be managed by silvicultural practices. Upon such disturbances as forest fire or clear-cutting, the carbon balance of a forest is profoundly changed. First the carbon assimilation in photosynthesis of trees is ceased and secondly a large amount of fresh litter is released to the soil. When the tree canopy is removed, the solar radiation on the soil surface is increased resulting in higher diurnal temperature fluctuation in the soil. Because the decomposition of soil organic matter is dependent on soil temperature and soil moisture, an increase in these factors can increase the decomposition rate of organic matter. In addition to clear-cutting and residue removal, the site preparation used for promoting the germination of seeds and helping the survival of planted seedlings also affects the decomposition of soil organic matter. There is also a major shift from autotrophic to heterotrophic respiration due to the removal of trees. In this project, we studied soil CO2 efflux and carbon stocks on 5-15 year-old clear-cut sites exposed to site preparation and on adjacent non-cut control forests close to Hyytiälä in Southern Finland. The sites varied from fertile Norway spruce (Picea abies) and Silver Birch (Betula pendula) dominated sites on till soil to Scots pine (Pinus sylvestris) dominated sites on sedimented sandy soil.

Soil CO2 efflux at the sites showed a typical seasonal variation following soil temperature the effluxes ranging from 1.3 μmol CO2 m-2 s-1 in the beginning of June to 7.6 μmol CO2 m-2 s-1 in July. In general the CO2 effluxes measured from the most recent clear-cut sites were higher compared to the control forest, but the differences were usually not statistically significant. The CO2 efflux from the clear-cut sites remained high even if a major proportion of the actively respiring root biomass was killed upon clear-cutting. In previous studies, the contribution of root and rhizosphere respiration to soil CO2 efflux has been shown to be around 30-70% of the total respiration in forest soils. Here, the lost root and rhizosphere respiration was probably first masked by the decomposition of logging residue remained in the soil and later by the root respiration of the quickly emerging new ground vegetation. Another explanation to the high CO2 effluxes observed on the clear-cut sites was the soil temperature, which was substantially higher on the clear-cut sites compared to the control forests. We also determined the amount of branches, leaves, needles and other litter as well as the amount of root biomass and humus on the sites. The amount of branches was higher and the root biomass lower on the clear-cut sites compared to control forests still 12 years after clear-cutting, but no systematic difference in the amount of humus was observed between the clear-cuts and controls.

We will continue studying the carbon stocks and fluxes at the sites with a process based model taking into account the decomposition rates of different fractions of soil organic matter, root and rhizosphere respiration and carbon input from photosynthesis.