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Short-term effects of whole-tree and stem-only harvesting on C and N fluxes in two Picea abies stands, Norway

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Tree harvest and different harvesting methods may affect the soil carbon (C) pool in forest ecosystems. In conventional stem-only timber harvesting (SOH), branches and tops that are left in the forests may contribute to the build-up of the soil carbon pool. In whole-tree harvesting (WTH), inputs of organic matter from branches and tops are strongly reduced. We established field experiments at Gaupen, SE and Vindberg, SW Norway, to study the short-term effects of SOH and WTH on processes affecting the accumulation and loss of soil C. Logging residues on the WTH plots were collected in piles that were removed after 6 months, rendering two sub treatments (WTH-pile and WTH-removal areas). We weighed selected trees and logging residues, surveyed understorey biomass production, quantified pre-harvest soil C and nutrient pools down to 30 cm. Soil respiration was measured and soil water sampled monthly during the growing season, while temperature and moisture were measured continuously. Organic and mineral horizons were incubated at different temperatures to estimate potential C and N mineralization, and deep sequencing of the ITS2 barcode region of fungal DNA was performed on the samples. Litterbags were deployed in the SOH plots.

The logging residues amounted to 2.2-2.4 kg C m^{-2}. At Gaupen, the mean *in situ* soil respiration rates increased following harvest with all treatments, but were significantly higher in WTH-pile and SOH relative to the WTH-removal areas in the first year as well as the fourth year of treatment. The former rates included aboveground decomposing needles and twigs but excluded coarser branches. The observed increase in the WTH-removal areas may be related to decomposing roots, as well as to increased C mineralization partly due to the higher soil temperatures following harvest. Soil temperature was the single most important factor explaining the variability in soil respiration rates over all treatments. At Vindberg, a decrease in soil respiration was observed with all treatments in the second and third years following harvest. At both sites, decomposition of logging residues from needles was more rapid relative to twigs and fine roots. The decomposing residues released a substantial amount of nitrogen which was gradually reflected in the soil water at 30 cm soil depth. A considerable increase in the NO_3-N concentration also in the WTH-removal areas in the second year following harvest suggests an increase in N availability from decomposing fine roots and/or soil organic matter. The increased N availability in the WTH-removal areas was supported by results from short term lab incubations of undisturbed soil from the forest floor. The changes in the WTH-removal areas were also reflected in the soil fungal diversity: saprophytic ascomycetes on decaying plant material showed a striking increase in all treatments. For the WTH-removal areas, this may, again, be related to the increased input of root litter; however, the decrease in mycorrhizal basidiomycete species and the vigorous increase of ascomycetes following harvest may also affect the C mineralization of soil organic matter.