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Effects of increased biomass removal on the biogeochemistry of two Norwegian forest ecosystems

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Increased removal of biomass from forested ecosystems for use as an alternative source of energy is an option in several countries. E.g., it is planned to double the use of bioenergy from all sources until 2020 in Norway. A large fraction of this increase is coming from forest resources, e.g. by removing harvest residues like branches and tops. This removal will reduce the supply of nutrients and organic matter to the forest soil, and may in the longer term increase the risk for future nutrient imbalance, soil erosion on steep slopes, reduced forest production, and changes in biodiversity and ground vegetation species composition. However, field experiments so far have found contrasting results in this respect. Soil effects of increased biomass removal will be closely related to soil organic matter (SOM) dynamics, litter quality, and turnover rates. Harvest intensity may affect the decomposition of existing SOM as well as the build-up of new SOM from litter and forest residues, by changing factors like soil temperature and moisture as well as amount and type of litter input. Changes in input of litter with different nutrient concentrations and decomposition patterns along with changes in SOM decomposition will affect the total storage of carbon, nitrogen and other vital nutrients in the soil.

In the context of a Norwegian research project started in 2009, we will quantify how different harvesting regimes lead to different C addition to soil, and determine which factors have the greatest effect on decomposition of SOM under different environmental conditions. Two Norway spruce forest ecosystems will be investigated, one in eastern and one in western Norway, representing different climatic conditions and landscape types. At each location, two treatment regimes will be tested: (1) conventional harvesting (CH), with residues left on-site, and (2) aboveground whole-tree harvest (WTH), with branches, needles, and tops removed. Input of different forest residues will be quantified post harvest. Soil water at 30 cm soil depth will be analysed for nutrients, and element fluxes will be estimated to provide information about nutrient leaching. Soil respiration will be measured, along with lab decomposition studies under different temperature and moisture regimes. Long term in situ decomposition studies will be carried out in the WTH plots using three different tree compartments (needles, coarse twigs, fine roots) decomposing in litter bags, in order to determine their limit value. The structure of the fungal community will be determined by soil core sampling and molecular techniques. Understory vegetation will be sampled to determine its biomass, and the frequency of all vascular plants, bryophytes and lichens will be estimated. After harvesting, replanting will be carried out. Seedling survival, causes of mortality and potential damage, growth, and needle nutrients will be monitored. Results from these studies will be used to identify key processes explaining trends observed in two series of ongoing long-term whole-tree thinning trials. We shall combine knowledge obtained using field experiments with results of modelling and data from the Norwegian Monitoring Programme for Forest Damage and the National Forest Inventory. The overall project aim is to predict and map the ecologically most suitable areas for increased harvesting of branches and tops on a regional scale, and to identify uncertainties and additional knowledge needed to improve current predictions.