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Modelling the ecological consequences of whole tree harvest for bioenergy production

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There is an increasing demand for energy from biomass as a substitute to fossil fuels worldwide, and the Norwegian government plans to double the production of bioenergy to 9% of the national energy production or to 28 TWh per year by 2020. A large part of this increase may come from forests, which have a great potential with respect to biomass supply as forest growth increasingly has exceeded harvest in the last decades. One feasible option is the utilization of forest residues (needles, twigs and branches) in addition to stems, known as Whole Tree Harvest (WTH). As opposed to WTH, the residues are traditionally left in the forest with Conventional Timber Harvesting (CH). However, the residues contain a large share of the tree′s nutrients, indicating that WTH may possibly alter the supply of nutrients and organic matter to the soil and the forest ecosystem. This may potentially lead to reduced tree growth. Other implications can be nutrient imbalance, loss of carbon from the soil and changes in species composition and diversity.

This study aims to identify key factors and appropriate strategies for ecologically sustainable WTH in Norway spruce (Picea abies) and Scots pine (Pinus sylvestris) forest stands in Norway. We focus on identifying key factors driving soil organic matter, nutrients, biomass, biodiversity etc. Simulations of the effect on the carbon and nitrogen budget with the two harvesting methods will also be conducted.

Data from field trials and long-term manipulation experiments are used to obtain a first overview of key variables. The relationships between the variables are hitherto unknown, but it is by no means obvious that they could be assumed as linear; thus, an ordinary multiple linear regression approach is expected to be insufficient. Here we apply two advanced and highly flexible modelling frameworks which hardly have been used in the context of tree growth, nutrient balances and biomass removal so far: Generalized Additive Models (GAMs) and Random Forests.

Results obtained for GAMs so far show that there are differences between WTH and CH in two directions: both the significance of drivers and the shape of the response functions differ. GAMs turn out to be a flexible and powerful alternative to multivariate linear regression. The restriction to linear relationships seems to be unjustified in the present case. We use Random Forests as a highly efficient classifier which gives reliable estimates for the importance of each driver variable in determining the diameter growth for the two different harvesting treatments. Based on the final results of these two modelling approaches, the study contributes to find appropriate strategies and suitable regions (in Norway) where WTH may be sustainable performed.