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Upscaling of greenhouse gas emissions in upland forestry following clearfell

Sylvia Toet (1), Ben Keane (1,6), Sirwan Yamulki (2), Emanuel Blei (3), Simon Gibson-Poole (4), Georgios Xenakis (5), Mike Perks (5), James Morison (2), and Phil Ineson (6)

(1) Environment Department, University of York, York, UK (sylvia.toet@york.ac.uk), (2) Centre for Sustainable Forestry and Climate Change, Forest Research, Alice Holt Lodge, UK, (3) School of Geosciences, University of Edinburgh, Edinburgh, UK, (4) Scotland's Rural College (SRUC), Edinburgh, UK, (5) Centre for Sustainable Forestry and Climate Change, Forest Research, Northern Research Station, Roslin, UK , (6) Department of Biology, University of York, York, UK

Data on greenhouse gas (GHG) emissions caused by forest management activities are limited. Management such as clearfelling may, however, have major impacts on the GHG balance of forests through effects of soil disturbance, increased water table, and brash and root inputs. Besides carbon dioxide (CO_2), the biogenic GHGs nitrous oxide (N_2O) and methane (CH_4) may also contribute to GHG emissions from managed forests. Accurate flux estimates of all three GHGs are therefore necessary, but, since GHG emissions usually show large spatial and temporal variability, in particular CH_4 and N_2O fluxes, high-frequency GHG flux measurements and better understanding of their controls are central to improve process-based flux models and GHG budgets at multiple scales.

In this study, we determined CO_2, CH_4 and N_2O emissions following felling in a mature Sitka spruce (*Picea sitchensis*) stand in an upland forest in northern England. High-frequency measurements were made along a transect using a novel, automated GHG chamber flux system ('SkyLine') developed at the University of York. The replicated, linear experiment aimed (1) to quantify GHG emissions from three main topographical features at the clearfell site, i.e. the ridges on which trees had been planted, the hollows in between and the drainage ditches, and (2) to determine the effects of the green-needle component of the discarded brash. We also measured abiotic soil and climatic factors alongside the 'SkyLine' GHG flux measurements to identify drivers of the observed GHG emissions. All three topographic features were overall sources of GHG emissions (in CO_2 equivalents), and, although drainage ditches are often not included in studies, GHG emissions per unit area were highest from ditches, followed by ridges and lowest in hollows. The CO_2 emissions were most important in the GHG balance of ridges and hollows, but CH_4 emissions were very high from the drainage ditches, contributing to over 50% of their overall net GHG emissions. Ridges usually emitted N_2O, whilst N_2O emissions from hollows and ditches were very low. As much as 25% of the total GHG flux resulted from large intermittent emissions from the ditches following rainfall. Addition of green needles from the brash immediately increased soil respiration and reduced CH_4 emission in comparison to controls.

To upscale our high-frequency 'SkyLine' GHG flux measurements at the different topographic features to the field scale, we collected high resolution imagery from unmanned aerial vehicle (UAV) flights. We will compare results using this upscaling technique to GHG emissions simultaneously measured by eddy covariance with the 'SkyLine' system in the predominant footprint. This detailed knowledge of the spatial and temporal distribution of GHG emissions in an upland forest after felling and their drivers, and development of robust upscaling techniques can provide important tools to improve GHG flux models and to design appropriate management practices in upland forestry to mitigate GHG emissions following clearfell.