14. Approaches to incorporate the effects of climate change and land use change in LULUCF projections (WP 2.11)

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14.1 Introduction

The impact of changes in the environmental drivers (climate, nitrogen deposition and CO_2) upon the LULUCF projections has not been considered in previous inventory contracts (Milne *et al.* 2003). However, recent research has shown that C-sinks in European forests have been affected by 20th century changes in climate, atmospheric CO_2 and particularly nitrogen deposition, and that changes in these environmental drivers will continue to affect carbon budgets(e.g. van Oijen *et al*. 2004 and in press). In order to include the effects of climate change (and other indirect factors), mechanistic models are needed which represent the processes which are actually affected by these changes (principally photosynthesis, respiration, growth and decomposition), and that include the effects of land use change and land management. Here, we propose to apply two such models (both developed at CEH Edinburgh) to the UK at a 20km grid scale, to estimate the total flux and the components attributable to direct and indirect factors. The first simulates forest growth influenced by stand management (BASFOR)); (the second is a dynamic global vegetation model linked to global climate models (GCMs) (HyLand). Using these models, we will perform simulations with and without climate change to calculate the effect on LULUCF carbon fluxes. We can thereby 'factor out' the component of the LULUCF flux which results from anthropogenic climate change. We will then repeat this for other the indirect factors - CO_2 and nitrogen deposition and can account for interactions using a partial factorial design.

14.2 Methods

14.2.1 BASFOR methodology - afforestation

This work builds on development of BASFOR in the previous inventory contract (van Oijen *et al* 2005) to determine whether robust relationships between environmental drivers and carbon storage can be identified that can be used to improve the simple semi-empirical forest model CFLOW. BASFOR is a suitable tool for this work because it is of sufficient complexity to account for the different environmental drivers in a mechanistic way, while still being fast enough to allow the large number of runs required by the Bayesian calibration.

BASFOR will be calibrated using data collected in the UK plots of the Intensive Forest Monitoring Network (Level II). A range of data-sets are collected, including growth, foliar chemistry, soil chemistry and characteristics, leaf area index and phenology, will be processed and made available. These data, augmented by data from FR's Permanent Measurement plot network as appropriate, will provide input to Bayesian calibration of the model.

1. Parameterize BASFOR using new data from the Forestry Commission using Bayesian calibration
2. Uncertainty analysis to determine whether the effects of the environmental drivers can be captured in simple, robust algorithms for incorporation in CFlow.
3. Identify the most suitable algorithms for representing the nitrogen cycle in Hyland.

14.2.2 HyLand methodology – all land use change

As the HyLand model has been applied previously at the global scale, the main computational procedures are in place.

1. Assemble and format climate data for the historical period for the UK 20 km grid, and extend to 2100 using the UKCIP projections for climate.
2. Calculate land use change matrices for the 20 km grid for the historical period, based on previous CEH work, and extend to 2100 using the SRES scenario projections, as down-scaled in the EU ATEAM (Rounsevell *et al*. 2006) project.
3. Calibrate the model to correctly predict the UK vegetation and soil carbon stocks for the near-present day (to 2020).
4. Perform full simulations to estimate the LULUCF flux from a pre-history "spin-up" period to 2100. Long simulations are necessary, because of the long time scale of soil carbon turnover, but interest in the results will be focussed on 1990 to 2020. An incomplete factorial experimental design will be used, to allow the effects of climate change and CO_2 on the LULUCF flux to be quantified (as in Levy *et al*. 2004).

14.3 Progress to date

The bulk of this work is planned for winter 2007/08, but the initial task is to produce the input data sets required by the two models for these simulations. The key inputs are land use, land use change, climate, soil nitrogen, and nitrogen deposition, all on a 20km grid covering the UK. This is largely complete for climate, and relatively straightforward for land use change and nitrogen deposition. An MSc student from University of York (Andrew Clark) will work on this project for three months from June 2007 as a summer placement, and is expected to complete the input data sets and perform preliminary model runs. The simulations are likely to be repeated later in the project, when the estimated land use change matrices change as data analysis proceeds in related work packages.

14.4 References

Levy, P.E., Cannell, M.G.R. and Friend, A.D. (2004) Modelling the impact of future changes in climate, CO_2 concentration and land use on natural ecosystems and the terrestrial carbon sink. *Global Environmental Change-Human and Policy Dimensions*, 14, 21-30.

Meir P., Conen, F. and Nagy, L. (2003) Baseline survey of carbon stocks at selected SFA sites in Scotland. Interim report for 2003, covering measurements made at three sites: Abernethy Forest Reserve, Glen Sherup and Darrochwids. Unpublished report to SFA/BP/ECCM, Edinburgh.

Milne R.M. *et al.* (2003). UK Emissions by Sources and Removals by Sinks due to land Use, Land Use Change and Forestry Activities. Report, April 2003, DEFRA Contract EPG1/1/160.

Rounsevell M.D.A., Register I., Araùjo M.B. *et al.* (2006) A coherent set of future land use change scenarios for Europe. *Agriculture, Ecosystems and Environment* (in press).

van Oijen, M., Cannell, M.G.R. & Levy, P.E. (2004). Modelling biogeochemical cycles in forests: state of the art and perspectives. In: Andersson, F., Birot, Y. & Päivinen, R. (Eds.), *Towards the Sustainable Use of Europe's Forests – Forest Ecosystem and Landscape Research: Scientific Challenges and Opportunities.* EFI Proceedings No. 49, European Forest Institute: 157-169.

van Oijen, M., J. Rougier and R. Smith (2005). Bayesian calibration of process-based forest models: bridging the gap between models and data. *Tree Physiology*. 25:915-927.

van Oijen, M., Ågren, G.I., Chertov, O.G., Kellomäki, S., Komarov, A., Mobbs, D.C. & Murray, M.B. (in press). Evaluation of past and future changes in European forest growth by means of four process-based models. In: *Causes and Consequences of Forest Growth Trends in Europe - Results of the RECOGNITION Project*. Eds. T. Karjalainen and A. Schuck. Brill, p. Chapter 4.4.