SECTION 8
Modelling of carbon uptake in UK forests using the EuroBiota model

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Introduction

Within the EU funded project "Long-term effects of climate change on carbon budgets of forests in Europe" (LTEEF II) (Kramer & Mohren, 2001) a process based model of the growth of plantation forests was developed. This "EuroBiota" forest ecosystem model primarily describes the effect of changing temperature and atmospheric carbon dioxide concentration on productivity. The model is based on the work of Wang & Polglase (1995) who described these effects on 3 different biomes. Extensive modification of the original model has taken place to allow the influence of geographical variation in weather and the presence of evergreen and deciduous forest at different locations to be taken into account. The model was paramaterised using results from site specific process models which had been calibrated against field data at a range of locations across Europe. For application to European forest areas for each cell of size 0.5^o x 0.5^o across the continent were estimated from the USGS/IGBP-DIS Global Land Cover Characteristics 1 km scale data projected to latitude/longitude. Conifer and deciduous forests were distinguished. The effect of changing air temperature was described using a version of the CRU 1901 - 1995 climate data but regridded to the 0.5^o cell size. Changes in carbon dioxide concentration throughout Europe followed the IS92a emission scenario and were as estimated by University of Berne for the IPCC Second Assessment Report.

Progress in application of EuroBiota to UK forests.

The EuroBiota model has now been tested for use specifically in the UK. A major difference with the European scale work was to estimate the forest area in each 0.5^o cell in the UK from the CEH/DETR 1 km scale carbon database. The total area from this database is closer to that recorded by the Forestry Commission and DARDNI compared to the USGIS map due to the better resolution.

The model was run for UK forests in 3 stages. 1: The carbon pools were initialised with effectively zero value and 1901 weather and carbon dioxide conditions assumed for each subsequent year and the model run to equilibrium carbon stocks. 2: Using these equilibrium tree and soil carbon stocks as new starting values, the model was rerun with changing temperature and carbon dioxide for the years from 1901 to 2100 3: To assess the effect on productivity of the specific age structure in the UK this transient run was recalculated, but all forests had a simulated felling and replanting in the year indicated by the average age of forest for the year under consideration. The average of forest age for

the UK was calculated from the distribution of ages for 1990 used in the EFISCEN model, also developed in LTEEF II.. This felling and replanting was modelled by removing in the appropriate year all stem carbon from the model and transferring leaf and root carbon to the litter pools. The forest was then forced to re-established. The result of this approach is that productivities will depend, not only due to local weather conditions, but on the stage of recovery which the model forest has reached since the simulated felling/regrowth.

Results

Some preliminary results have been obtained for conifer forests. The model did nor perform well for broadleaved forests in the UK. This is presently being investigated and may be due to inappropriate parameters describing the initial and cessation of growth in summer.

In Table 1 the weighted mean uptake rate of carbon per unit area of UK conifer forest is shown to be about 1 tC ha^{-1} a^{-1}. The distribution of forest used in the EuroBiota modelling is shown in Figure 1a and of Net Ecosystem Productivity in Figure 1b. Taking into account the total area of conifer forest the total uptake of carbon is 1.7 MtC a^{-1}. The results in Table 1 are in broad agreement with carbon stocks and fluxes estimated previously from inventory data and the C-Flow model for the UK Greenhouse Gas Inventory submissions relating to afforestation. This suggests further development of the model for assessing the future sink strength of forestry will be useful.

Future work

- Development of parameters for broadleaf forests
- Projection of future carbon uptake using climate change scenarios
- Investigation of possible use of forest area and age data from the Forestry Commission (This data to be obtained under funding from sub-contract from NETCEN, primarily to disaggregate national GHG LUCF sink data)

Table 1: Stocks and fluxes of carbon for UK coniferous forests in 1990 estimated from the EuroBiota model. NPP is Net Primary Productivity, Rs is Soil Respiration and NEP Net Ecosystem Productivity. Forest area was estimated from Forestry Commission data.

	Plant carbon ($tC\ ha^{-1}$)	**Soil carbon ($tC\ ha^{-1}$)**	**NPP ($tC\ ha^{-1}\ a^{-1}$)**	**Rs ($tC\ ha^{-1}\ a^{-1}$)**	**NEP ($tC\ ha^{-1}\ a^{-1}$)**
	35	40	3.1	2.0	1.1
Forest area (km^2)	**Plant carbon (MtC)**	**Soil carbon (MtC)**	**NPP (MtC a^{-1})**	**Rs (MtC a^{-1})**	**NEP (MtC a^{-1})**
15,820	56	64	4.9	3.2	1.7

References

Kramer, K. & Mohren G.M.J. (2001) *Long-term effects of climate change on carbon budgets of forests in Europe.* Final report of EU-funded project "Long-term regional effects of climate change on European forests: impact assessment and consequences for carbon budgets (LTEEF-II, ENV4-CT97-0577)"

Wang, Y-P. & Polglase, P.J. (1995) Carbon balance in the tundra, boreal forest and humid tropical forest during climate change: scaling up from leaf physiology and soil carbon dynamics. *Plant, Cell and Environment*, **18**, 1226-1244.

Figure 1: Distribution of forest area and Net Ecosystem productivity (NEP) for each 0.5° x 0.5° grid cell in the UK. Forest area distribution is derived from CEH/DETR carbon database. NEP is output for 1990 from EuroBiota model.