Combining land-use statistics with process-based ecosystem modelling to estimate the European carbon balance

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Introduction

Recent studies based on eddy-covariance measurements and statistical approaches indicate that Europe's terrestrial biosphere presently acts as a small net carbon sink (e.g. Janssen *et al.*, 2003). Uncertainty inherent to the upscaling is of a similar magnitude than the net C flux itself. Complementary approaches to constrain to the C budget of the European terrestrial biosphere and to scale ecological knowledge from sites to a continental scale include ecosystem models.

Here we present and evaluate an advanced version of the LPJ-DGVM (Sitch *et al.*, 2003) that combines generic representations of croplands, managed forest ecosystems, and natural vegetation dynamics within a common land-atmosphere coupling scheme. The model is forced with present-day climate and patterns of landuse change derived from landuse statistics to estimate the net C balance of Europe on a 10' grid.

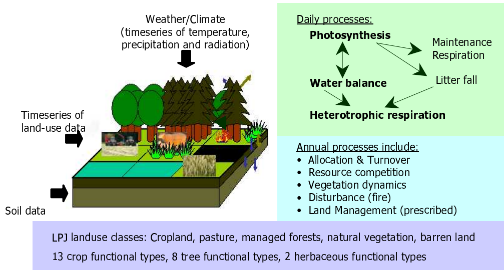

Fig 1: Schematic digramm of the main processes, landcover classes and functional types represented in LPJ

Model Evaluation

C Fluxes, FPAR and yields of croplands

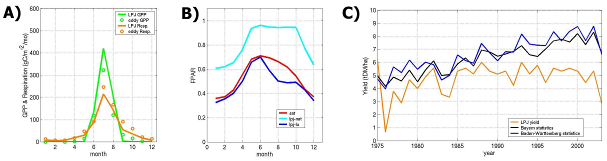

Fig. 2: A) Modelled GPP and ecosystem respiration for a spring barley site in Southern Finland (60°54' N 23°30' E) agree well with eddy-covariance data even without site-specific parameterisation. **B)** Mean seasonal cylce of FPAR (1982-2000) for a European window (34°N-70°N / 11°W-40°E) from LPJ (lpj-nat: potential natural vegetation) is improved in comparison to AHVRR (sat) data when accounting for actual landcover and crop functional type phenology (lpj-lu). **C)** Grain maize yield estimates for two federal states in Southern Germany show fair agreement with yield statistics, apart from a linear trend due to technological advances.

C Fluxes and developemt of growing stock in forests

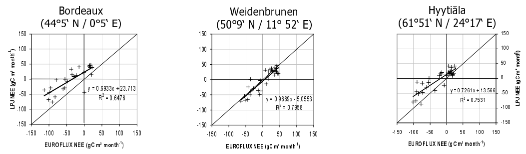

Fig. 3: Seasonal C fluxes at three coniferous forest sites as simulated by LPJ agree well with eddy-covariance measurements along a climatic gradient from mediterranean to boreal conditions (1996-2000)

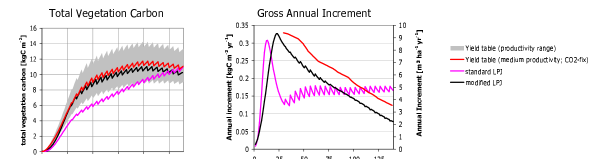

Fig. 4: Tree growth in LPJ compared to the yield table of *pinus sylvestris* in Germany (reference period 1931-1960). Allocation in LPJ was modified to account for the age-related decline in forest productivity, following a version of the hydraulic limitation theory as proposed by Magnani *et al.* (2000)

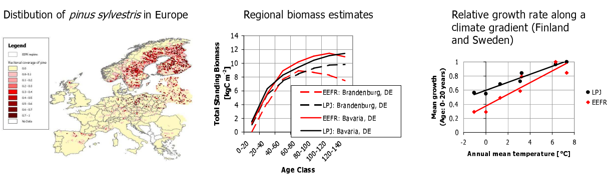

Fig. 5: Example for the comparison of LPJ simulations against EEFR inventory data on a regional scale. LPJ is capable of reproducing reasonably the temporal development of growing stock, as well as the gradient in growth along a climatic gradient from Nothern Finland to Southern Sweden.

Model Drivers

Landuse data and landuse change

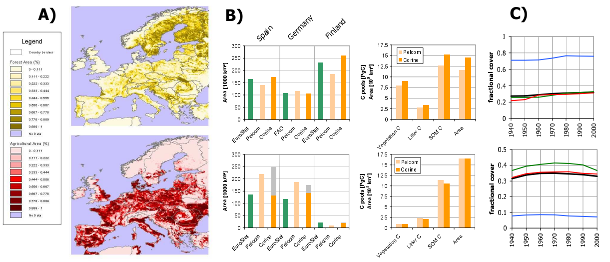

Fig. 6: Panal **A** shows the current distribution of forest (above) and agriculture (below) from a combined CORINE and PELCOM map. Both remote-sensing landuse classications differ in their area estimates, partly due to classification differences (grey bars). Panel **B** also shows the implications of this difference for carbon stock estimates in EU15+Norway and Switzerland. Panal **C** shows the change in landcover (1940-2000). These changes have been mapped onto the landcover map extending the algorithms from Ramankutty and Foley (1999) and Goldwijk (2001).

Forest management

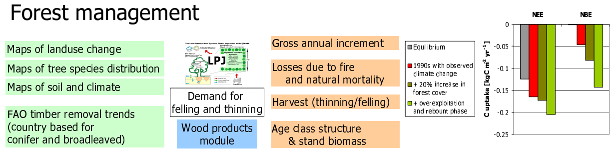

Fig. 7: Conceptual diagram of the forest management implementation in LPJ. Climate, landuse change, and changes in wood demand affect forest growth and age-structure. Right: NEE and NBE (accounting for the flux from wood-products) in equilibrium, taking account of observed climate and CO_2 change, after a hypothetical 20% increase in forest area and following overexplaiotation

Preliminary Results

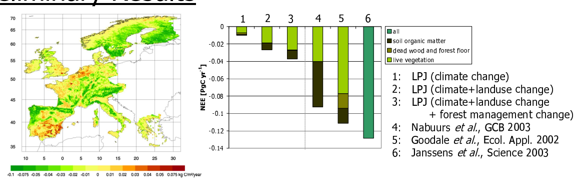

Fig 8: NEE (all landuses, excluding flux from wood products) for the 1990s. Right: C uptake of forests, split into the components climate change, landuse+climate change and management+landuse+climate change, in comparison estimates based on inventory and upscaled eddy-covariance measurements.

Preliminary runs confirm that Europe presently acts as a small net C sink, mainly resulting from C sequestration in forest ecosystems, whereas agricultural landscapes appear as net C emitters. The effect of landuse change and changes in large-scale forest management affect Europe's terrestrial C balance to at least a similar extent than growth increases as a consequence of observed climate change.