Modelling Carbon Storage of a Temperate Mountain Grassland as Affected by Management

Albin Hammerle*, Georg Wohlfahrt[a] & Mathew Williams[b]

TERRESTRIAL ECOSYSTEM PHYSIOLOGY

* ETH Zurich | Institute of Plant, Animal and Agroecosystem Sciences | 8092 Zurich | Switzerland | halbin@ethz.ch

ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich

Background

Around 30% of the anthropogenic emitted CO_2 is sequestered by terrestrial ecosystems.

Grasslands cover 40% of ice-free land surface and 22% of the area of the EU-25 (greater part of them managed).

Management practices decisively influence the net ecosystem carbon balance (NECB).

OBJECTIVE

Can the NECB be improved by changing the cutting dates and/or frequency without compromising yield?

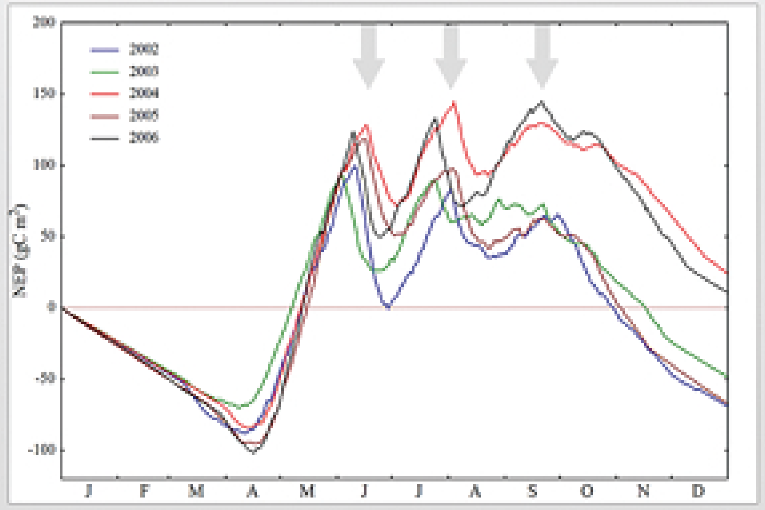

Fig. 1 Time-series of net ecosystem production (NEP) for the years 2002 to 2006. Arrows indicate cutting dates.

[a] University of Innsbruck, Institute of Ecology, Sternwartestr. 15, 6020 Innsbruck, Austria

[b] University of Edinburgh, Institute of Atmospheric and Environmental Sciences, School of GeoSciences, Edinburgh EH9 3JN, UK

Williams M., Schwarz P. A., Law B. E., Irvine J. and Kurpius M., 2005 An improved analysis of forest carbon dynamics using data assimilation. Global Change Biology, 11, 89–105.

Methods

i) Experimental approach:

The meadow, situated at an elevation of 970 m a s l. in the vicinity of the village Neustift in the Stubai Valley (Austria), is cut three times a year (Fig. 1) and receives organic fertiliser in late autumn.

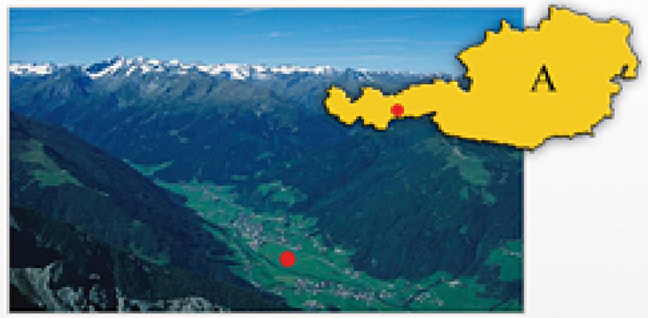

Fig. 2 View of the site in the Stubay Valley (Austria).

Turbulent CO_2 fluxes were measured with the eddy covariance method and the amount of above-ground-bio mass was determined in a destructive way by harvesting.

ii) Modelling:

To examine the question adressed we adapted the DALEC model developed by Williams et al. (2005) for a managed grassland to model the C-balance of the grassland ecosystem.

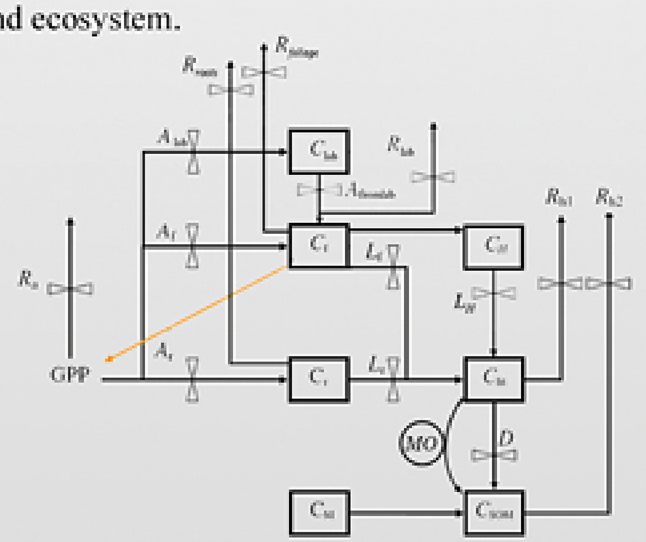

Fig. 3 Schematic structure of the model used, showing pools (boxes) and fluxes (arrows). Allocation fluxes are marked A, litterfall fluxes by L, and respiration by R. D is a decomposition flux and GPP is gross primary production. MO represents a possible priming effect via micro organisms.

Results & Outlook

Reasonable agreement between the model data and the measured variables is achieved as shown in Fig 4. Short-term high carbon losses following the cutting events can not be explained satisfactorily by the current model version as R_{eco} is underestimated (Fig. 5), the reason for which are currently unclear.

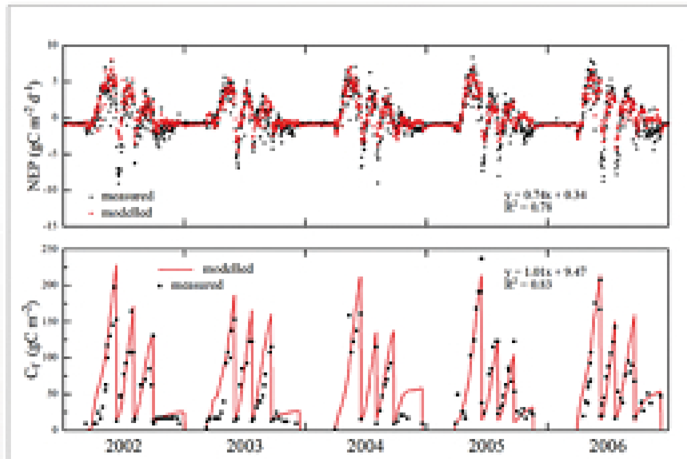

Fig. 4 Time series of measured and modelled NEP and foliar carbon pools (C_f) from 2002 to 2006.

i) Current cutting dates result in close-to-optimal yields and a more or less neutral C balance.

ii) Pre- or postponing cutting dates may improve the NECB, but these shifts would lead to reductions in yield.

iii) Implementing a fourth cut per season would lead to comparable yields but would generally worsen the carbon balance

iv) Reducing the cutting frequency to two cuts per season has an enormous positive effect on the NECB at the expense of yield (Fig. 6).

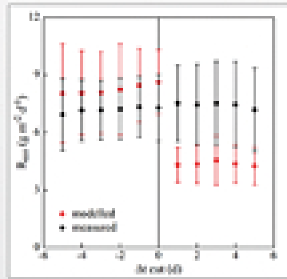

Fig. 5 Average daily ecosystem respiration (2002 - 2006) five days prior and five days after the 15 cutting dates.

The MAJOR CONCLUSIONS from this simulation study are that the current traditional management results in close-to-optimal yields with a close-to-neutral NECB.

Intensification of management appears to lead to marginal improvements in yield alongside with larger carbon losses, while extensification promotes carbon storage but is associated with appreciable reductions in yield.

The underestimation of ecosystem respiration after cutting events requires further analysis.

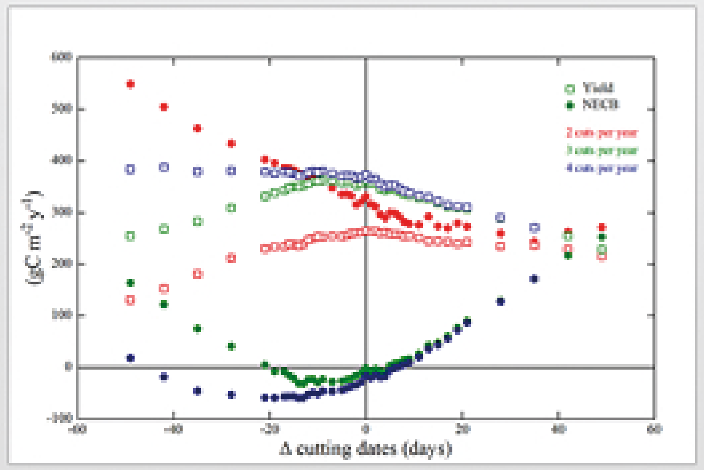

Fig. 6 Effects of parallel pre- or postponed cutting dates and of different cutting frequencies on the NECB and yield.

Outlook

Experimental validation of model by means of management manipulation experiments.

Explore interactive effects of changes in management and likely future changes in climate and to develop appropriate mitigation options