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PREFACE TO CARBOMONT SPECIAL FEATURE

Effects of Land-Use Changes on Sources, Sinks and Fluxes of Carbon in European Mountain Grasslands

Alexander Cernusca,[1]* Michael Bahn,[1] Frank Berninger,[2] Ulrike Tappeiner,[1,3] and Georg Wohlfahrt[1]

[1]*Institut für Ökologie, Universität Innsbruck, Sternwartestr. 15, 6020 Innsbruck, Austria;* [2] *Department of Biological Science, University of Quebec at Montreal, P.O. Box 8888, H3C 3P8 Montreal, Canada;* [3] *Institute for Alpine Environment, European Academy Bozen/Bolzano, Viale Druso 1, 39100 Bolzano, Bolzano-Bozen, Italy*

Mountain regions are important sources of water (Mountain Agenda 1998), centers of biodiversity (Körner and Spehn 2002) and areas for recreation and tourism, but they are also highly sensitive to human (Cernusca and others 1999) and climate effects (Beniston 1994). Ongoing socio-economic changes have strongly influenced land use in mountain areas, resulting in patterns of intensification and abandonment that differ across Europe (Tappeiner and others 2003). During the last decade there have been considerable efforts to assess the contribution of different ecosystems to the global carbon cycle (Baldocchi 2008). There is already substantial information on the carbon sequestration of forest ecosystems (Valentini and others 2000); however, data on the carbon cycling of non-forest ecosystems are still underrepresented (Falge and others 2002). Grasslands cover about 40% of the global terrestrial ice-free surface, but their contribution to local and regional carbon fluxes remains uncertain (but see Gilmanov and others 2007; Sousanna and others 2007). Furthermore, there are no studies that address the carbon balances of European semi-natural grasslands, as most of the mountain grasslands are, but studies have focussed on more intensively managed cultivated grasslands or semi-arid grassland areas. The studies carried out so far suggest that grasslands can be either a sink or a source of carbon (Novick and others 2004; Gilmanov and others 2007). The causes for the observed variability, in particular inter-active effects of climate and land use on the grassland CO_2 source/sink strength, have not yet been addressed.

This special feature investigates the dynamics of and the controls on the carbon cycling of mountain grasslands across a European transect and develops a perspective of landscape-scale changes of carbon fluxes in relation to scenarios of future land use resulting from likely socio-economic developments. It is based on results of the European Union project CarboMont (EVK2-CT2001-00125), which has studied effects of land-use changes on carbon sources, sinks and fluxes in mountain grasslands at 13 sites across Europe (Figure 1).

The first paper (Wohlfahrt and others 2008) analyses biotic, abiotic and anthropogenic controls on the net ecosystem CO_2 exchange (NEE), and its components gross primary production and total ecosystem respiration. It provides a large-scale functional analysis of the major driving forces

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*Corresponding author; e-mail: Alexander.Cernusca@uibk.ac.at

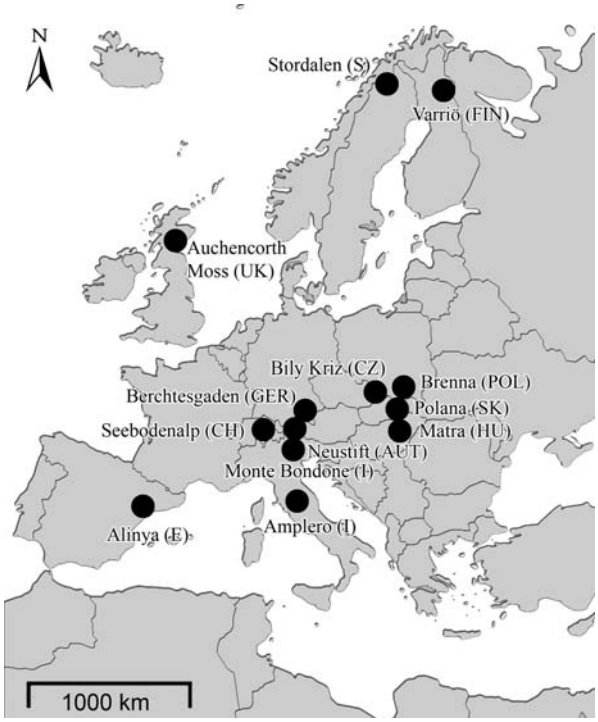

Figure 1. Map of Europe showing the location of the CarboMont study sites; country abbreviations are shown in parentheses for each site.

determining the carbon cycle of grasslands across Europe. The main finding of Wohlfahrt and others (2008) is that the timing and frequency of land management practices, through triggering rapid changes in the amount of aboveground plant matter, is crucial for the short-term sensitivity of NEE to climatic drivers.

The second paper (Bahn and others 2008) addresses the topic of soil respiration, which has received considerable attention in a vast range of ecosystems, but so far still awaits a synthetic exploration for grasslands, where it has a potentially higher impact on the total ecosystem respiration as compared to many other ecosystems. Bahn and others (2008) show that soil respiration of Central European mountain meadows are amongst the highest so far reported for any type of ecosystem. They demonstrate that assimilate supply, as modulated by climate and grassland management, may affect soil respiration at timescales from annual to daily. Across sites, soil respiration at a reference temperature increased with mean annual soil temperature, leaf area index and gross primary productivity, indicating that assimilate supply overrides potential acclimation to prevailing temperatures.

Papers three and four expand the ecosystem studies presented in papers 1–2 to the larger context of landscape dynamics. Paper three (Bayfield and others 2008) investigates the likely effects of different policy scenarios on the future land use in different European mountain regions, as derived from stakeholder consultation and decision modelling. Bayfield and others (2008) predict that there will be widespread reductions in the agricultural sector across Europe in the next 20 years at the expense of increases in transport, built environment and tourism sectors. Reductions are expected to be most severe under the scenario of a rapid reduction in farm income support, less when current rural funding continues, and were predicted even for the scenario of increasing funding for rural diversification.

Based on likely future scenarios developed by Bayfield and others (2008) and by means of a Markovian model, paper four (Tappeiner and others 2008) derives spatially explicit historical, actual and future scenarios of landscape development and analyses their effects on the landscape carbon pools. A closely related study by Tenhunen and others (2008), which simulates the cycling of carbon and water at the landscape-scale, is currently in press. The main finding of Tappeiner and others (2008) is that during the past 140 years more than 47% of the total and more than 90% of the usable agricultural land in the study area have undergone change in land use and that these changes have led to an increase in carbon stocks by 21%. All future scenarios predict only minor increases in carbon stocks because major landscape elements will be either largely unaffected (forest, rocks, screes) or are unimportant in their spatial extent (built environment).

In summary, the set of papers compiled in this special feature attributed to the EU CarboMont project shows that land management, through triggering rapid changes in the amount of assimilating plant matter and assimilate supply to belowground organs, is a crucial driver for both the uptake and the release of CO_2 by/from European mountain grasslands. Land management, in turn, is to a large extent the result of socio-economic framework conditions set by agricultural policies. In this special feature three contrasting likely future European policy scenarios are considered and it is predicted that they lead to widespread reductions in the agricultural sector. As exemplified for a typical Alpine Valley, these reductions in land use are likely to cause, as opposed to historical changes, only modest increases in landscape carbon stocks.

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