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Carbon balance of Hungarian grasslands in years with contrasting weather conditions

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ABSTRACT Net ecosystem exchange (NEE) was continuously measured by the eddy covariance technique over sandy and mountain (heavy clay soil) grasslands at Bugacpuszta and Szurdokpüspöki (Mátra) in 2003 and 2004. The heat wave in 2003 caused the grasslands to become net sources of carbon dioxide. Drought affected the C-balance of mountain grassland more adversely than that by the sandy grassland. Similar differences between the grasslands in their after drought recovery capacities (in terms of NEE) have also been observed. These differences are probably related to the different water economy of the soils and to the fact that significant part of the root system is in the upper 20 cm in the case of the grasslands. While the climate conservation potential of terrestrial vegetation is doubted, existence of a positive feedback at the global scale (between temperature and source activity of vegetation) may lead to desertification through loss of soil organic C by soil respiration as a first step.
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KEY WORDS

carbon balance
eddy covariance
global warming
grasslands

Grasslands are significant type of natural vegetation. On global scale grasslands cover about 24% of the Earth's vegetated area. They occur over a very broad range of climatic and soil conditions and vary from natural grasslands to intensively managed sown pastures. Grasslands account for about 12% of the total carbon storage in the terrestrial biosphere and might therefore contribute significantly to the changes in carbon cycling (Campbell and Smith 2000). Hence the reasons for the global changes in climate and the composition of the atmosphere and their influences on the near and distant future of life cannot be predicted without knowing the role of natural grassland ecosystems. Moreover a wider knowledge of the carbon cycle of grassland ecosystems could modify or overwrite the currently prevalent international agreements on CO_2 emission.

The paper describes some of the preliminary results of the ecological research on carbon cycling and greenhouse gas balances in Hungarian grasslands. The main goals of the research are to describe the structure, function and functional-ecological responses of natural grassland vegetations of the Carpathian Basin under changing climatic conditions. The ecophysiological research activities are extended to the CO_2 fluxes, C-cycling in the atmosphere-vegetation-soil system and the greenhouse gas (GHG) balances of the concerned ecosystems. The results can also be extrapolated to the surrounding geographical region.

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Materials and Methods

Investigated grasslands and their land use. Bugac site (Great Plain, 46°41′ N 19°36′ E): Potentillo-Festucetum pseudovinae temperate semiarid sand grassland, grazing; Mátra site: Festuca rupicola dominated mountain pasture (*Festucetalia valesiaca*) and managed sown grassland (Mátra mountain, 47°50′ N 19°42′ E), grazing/cut and fertilization; Gödöllő site: temperate semiarid nutrient rich loess grassland (*Salvio-Festucetum rupicolae*), irrigation and fertilization; Vácrátót site: temperate semidesert sand grassland (*Festucetum vaginatae-danubiale*), unmanaged.

CO_2 and N_2O flux and CO_2 exchange measurements: At Bugac and Mátra site the CO_2 flux measurements were carried out by eddy covariance method (Aubinet et al. 2000) using a LI-COR 7500 open path infrared gas analyser and an Gill R3 (Gill instruments Ltd.) or a CSAT3 (Campbell Sci. Ltd., USA) three-dimensional sonic anemometers. CO_2 exchange rates and carbon balances have been measured by the chamber technique (sites: Gödöllő, Vácrátót). N_2O flux measurements were done by cuvette methods (Ambus and Christensen 1995) at Bugacpuszta and Gödöllő.

Results and Discussion

Carbon balances: The grassland at "Bugac puszta" in the first measuring year from July, 2002 to June, 2003 the grassland acted as a weak CO_2 sink, as the yearly carbon uptake was around 30 g m^{-2} $year^{-1}$. In 2003 due to the unusually heavy summer drought the C-balance was negative; but over the

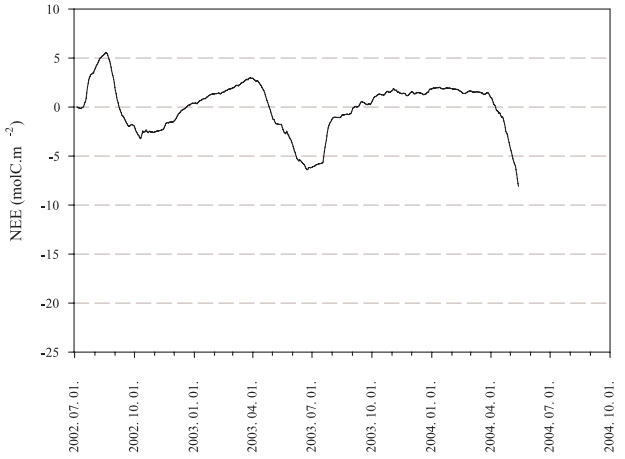

Figure 1. Cumulative daily values of Net Ecosystem Exchange at the Bugac site from the start of the eddy covariance measurements in July, 2002 to the end of September 2004.

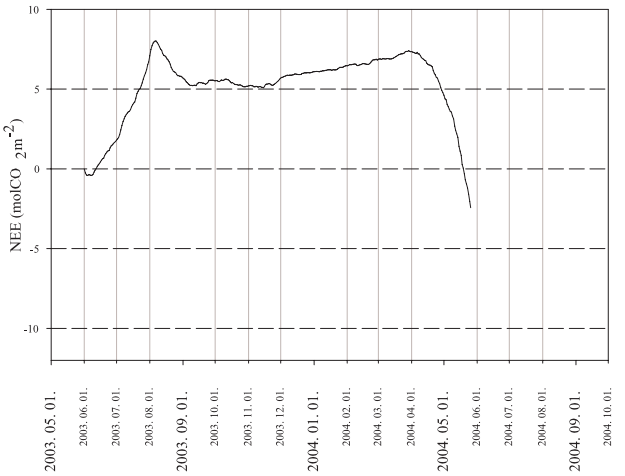

Figure 2. Cumulative daily values of Net Ecosystem Exchange at the Mátra site from the start of the eddy covariance measurements in June, 2003 to the end of September 2004.

whole year, the grassland was a slight C-sink. C-incorporation was around 220 g CO_2 m^{-2} $year^{-1}$ (Fig. 1). The *Festuca rupicola* grassland in the Mátra mountains also proved to be a source of CO_2 in the summer of 2003 (Fig. 2), while it was a sink in the summer of 2004, similarly to the Bugac site due to the favorably wet spring period in that year.

The extreme drought event in 2003 resulted in the dominance of ecosystem respiration processes over the assimilation. The grassland at Bugac was more tolerant to drought in terms of NEE than the grassland at the Mátra site. The reason behind much probably is in the contrasting water economies of the soils at the two sites, as the amount of water available to plants was less in the heavy clay soil at the Mátra site than in the sandy soil at the Bugac site.

Dominance of respiration processes under drought can lead to opening up and desertification of the grasslands and present a potential positive feedback to global warming.

The *Salvio-Festucetum rupicolae* associations on loess soils, absorbed large quantities of C in late spring. The sandy grasslands, *Festucetum vaginatae danubiale* associations (Vácrátót) proved to be a C-sink in spite of the drought. In this grassland the maximum CO_2 uptake and release measured by chamber technique, were -3.24 µmol m^{-2} s^{-1} and 1.903 µmol m^{-2} s^{-1} respectively, indicating a relatively low carbon sequestration potential.

Grasslands on loess soils were weak sinks of CO_2, two years after being treated with chemical fertilizers, whereas irrigation resulted in threefold increase of the amount of absorbed CO_2. Preliminary results on the nitrous oxide emission indicate that the flux strongly correlates with the soil temperature. The results are highly differing between sites the, emission flux ranges between 0.2 and 125 µg N m^{-2} h^{-1}.

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