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Effects of different land use change on temperate semi-natural grasslands

Szilárd Czóbel[1]*, János Balogh[2], Szilvia Fóti[1], Orsolya Szirmai[2], Zoltán Nagy[1], Evelin Péli[2], János Nagy[1], Tibor Szerdahelyi[1], Attila Engloner[1], László Horváth[3], Krisztina Pintér[4], Zoltán Tuba[1,2]

[1]Department of Botany and Plant Physiology, Szent István University, Gödöllő, Hungary, [2]Plant Ecology Research Group of Hungarian Academy of Sciences, Gödöllő, Hungary, [3]Forest Research Institute, Budapest, Hungary, [4]Department of Meteorology, Eötvös Loránd University, Budapest, Hungary

ABSTRACT The specific objectives of this study were to determine the effects of different land use changes (extensive grazing, fertilization and irrigation) on the botanical and soil parameters, plant biomass production and CO_2 gas exchanges and to provide data for model development. Experimental work has been carried out for 3 years in two characteristic semi-natural temperate grassland type of Hungary. Small grassland plots were positioned along two transects at fertilized and irrigated sites of loess steppe. At the fertilized (Isaszeg) site, mineral fertiliser was applied once a year at the beginning of the vegetation period, while top spray irrigation was operated continuously during each vegetation period at the irrigated site (Gödöllő). On the plain site an area of 6 ha of dry sand grassland was fenced off from the extensively grazing cattle herd. The shortest response of land-use change can be observed at botanical composition and partly at NEE (CO_2), whereas soil parameters are significantly affected at longer time-scale. The observed changes were strongly correlated to climatic conditions, emphasized the importance of the water regime. **Acta Biol Szeged 49(1-2):133-135 (2005)**

KEY WORDS

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Temperate grasslands represent of the earth's major biomes, and one of the most productive and diverse of all terrestrial ecosystems (IUCN 1999). Unlike forest ecosystems, generally less than 1% of grassland organic C is in aboveground plant biomass (Burke et al. 1997), with the majority of plant C residing in plant roots (~90%). Yet few studies have actually measured the complete C budgets of grasslands, but the data available suggest that C content varies widely among different grassland types (Reeder and Schuman 2002). Variation in C content across grassland types is largely a function of climatic and edaphic factors. Organic C tends to increase with annual precipitation, and decrease with increases in mean annual temperature (e.g. Burke et al. 1989).

Grassland plant communities (both semi-natural and anthropogenic), are considered as an indicator of the land use management factor, such as inappropriate agricultural practices or land use changes could generate biodiversity loss, hereby modification in botanical and soil composition (Alard et al. 1994). Managed grasslands play an important role in the European carbon balance, but despite this fact most of the related studies deal only with their impact on soil respiration rate (Bouma and Bryla 2000).

The main goals of this study were to determine the short-term (3-year period) effects of different land use changes (extensive grazing, fertilization and irrigation) on the botanical and soil composition, production and CO_2 gas exchanges and to provide data for model development. Experimental work has been carried out for 3 years in two characteristic semi-natural temperate grassland type of Hungary since 2002. In an attempt to schematize these issues, we focus on a multiscale approach, involving synecological and synecophysiological (flux measurements) levels. The results can be extrapolated for the surrounding geographical region too, what makes this research even more meaningful.

*Corresponding author. E-mail: Czobel.Szilard@mkk.szie.hu

Materials and Methods

In situ measurements were carried out on a tall-grass loess steppe (*Salvio-Festucetum rupicolae*) near Isaszeg (47°42'N, 19°24'E, 255 m a.s.l.) and in the Botanical Garden of Szent István University (47°36'N, 19°26'E, 220 m a.s.l.), Gödöllő (transplanted monoliths from Isaszeg), and parallel on a semi-arid short-grass sand vegetation (*Cynodonti-Festucetum pseudovinae*) close to Bugacpuszta (46°41'N, 19°36'E, 230 m a.s.l.). Small grassland plots (5-5 treated and control) were positioned along two transects at fertilized and irrigated sites of loess vegetation. Fertilizer at Isaszeg Site was applied once a year in early summer in 2002 and at the beginning of the vegetation period in the ensuing years. The following amount were dispersed: 100 kg N ha^{-1}, 50 P ha^{-1}, 50 K ha^{-1}. Top spray irrigation of the treated plots was adopted at Gödöllő Site, which started in early summer in 2002 and was continuous during the vegetation period of the studied years. Irrigation started at each midnight until the soil water content in the irrigated plots reached a predefined value ($0.35 m^3/m^3$, >-0.2MPa). On the plain site an area of 6 ha was fenced off from

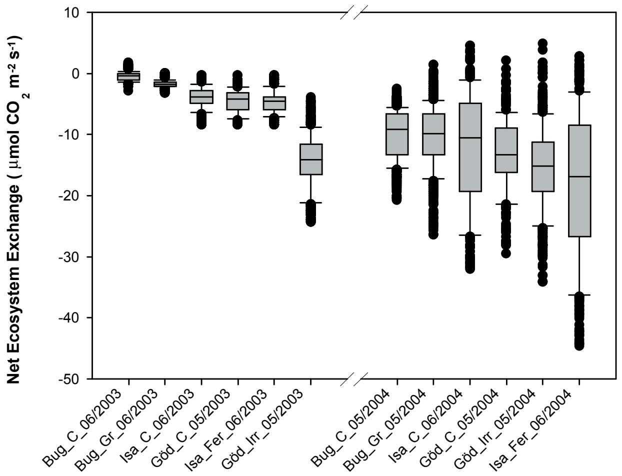

Figure 1. Comparison of the Net Ecosystem Exchange (NEE) values at peak C-sequestration, between two substantially different years (2003, 2004), and amongst treatments.

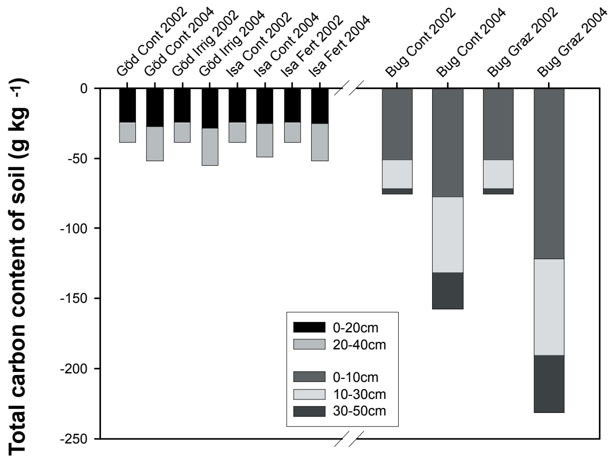

Figure 3. Changes of soil carbon stocks in soil depths under different management practices.

the extensively grazing Hungarian Grey Cattle herd.

Stand Net Ecosystem Exchange (NEE) measurements of CO_2-fluxes, soil respiration, transpiration rate and stomatal conductance, parallel with the micrometeorological variables were carried out seasonally in each site, as described in Balogh et al. 2002; Fóti et al. 2002 and Nagy et al. 2002, according to Czóbel et al. 2004. Above and below (by soil core) ground biomass samples, were collected twice a year (late spring & autumn) from all tall-grass plots, and with 5 replications at Bugac site by clipping $0.2m^2$ quadrats at each sampling site along a transect. Soil samples from each site were gathered and assayed four times in the microbiotically active seasons (spring & autumn). Soil samples were segregated into 0-10, 10-30, and 30-50cm increments at sandy soil of Bugac, while 0-20, and 20-40cm layers at chernozem soil of Isaszeg/Gödöllő site in accordance with the GreenGrass protocol. For the collection of vegetation data Braun-Blanquet approach was used. Sampling is carried out by the use of different quadrat size, according to the plot areas. At the grazed site a 40-m transects were established in each plot as representative area of the vegetation type. Besides, the effects of management practices alone on species diversity were also studied by calculation of Shannon-diversity and it was compared between the treated and control plots at each location.

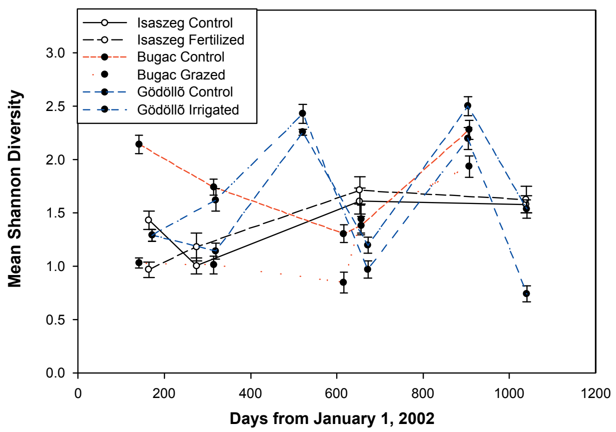

Figure 2. Temporal variation of Shannon Diversity in differently managed and non-managed control plots.

Results

The pattern of NEE changes (Fig. 1) was, it was largely affected by soil moisture regime and vegetation status (e.g. LAI) during the measurements, thus balanced only at irrigated plots. Despite of the extremely dry year of 2003 CO_2 uptake was measured at each of the measured stands, but most of the C gained during 2004. The soil respiration of the ecosystem has not increased significantly due to irrigation, similarly to other studies (e.g. Knapp et al. 1998).

Species number at all levels of sub-sampling decreased significantly with irrigation and fertilization, because the dominance of *Dactylis glomerata* and *Salvia nemorosa* had a detrimental effect on it. Although the general response in these plots was similar, there were important differences, with graminoids diversity affected more under *D. glomerata* than *S. nemorosa* at the fertilized site. Temporal change of species diversity differed significantly among management regimes (Fig. 2). Fertilization proved to be least interfere it in countering the negative effects of irrigation supply, but could not prevent competitors from becoming dominant, moreover large shifting occurs at short-grass steppe plots. Decreased light availability, the loss of gap formation, a decrease in small-scale environmental heterogeneity and proliferation of strong competitors, all may have contributed to the observed decrease in species richness.

Out of the management practices, only grazing increased considerably the soil C stock at each examined layer (Fig. 3). The initial C-residual of soil was low due to the dry year of 2002.

Discussion

The shortest response of land-use change can be observed at botanical composition and partly at NEE (CO_2), whereas soil parameters are significantly affected at longer time-scale. The loss of plant richness and biodiversity observed is mainly due to the increasing dominance of competitive species characterizing communities, which occurs along both dynamic and nutrient gradients in grassland. The initial sensitivity of NEE in tall-grass loess steppe in 2002 to different land use practices (fertilization and irrigation) suggests that it is critical to include the acclimation period of the vegetation. The study period covers 2003 and 2004 too, when the weather conditions were substantially different. In 2003 the main part of the growing season was dry and hot, while in the next year the amount of precipitation was considerable higher during the vegetation period. According to the weather conditions the water content of the soils and thus the CO_2 exchange of the examined vegetations differed substantially in these subsequent years. The results address the importance of extensive management for maintaining heterogeneous habitat mosaics and plant diversity on the landscape scale. A permissible grazing capacity of the studied temperate semi-arid grassland is significantly affected by the inter-annual climatic variations, thus underline the importance of climate change studies for future grassland management.

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