

# Grazing effects on the spread of fire in open sand grassland

GÁBOR ÓNODI<sup>1</sup>, MIKLÓS KERTÉSZ, ZOLTÁN BOTTA-DUKÁT AND VILMOS ALTBÄCKER<sup>2</sup>

## Abstract

We studied the effects of sheep and rabbit grazing on the spread of induced fire on an open sand grassland community in the Hungarian Plain. Patches of open sand grassland were grazed by sheep in April and by sheep and rabbit in May of 2003. Half of each patch was burned in July. Canopy cover of the litter and vascular plant species, species number, plant height, burnt area and the speed of fire-spread were estimated in one by one meter quadrates. Burnt area was significantly smaller with late sheep grazing, while the speed of fire-spread decreased significantly due to rabbit grazing compared to that of the control. Plant height was significantly decreased by early and late sheep grazing, while rabbit grazing resulted in significantly lower canopy cover values of vascular plants compared to the control.

## Introduction

Grazing and fire regimes are the most important large scale disturbances on semiarid and arid grassland communities (VAN LANGEVELDE et al. 2003, GHERMANDI et al. 2004, FELDMAN and LEWIS 2005). In most cases, fire and herbivory are independently investigated. However, there is very little research on how these two agents influence the function of each other (ARCHIBALD et al 2005). In our study, we intended to look deeper into how herbivory affects fire-spread of an open semiarid sand grassland community.

Herbivore density has decreased in the Kiskunság National Park since the beginning of the 1990s (KATONA et al. 2004). One important cause for this was the decline in stock density of cattle and sheep in Hungary. Additionally, the abundance of rabbit decreased dramatically in 1994 and 1995 due to a combination of myxomatosis and hemorrhagic disease, followed by an exceptionally long snow cover that winter. We assumed that decreased herbivory increases the extent of both anthropogenic and naturally ignited wildfires.

In this paper, we present a field experiment conducted on a forest-steppe mosaic of open sand grassland and *Juniperus-Populus* woody patches in the Kiskunság National Park. We wanted to know whether moderate rabbit and sheep grazing could affect the spread of fire in this open grassland community as has been demonstrated with persistent heavy grazing in denser communities (ARCHIBALD et al. 2005). We conducted our experiment on the grassland patches which play a substantial role in transmitting fire among the woody patches of the *Juniperus-Populus* community in the forest-steppe vegetation.

## Material and Methods

Our study site lies on the Hungarian Plain, in the outskirts of Orgovány (N46°47.369, E19°26.829), on a forest-steppe area, which is one of the westernmost extensions of the forest-steppe zone in Europe (KOVÁCS-LÁNG et al. 2000). The area is part of the Kiskunság National Park. The study site is a mosaic of open sand grassland and woody patches of

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<sup>1</sup> gabor.onodi@botanika.hu

<sup>2</sup> Department of Ethology, Eötvös Loránd University, 1117 Budapest, Pázmány Péter sétány 1/c

*Juniperus communis* (L.), *Populus alba* (L.), and *Populus nigra* (L), based on the nomenclature of SIMON (2000).

We conducted the experiment in 2003, in an extreme dry year. The size of the study site was one hectare. Within the study site, we marked 10 blocks of the open sand grassland among the woody patches. Each block consisted of four differently treated grassland patches, namely, an ungrazed control plot, an early sheep grazed (middle of April), a late sheep grazed (end of May), and a rabbit grazed (end of May) plot. Each patch consisted of 1 m x 1 m quadrates. The patches were fenced during the grazing period which lasted until the sheep or rabbit (one animal per patch) reduced the original vegetation cover to 50% (estimated visually) through plant removal and trampling. We performed the burning treatment in July for all blocks on the same day. We burned half of each patch, including two of the four quadrates. There remained two unburned quadrates in each patch to examine regeneration following the grazing treatments.

We took samples three times in 2003. Sampling periods were before the grazing treatments in April, before the burning treatment in July, and after the burning treatment in September. We estimated the effects of treatments and sampling date on the species number, on the canopy cover of the vascular plants, and on the litter, using a three-way repeated measure ANOVA. Treatments (grazing, burning) were fixed factors, while the third factor (the block) was random. We analyzed the effects of grazing on plant height, burnt area, and speed of fire-spread by two-way ANOVA with one fixed factor (grazing) and one random factor (block). After both ANOVA analyses, pairwise comparisons by Tukey's HSD tests were carried out.

## Results

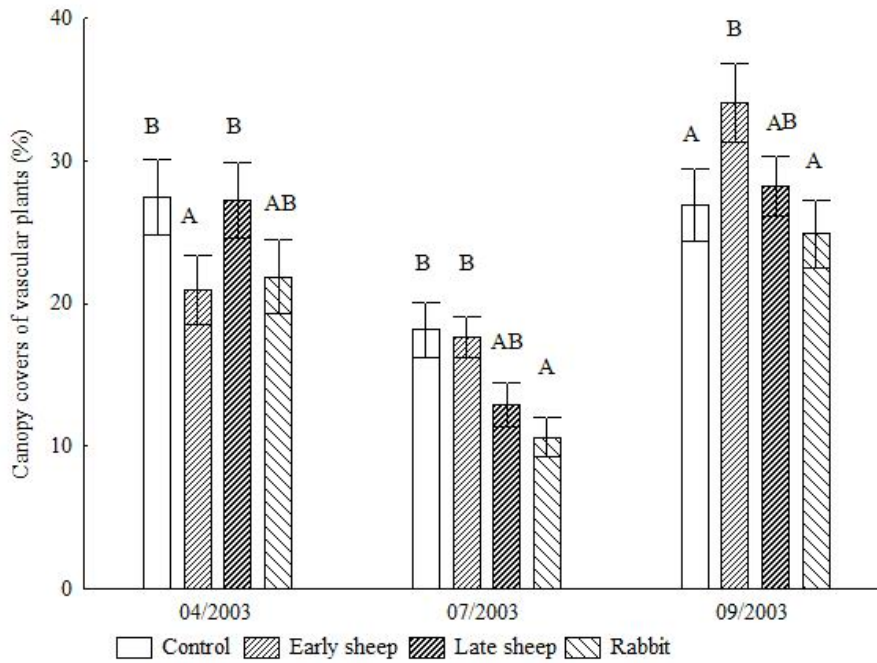
Canopy cover of litter increased between April and July in the case of the grazing control quadrates, while it did not change in relation to the three grazed treatment types.

Canopy cover of vascular plants (**Figure 1.**) decreased between April and July, however, there was no change in the case of early sheep grazing. Consequently, in July before the burning treatment we found no difference between grazing control and early sheep grazing, while rabbit grazing decreased the canopy cover compared to both the control and the early sheep grazing. Late sheep grazing resulted in non-significantly lower canopy values. Canopy cover of vascular plants increased from July to September in all grazing treatments. Early sheep grazing resulted in higher values compared to the control in September.

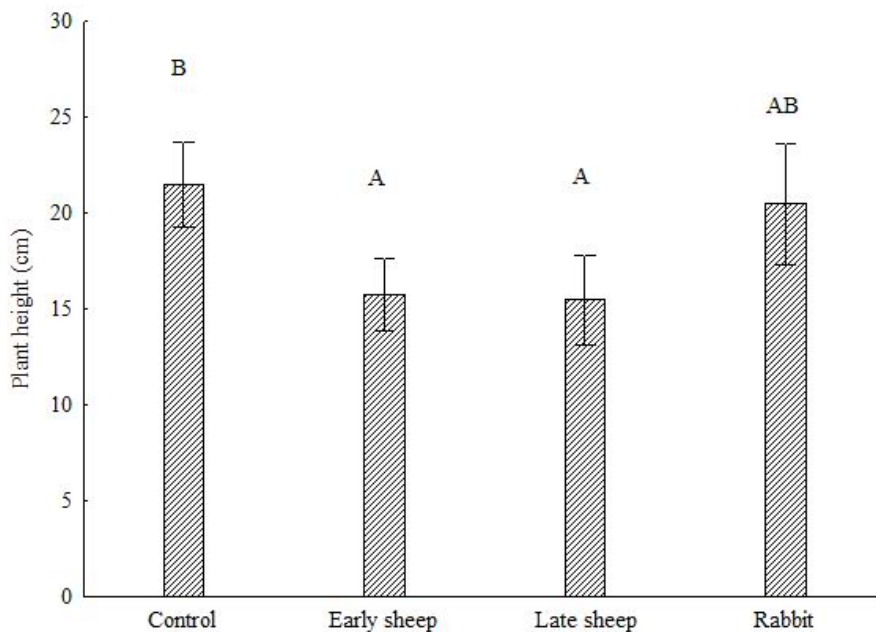
Plant height was lower in the grazed quadrates due to the early and late sheep grazing compared to the control, while rabbit grazing resulted in intermediate values (**Figure 2.**).

Burnt area was smaller in the case of late sheep grazing compared to that of the early sheep grazing and the control, while rabbit grazing insignificantly decreased the extent of fire (**Figure 3.**). The speed of fire-spread decreased due to rabbit grazing compared to the control (**Figure 4.**).

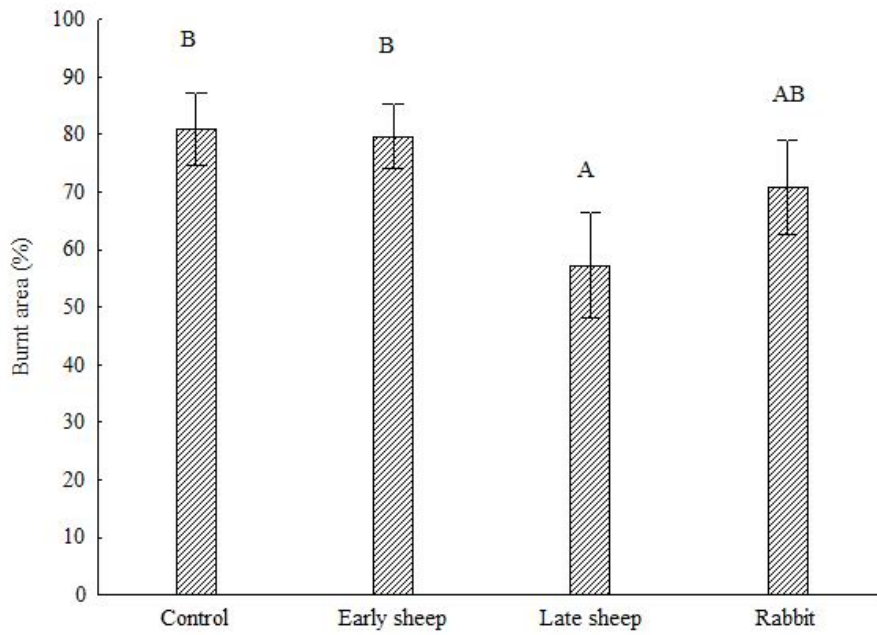
Species number was not affected by the grazing treatments.



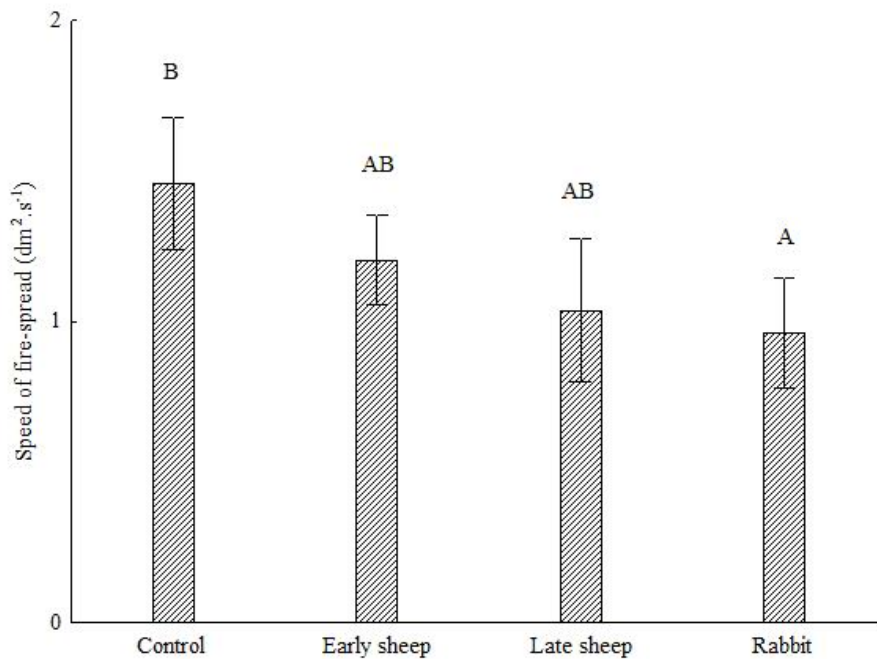
**Figure 1.** Canopy covers of the vascular plants (mean  $\pm$  SE) for the four types of grazing treatments at the sampling dates, before the grazing treatment in April, before the burning treatment in July and two months after the burning in September. Columns in the same cluster followed by the same letter are not significantly different according to Tukey's HSD test.



**Figure 2.** Plant height (mean  $\pm$  SE) for the four types of grazing treatments prior to the burning treatment in July. Columns in the same cluster followed by the same letter are not significantly different according to Tukey's HSD test.



**Figure 3.** The extension of the fire (mean  $\pm$  SE) for the four types of grazing treatments in July. Columns in the same cluster followed by the same letter are not significantly different according to Tukey's HSD test.



**Figure 4.** The speed of fire-spread (mean  $\pm$  SE) for the four types of grazing treatments in July. Columns in the same cluster followed by the same letter are not significantly different according to Tukey's HSD test.

## Discussion

We found that the effect of sheep grazing on the extension of fire depends upon the timing of the grazing treatments. According to our expectation, sheep grazing in late spring decreased the extension of fire during the mid-summer drought on the open sand grassland, while despite our preliminary assumption, sheep grazing in April had no effects on fire-spread. The reason for this is that the vegetation of the patches grazed in April had enough time to regenerate before July, thus the canopy cover of the vegetation was similar to the control prior to the burning treatment. The green vegetation of the patches grazed in late spring, either by sheep or by rabbit, did not regenerate by July, but was regenerated by September. On the prairie, long-term heavy grazing has a negative effect on fire-spread, because it breaks up the homogenous grass layer (GOSZ and GOSZ 1996, ARCHIBALD et al. 2005). We found that even moderate grazing causes decreased fire-spread on open sand grasslands.

However, species identity is also important in the case of fire-spread, because only rabbit grazing decreased significantly the speed of fire-spread, and only sheep grazing in May decreased significantly the extension of fire. These two animals have different grazing habits. Sheep eat the top of the vegetation, while rabbits consume the interior portions of it. Accordingly, sheep grazing resulted in a stronger decrease in plant height, while rabbit grazing more strongly decreased canopy cover of vascular plants. Our results show that both the amount of combustible biomass (canopy cover of vascular plant and litter) and the structure of the vegetation (height) play a role in the spread of fire (speed of fire spread and burnt area).

We suggest that the accumulation of litter (due to decreased herbivory on the sand grassland patches) might affect the structure of the whole forest-steppe habitat, because an enhanced litter layer on the open grassland can transmit fire among the woody patches. Therefore, in the absence of large herbivores spread of fire may increase in the *Juniperus-Populus* forest-steppe where woody patches are surrounded by a matrix of open sand grasslands. Woody patches play an important role in sustaining biodiversity, although most of the endemic and other protected species live on the sand grasslands. This is because they increase habitat diversity by producing shaded and more humus-rich habitat-patches, which results in the remarkable species richness characteristic of the Sand Ridge vegetation. Fire damages this pattern of the vegetation. According to our long term observations on the Kiskunság, *Juniperus communis* is not able to regenerate after fire; it is replaced by resprouter trees, such as the invasive *Robinia pseudo-acacia* or *Populus* species. Therefore, fire may affect the vegetation, not only in the short-term, but can cause long-term compositional changes, which has a greater effect on the grassland than burning itself.

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