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Working package A3.2: Population dynamics, phenology and yield - grassland

Impacts of long-term CO_2 enrichment on the soil seed bank of a temperate grassland

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Introduction and Objectives

In a grassland ecosystem, the prevailing geology, topography, soil type, water regime and climate determine the vegetation composition above and below ground. The latter is an underground reservoir of ungerminated seeds (soil seed bank) and plays an important role for the regeneration and longevity of grassland ecosystems.

Changes in one of the driving forces, such as climate or land-use practices, affect the grassland vegetation composition and the soil seed bank. Elevated CO_2, cutting dates and frequencies are potential factors inducing these changes. Effects on reproductive traits of the plants, like timing of flowering and seed-setting will be most crucial.

Here we present results of a comparative investigation on the soil seed bank in a temperate grassland ecosystem before the start of the Thermo-FACE experiment and after 17 years with elevated CO_2 (Gi-FACE). The main objective was to assess the initial state of plots before treatment and the differences in the soil seed banks between plots subjected to elevated and non-elevated CO_2 levels.

Methods

- 20 (Thermo-FACE) + 30 (Gi-FACE) soil cores per ring were taken and divided into three and four depth layer (0-1 cm; 1-5 cm; 5-10 cm;[10-20 cm only for Thermo-FACE]).
- Samples were spread in plant pots over sterilized potting soil and positioned into the greenhouse.
- Emerging seedlings were identified to species level, counted and removed.
- After 14 weeks, the pots were allowed to air dry for 5 weeks, where upon the pots were again incubated for another 10 weeks in the greenhouse [1].
- During the statistical analysis, the Gi-FACE blockdesign was not considered, therefore the mean soil moisture for September 2011-2013 as co-variable.

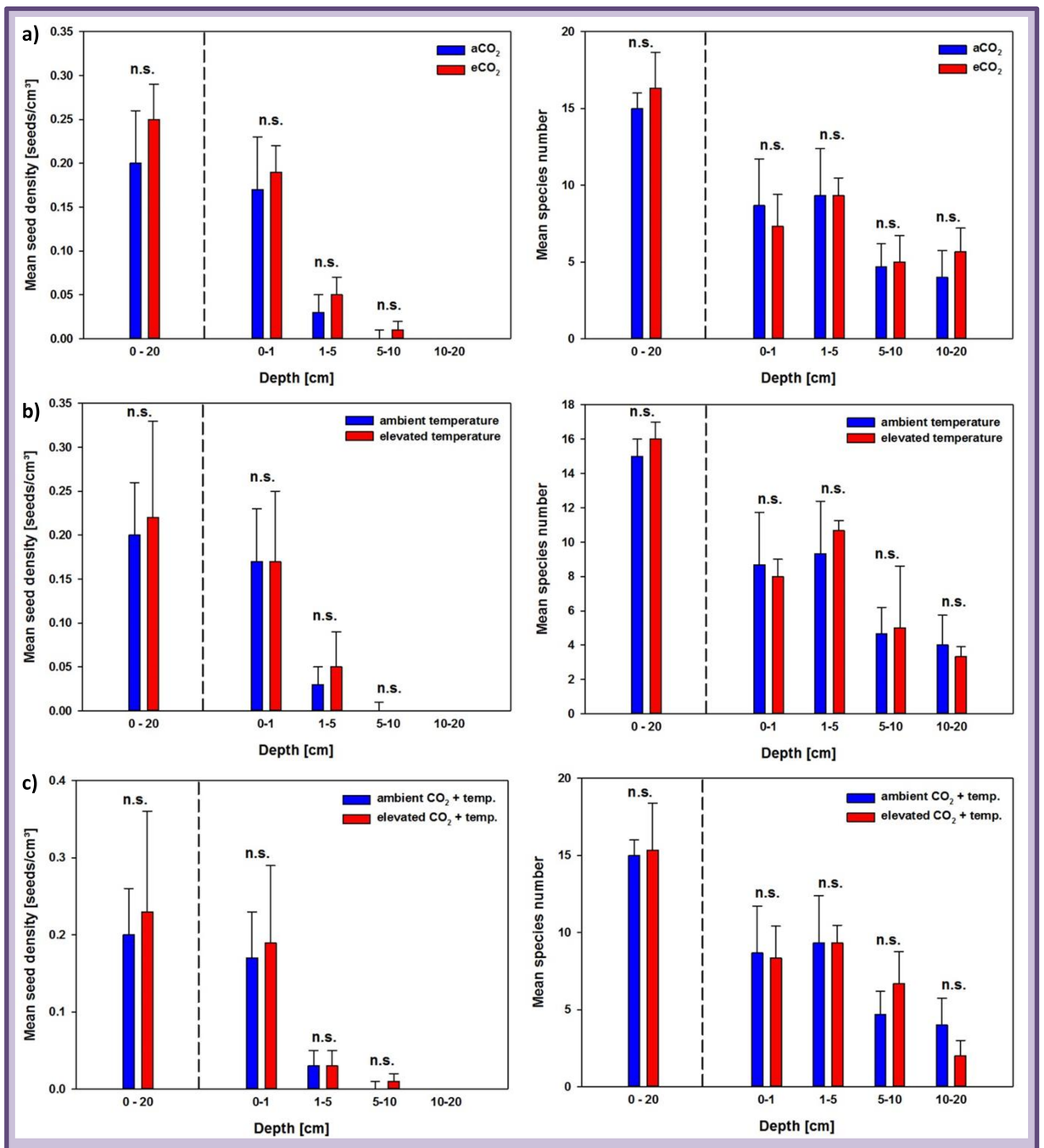

Fig. 1: Mean seed density and mean species number of seed bank samples of the Thermo-FACE plots, separated in total depth (0-20 cm) and seed bank layers (0-1 cm; 1-5 cm; 5-10 cm; 10-20 cm). Error bars indicate standard deviations. Letters a, b and c with bracket indicate: a) elevated and ambient CO_2; b) elevated and ambient temperature; c) elevated CO_2 + temperature and ambient CO_2 + temperature. Differences between the treatments were not statistically significant [n.s.] (two-factorial analysis of variance).

Results

Results of the Thermo-FACE plots showed no significant differences between plots, which will be under elevated climate conditions when the experiment starts and plots with ambient climate conditions. The mean seed density in the total depth was higher in plots which will be treated with elevated CO_2, elevated temperature or a combination of both in the future. Similar results were noticed at the analyses of the species number in the soil seed bank (Fig. 1).

A significant CO_2-effect was seen at the Gi-FACE plots. Analyses revealed a significantly higher seed density in plots with elevated CO_2, although there was a higher species number at the plots with ambient CO_2.
Analogous results were noticed when analysing for differences in functional traits of the plants, like seed bank type and reproduction type (Fig. 2).

These results showed no significant impact of elevated CO_2 on species distribution, but a positive effect on seed production and thereby a positive effect on the soil seed bank. This suggests an increase of the overall longevity of the seed bank and may lead to a increased regeneration potential of the grassland ecosystem.

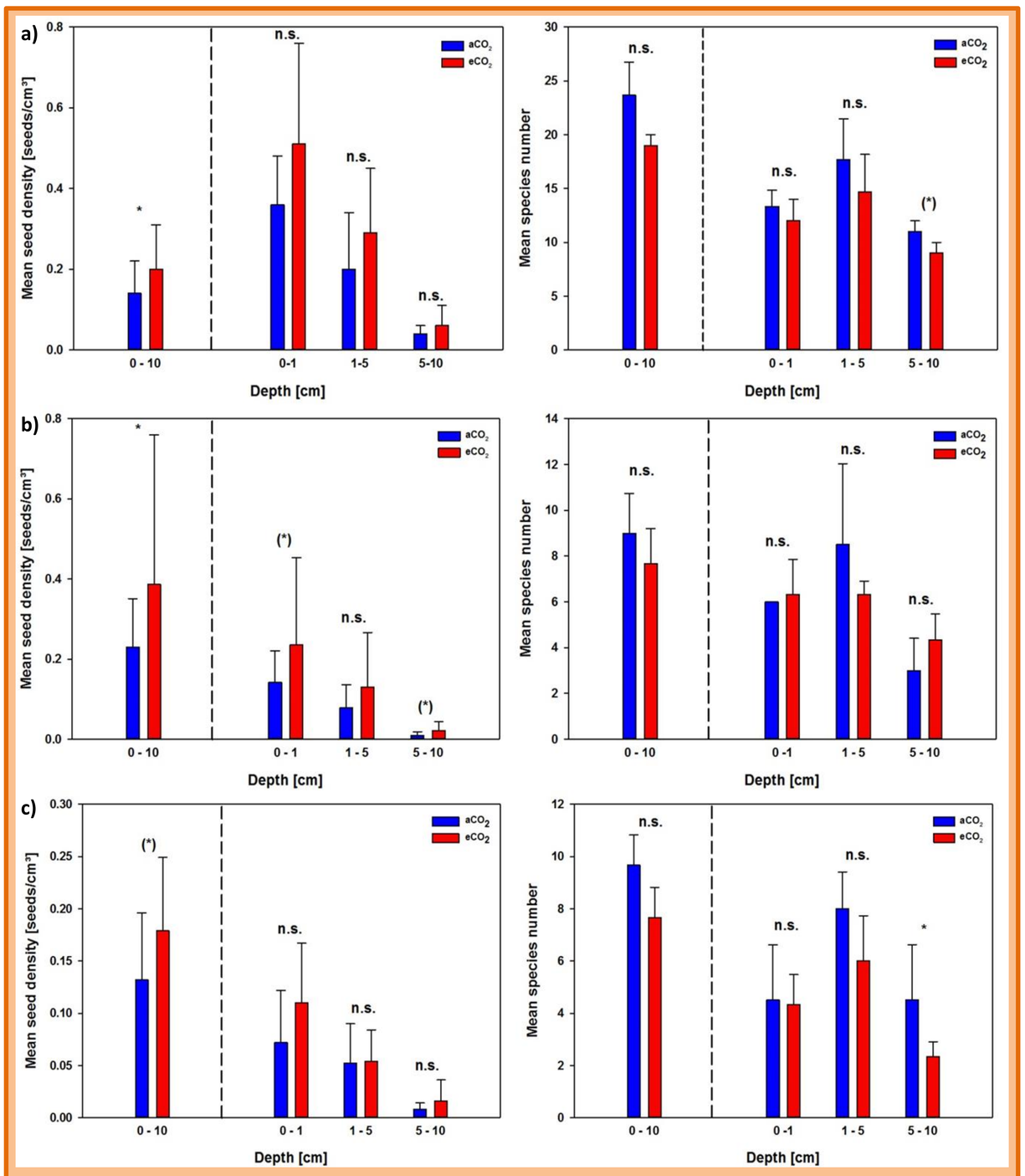

Fig. 2: Mean seed density and mean species number of seed bank samples of the Gi-FACE plots, separated in total depth (0-10 cm) and seed bank layers (0-1 cm; 1-5 cm; 5-10 cm). Error bars indicate standard deviations. Letters a, b, and c with bracket indicate: a) seed density + species number generally; b) seed density + species number of species with long-term persistent seed bank type; c) seed density + species number of species with generative reproduction type. Significant levels were reported as significant, $p \leq 0.05$ [*] significant by tendency $p \leq 0.1$ [(*)] and not significant [n.s.] (two-factorial analysis of covariance).

Outlook

- Thermo-FACE results show a good initial state before treatment
- Gi-FACE results show impact of elevated CO_2 on the soil seed bank
- Increased temperature influence flowering of plants and water regime in the soil
- Important to know about impacts of elevated air temperature or a combination of elevated CO_2 + temperature on the seed production

Literatur:
[1] Burmeier et al. (2010) Colonization processes and seed bank dynamics in flood meadows and their implications for ecological restoration: a synthesis. JLU Gießen.

FACE2FACE