Ecological Archives **E089-135-A1**

Appendix A. Supplementary materials, methods, and tables.

Soil origin and preparation
We used soils from 24 field monocultures (one per species), each measuring 1.5 × 2 m. We removed four subsamples of soil from the top 25 cm of each of the monocultures, insulated them against peak frosts and stored them outside for three months to mimic seasonal temperature changes. We mixed the soils by sieving (1 cm mesh width), removed stones, cut roots into 1.5 cm pieces and returned them to the soil.
Soils were either (1) sterilized by gamma irradiation (>25 kGray) to remove all soil organisms, (2) received twice the recommended dose of a broad-spectrum fungicide to remove all fungi (Carbendazim; Methyl-benzimidazol-2-ylcarbamat, Sintagro AG, Härkingen, Switzerland, 1.8 g/pot), (3) were mixed with activated carbon (washed with hydrochloric acid, Sigma-Aldrich, Switzerland, 2 % by volume) to remove allelochemicals or (4) were fertilized with a liquid NPK-fertilizer (Gesal, Compo Jardin AG, Allschwil, Switzerland, 110.7 mg/pot N (102.6 mg as carbamide and 8.1 mg as ammonium), 63.6 mg/pot P (as phosphoric acid), 180.0 mg/pot K (as potassium hydroxide) once at the beginning of the experiment. Nutrient concentrations were still significantly higher in the fertilizer treatment compared with the sterilization treatment at the end of the experiment (based on a subset of 9 soil types from 54 mixture pots (replicate pots were pooled): $F_{1,8}$ = 11.9, $P < 0.01$ for nitrogen and $F_{1,8} = 63.5$, $P < 0.001$ for phosphorus).

Experiment
The 24 species were grouped into eight sets, each containing one forb, one grass and one legume species (Table A2). Initially, species were grouped into four early- and four mid-successional sets with random assignment of species within functional group and successional stage. The factor "successional stage" was not significant ($F_{1,6} = 0.64$, $P = 0.451$, tested against "set" within the species term) and was dropped from the analysis. We surface-sterilized seeds with 7 % sodium-hypochlorite before the experiment. Plants were grown in the glasshouse under a 15/9h light/dark cycle (minimum light level 400 $\mu Em^{-2}s^{-1}$ during the day) and a mean temperature of 20°C (minimum 15°C, maximum 28°C). We watered all pots manually three times a week to keep soil moisture constant, avoiding any exchange of water between the pots. Pots were randomized every two weeks to remove spatial variation.

Supplementary Modeling: Incorporating local dispersal into the model framework

In the models presented in the main paper, we assume infinite fecundity and global dispersal. To incorporate local dispersal, we first need to make fecundity finite. The model also needs to be spatially explicit, with a grid of N patches which are fully occupied by the three functional groups. Some fraction (F) of the seeds produced by each individual remains within the local patch, while the remainder (1-F) is dispersed to form a global seed rain. All plants reproduce before mortality acts, thus the mean number of seeds of species i arriving in patch q at time t ($n_{i,q,t}$) follows a Poisson distribution, with mean equal to the sum of the within-patch and global dispersal terms:

$$\overline{n}_{i,q,t} = F.(R_i) + (1-F)R_i.N_i.(1/N)$$

where R_i is the reproductive output of an individual of species i. We chose $R_i = 100$ as this is typical of values found for grassland plants, and creates a suitable degree of stochasticity in the seed inputs. Otherwise the model is the same as described in the main paper with parameter values taken from the experimental and field data, i.e., $c_{ii}= 0.5$ for all i, $c_{ij}= 1$ for all i and j and $d_{legume} = 0.466$, $d_{grass}= 0.450$, $d_{forb}= 0.364$. We varied F in the range 0 – 1 in steps of 0.1 ($F = 1$ corresponds to full global dispersal). For each value in this range, the mean persistence time of all three functional groups was calculated from 100 runs each of 10,000 generations.

Local dispersal does indeed have dramatic consequences for the persistence of the three functional groups (Fig. D1). Only when $F \leq 0.7$ do the three functional groups persist for 10,000 generations. When $F = 0.6$, the three groups persist on average for around 6,000 years, but with $F \leq 0.5$, the functional group with the lowest fitness only persists on average for 2,000 years (and never persists for 10,000 years). This occurs because seeds are increasingly concentrated in patches where recruitment probability is low. This highlights the importance of dispersal away from the parent site when Janzen Connell effects or negative soil feedbacks operate. This is particularly true when species have unequal fitness, as the species with the lowest fitness must ensure that it disperses seeds into sites where it has a better chance of recruiting.

Supplementary Tables

TABLE A1. Results from the mixed-model ANOVA for log-ratio of biomass (biomass of individual plants on home soils divided by biomass of individuals on away soils for each species, log-transformed). The species term (bold) is split into one contrast (normal print), the row numbers of the respective error terms are given in the last column (fixed effects are tested against random effects, random effects against the residual).

Source of variation	df	*F*	*P*	Error term
1 Mean	**1**	**35.69**	**<0.001**	**4**
2 Competition	**1**	**16.68**	**<0.001**	**6**
3 Functional group of soil	**2**	**0.47**	**0.634**	**7**
4 Species	**23**	**12.33**	**<0.001**	**11**
4a Functional group	2	0.53	0.595	4b
4b Species	21	12.86	<0.001	11
5 Treatment	**4**	**4.68**	**0.002**	**8**
6 Competition × Species	**23**	**6.55**	**<0.001**	**11**
7 Functional group of soil × Species	**22**	**4.08**	**<0.001**	**11**
8 Species × Treatment	**92**	**10.24**	**<0.001**	**11**
9 Competition × Treatment	**4**	**9.59**	**0.010**	**10**
10 Competition × Species × Treatment	**91**	**1.67**	**0.001**	**11**
11 Residuals	**215**			
Total	478			

TABLE A2. The 24 species were grouped into eight experimental sets, each containing one grass, one forb and one legume of the same successional stage. Assignment of species to sets within successional stage and functional groups was random. Each species was then grown on home (soil from same species) and away soils (soils from the other two species in the set) either in monoculture or in competition with the other species in its set.

Set	Species	Functional group	Successional stage
1	*Panicum capillare*	GRASS	
	Lepidium campestre	FORB	early
	Trifolium incarnatum	LEGUME	
2	*Bromus sterilis*	GRASS	
	Arctium tomentosum	FORB	early
	Trifolium campestre	LEGUME	
3	*Echinochloa crus-galli*	GRASS	
	Berteroa incana	FORB	early
	Melilotus albus	LEGUME	
4	*Hordeum murinum*	GRASS	
	Tanacetum vulgare	FORB	early
	Vicia villosa	LEGUME	
5	*Arrhenaterum elatius*	GRASS	
	Plantago lanceolata	FORB	mid
	Medicago lupulina	LEGUME	
6	*Holcus lanatus*	GRASS	
	Centaurea jacea	FORB	mid
	Trifolium pratense	LEGUME	
7	*Festuca rubra*	GRASS	
	Leucanthemum vulgare	FORB	mid
	Vicia cracca	LEGUME	
8	*Dactylis glomerata*	GRASS	
	Galium mollugo	FORB	mid
	Trifolium repens	LEGUME	

TABLE A3. Results from a mixed-model ANOVA of log-ratio of seedling emergence (seedling emergence probability on home soils divided by seedling emergence probability on away soils, ratio log-transformed), random effects were the species term and its interaction, fixed effects were the overall mean and the treatment, they were tested against random effects. There was no competition treatment for seedling emergence.

Source of variation	df	*F*	*P*	Error term
1 Mean	**1**	**0.24**	**0.627**	**2**
2 Species	**23**	**11.78**	**<0.001**	**5**
3 Treatment	**4**	**0.81**	**0.524**	**4**
4 Species × treatment	**91**	**1.76**	**0.002**	**5**
5 Residual	**119**			
Total	237			

Appendix B. Mean soil feedback on seedling emergence.

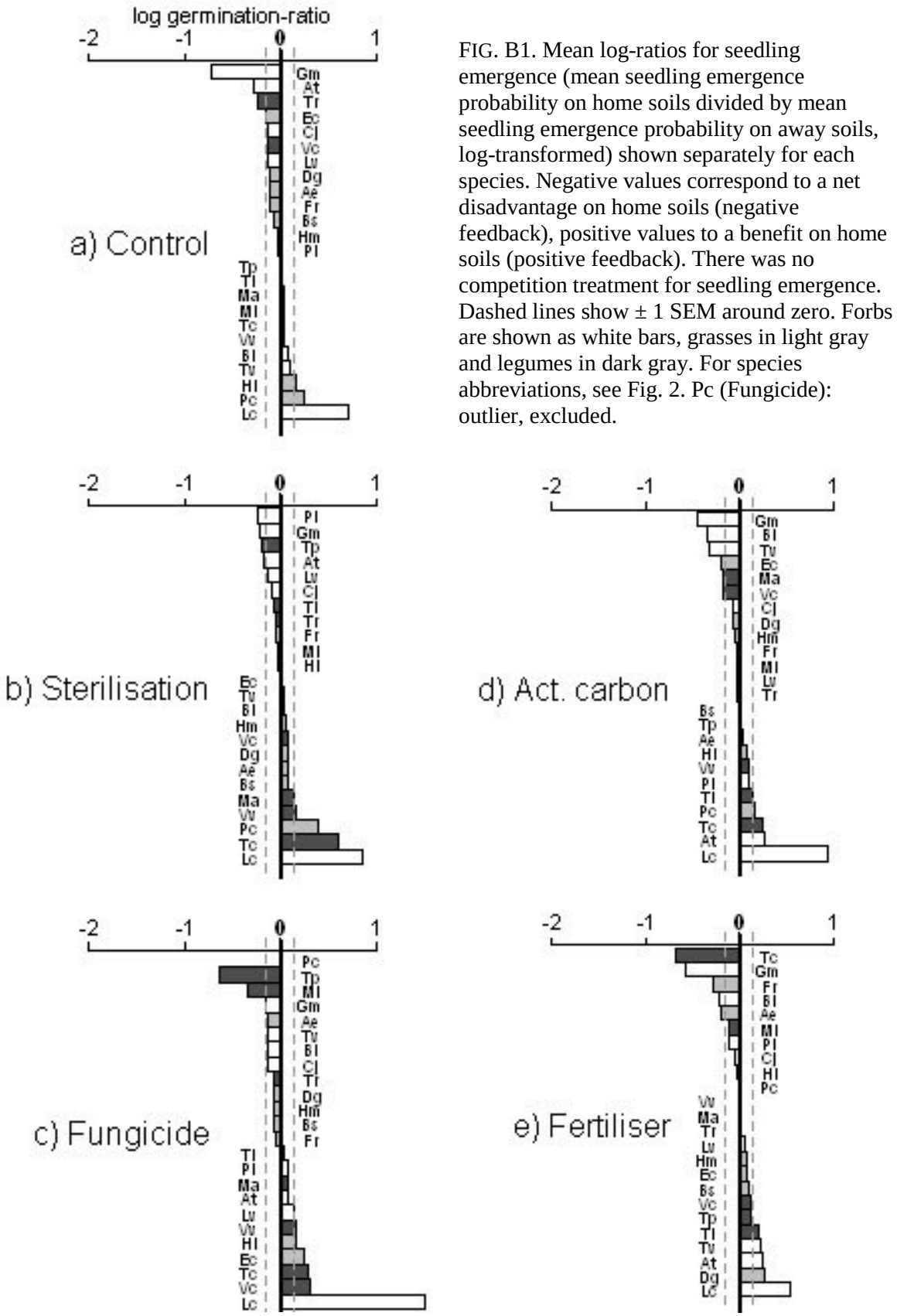

FIG. B1. Mean log-ratios for seedling emergence (mean seedling emergence probability on home soils divided by mean seedling emergence probability on away soils, log-transformed) shown separately for each species. Negative values correspond to a net disadvantage on home soils (negative feedback), positive values to a benefit on home soils (positive feedback). There was no competition treatment for seedling emergence. Dashed lines show ± 1 SEM around zero. Forbs are shown as white bars, grasses in light gray and legumes in dark gray. For species abbreviations, see Fig. 2. Pc (Fungicide): outlier, excluded.

Appendix C. Design of the main experiment.

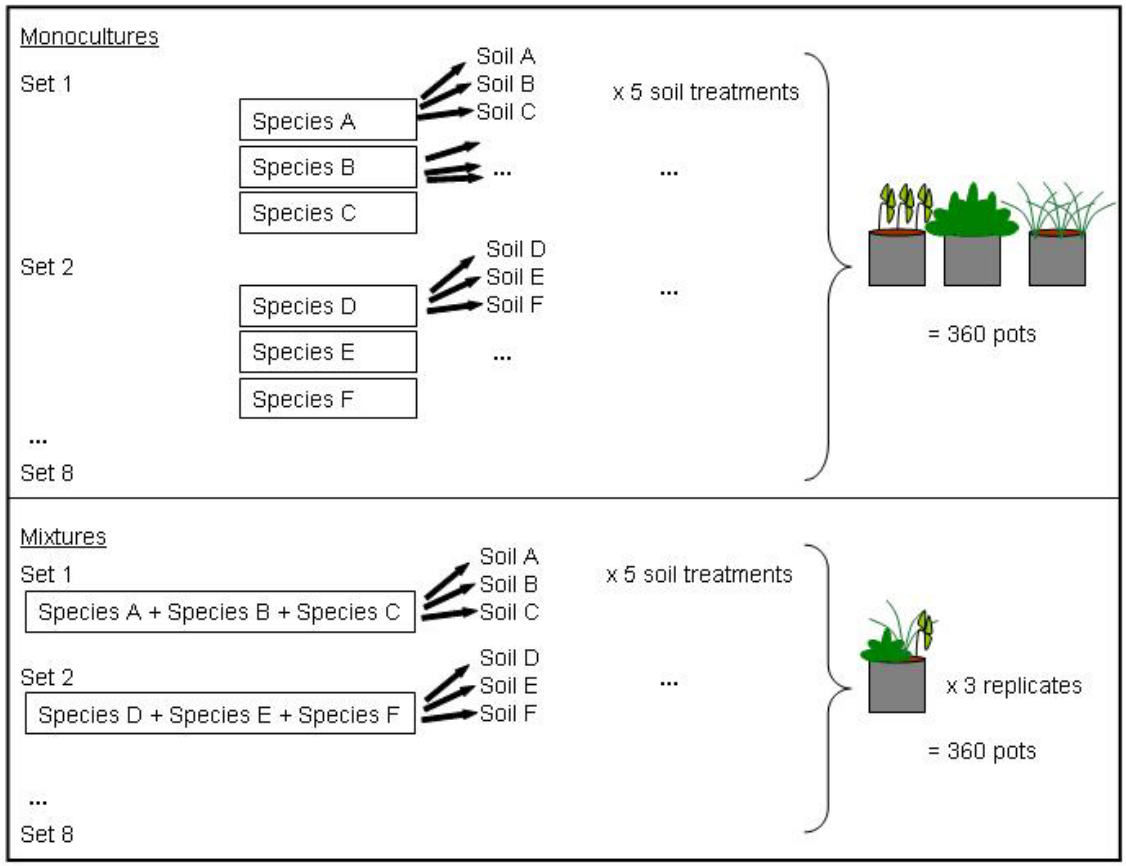

FIG. C1. Design of the main experiment: 24 species were grouped into 8 sets with one representative of each functional group (see Appendix A Table A2). For the monospecific communities ("Monocultures"), three individuals per pot were grown for each species on the three soils in its set (including its own). These 72 combinations were crossed with five soil treatments, adding up to a total of 360 pots. Multi-species communities ("Mixtures") were assembled by using one individual of each of the three species in the set per pot. This community was grown on each soil of the set, in five soil treatments. Because there were three replicates of each combination, there were also 360 mixture pots in the experiment.

Appendix D. The effect of seed dispersal on persistence time.

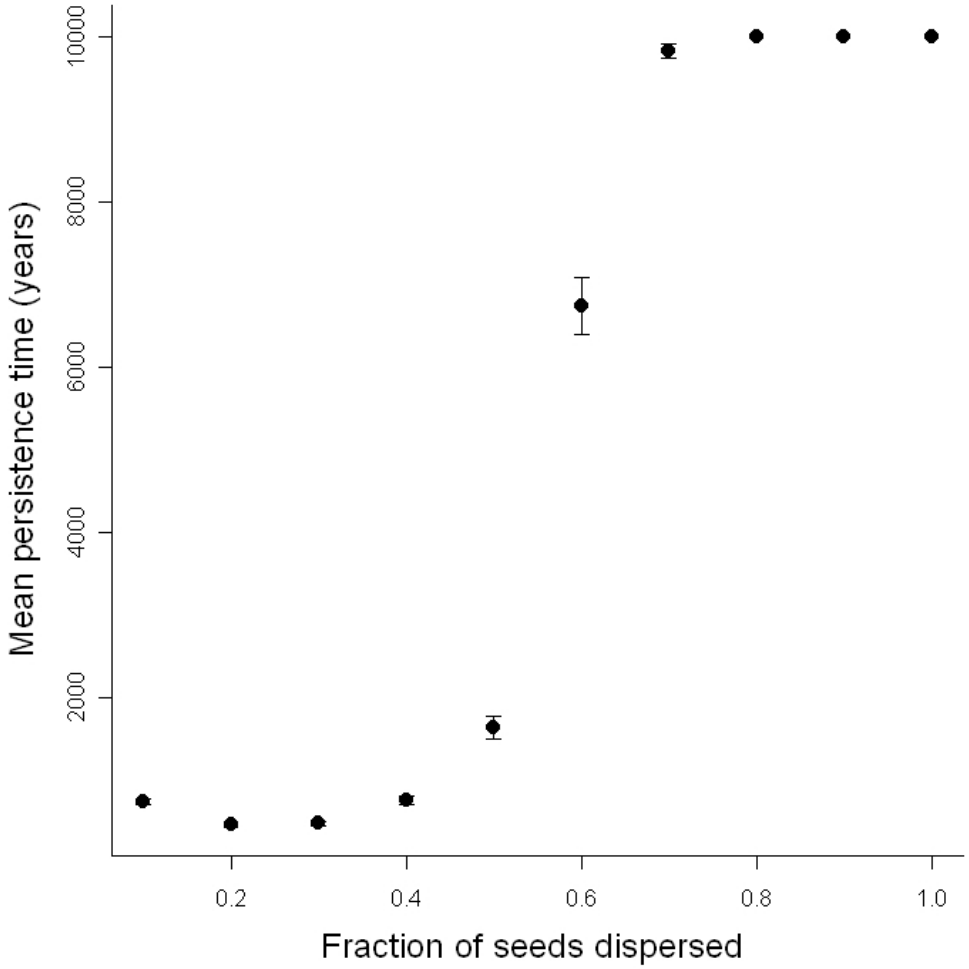

FIG. D1. The effect of increasing the fraction of seeds dispersed away from the parent site on mean persistence time. For other model parameters see text.