

## ***Ecological Archives E091-030-A1***

**Jana S. Petermann, Alexander J. F. Fergus, Christiane Roscher, Lindsay A. Turnbull, Alexandra Weigelt, and Bernhard Schmid. 2010. Biology, chance, or history? The predictable reassembly of temperate grassland communities. *Ecology* 91:408–421.**

Appendix A. List of internal invader species with corresponding numbers as in Fig. 2c.

1: *Trifolium hybridum*, 2: *Onobrychis viciifolia*, 3: *Lotus corniculatus*, 4: *Vicia angustifolia*, 5: *Lathyrus pratensis*, 6: *Dactylis glomerata*, 7: *Medicago lupulina*, 8: *Vicia cracca*, 9: *Trifolium pratense*, 10: *Festuca pratensis*, 11: *Ranunculus acris*, 12: *Trifolium repens*, 13: *Alopecurus pratensis*, 14: *Trifolium dubium*, 15: *Phleum pratense*, 16: *Poa trivialis*, 17: *Bromus hordeaceus*, 18: *Prunella vulgaris*, 19: *Crepis biennis*, 20: *Trifolium campestre*, 21: *Centaurea jacea*, 22: *Festuca rubra*, 23: *Arrhenatherum elatius*, 24: *Campanula patula*, 25: *Poa pratensis*, 26: *Primula veris*, 27: *Cirsium oleraceum*, 28: *Knautia arvensis*, 29: *Taraxacum officinale*, 30: *Plantago media*, 31: *Veronica chamaedrys*, 32: *Plantago lanceolata*, 33: *Galium mollugo*, 34: *Tragopogon pratensis*, 35: *Rumex acetosa*, 36: *Anthriscus sylvestris*, 37: *Leucanthemum vulgare*, 38: *Achillea millefolium*, 39: *Avenula pubescens*, 40: *Pimpinella major*, 41: *Geranium pratense*, 42: *Pastinaca sativa*, 43: *Leontodon hispidus*, 44: *Trifolium fragiferum*, 45: *Medicago varia*, 46: *Ranunculus repens*, 47: *Leontodon autumnalis*, 48: *Trisetum flavescens*, 49: *Glechoma hederacea*, 50: *Daucus carota*, 51: *Bellis perenne*, 52: *Ajuga reptans*, 53: *Bromus erectus*, 54: *Anthoxanthum odoratum*, 55: *Holcus lanatus*, 56: *Cardamine pratensis*, 57: *Carum carvi*.

The following species are missing from the graph because their average biomass as invaders at home or away was zero and hence no home-away effect could be calculated: *Luzula campestris*, *Cynosurus cristatus*, *Heracleum sphondylium*, *Sanguisorba officinalis*. The external species *Vicia angustifolia* (number 4) was accidentally sown as an internal invader into all subplots with seed addition and therefore treated as an internal invader in all analyses. Nomenclature follows Rothmaler (2002).

### LITERATURE CITED

Rothmaler, R. 2002. Exkursionsflora von Deutschland. Spektrum, Heidelberg-Berlin, Germany.

## ***Ecological Archives E091-030-A2***

**Jana S. Petermann, Alexander J. F. Fergus, Christiane Roscher, Lindsay A. Turnbull, Alexandra Weigelt, and Bernhard Schmid. 2010. Biology, chance, or history? The predictable reassembly of temperate grassland communities. *Ecology* 91:408–421.**

Appendix B. A figure depicting convergence of the proportion of the total number of species accounted for by the four functional groups.

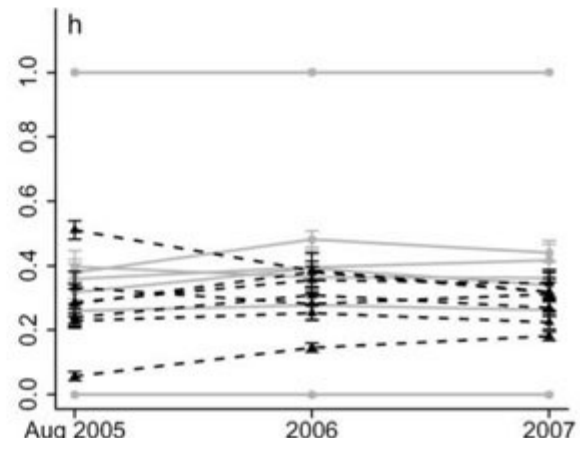
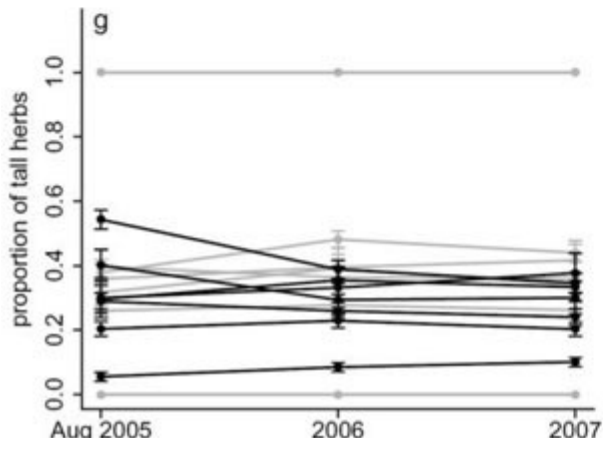
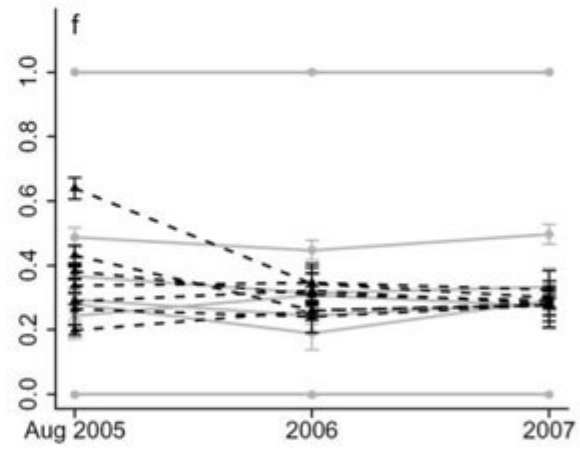
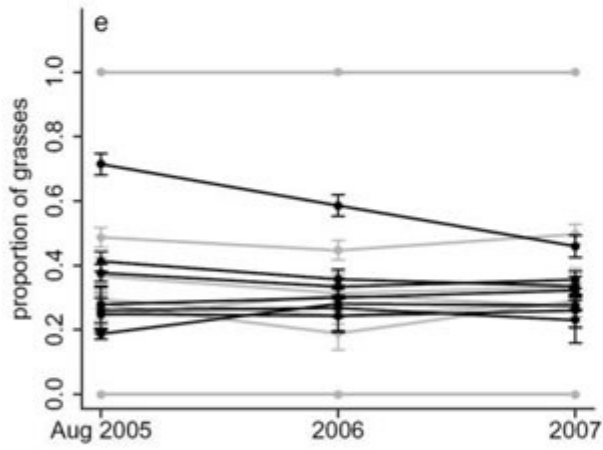
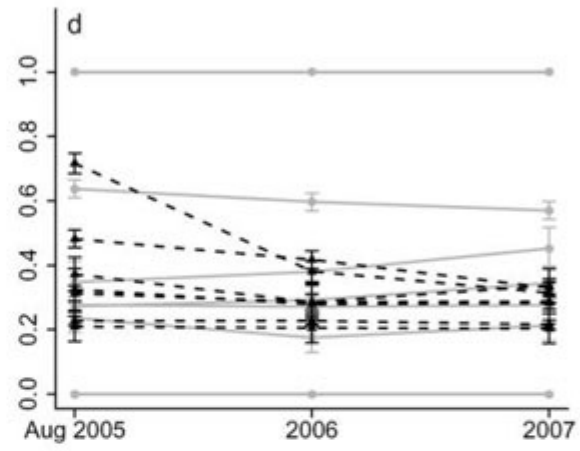
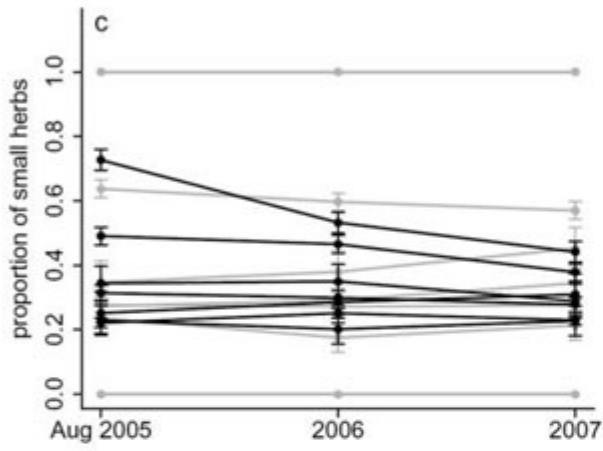
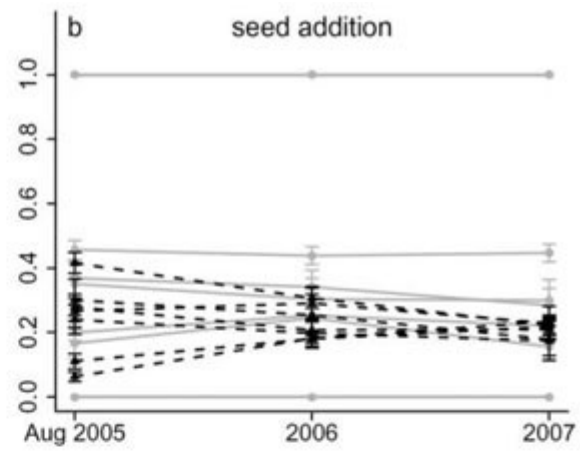
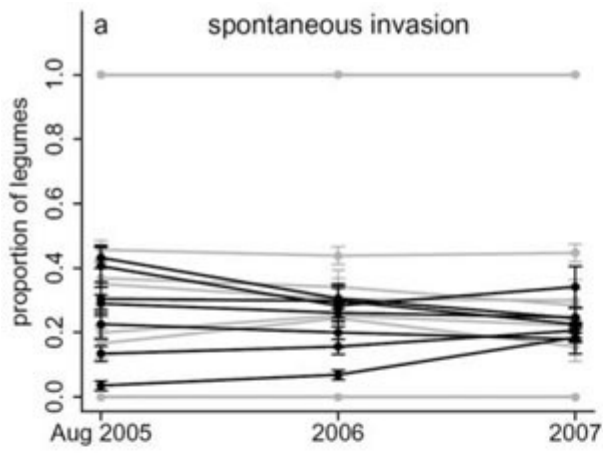


FIG. B1. Convergence of the proportion of the total number of species accounted for by the four functional groups. Observed (= realized) proportions were calculated as observed number of species of the respective functional group per observed number of total target species. Here, external invaders were excluded because they could not be grouped into the same four functional groups, so target species in this case were residents in weeded controls (gray lines, w-), but residents and internal invaders in non-weeded subplots (black lines in the left column: spontaneous invasion c-, black dashed lines in the right column: seed addition c+). Small herbs and legumes were originally sown in the following proportions in 2002: 0, 0.2, 0.25, 0.3125, 0.375, 0.5 and 1, tall herbs: 0, 0.25, 0.3125, 0.333, 0.375, 0.5 and 1 and grasses: 0, 0.25, 0.267, 0.3125, 0.375, 0.5 and 1.



<b>Species richness</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>8</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>16</b>	<b>60</b>	
grasses	8				4		4		2	3	3		2	16		8		8		5	5	6		4	16	
small herbs		8			4			4	3		3	2	2			8			8	6		5	6	4	12	
tall herbs			8			4	4		3	2		3	2		16		8	8		6	5		5	4	20	
legumes				8		4		4		3	2	3	2				8		8		6	5	5	4	12	
Replicates	1	1	1	1	1	1	1	1	1	1	1	1	1	4	1	1	1	1	1	1	1	1	1	1	4	4

TABLE C2. Analysis of variance (ANOVA) of the number of species and the biomass ( $\text{gm}^{-2}$ ) of internal invaders per functional group per harvest quadrat. Data exclude the 60-species level, because it always contains all four functional groups. The inclusion of resident biomass as a covariable did not change the significance of the results and was omitted from the model. "Species richness" stands for the  $\log_2$ -transformed sown species richness of the resident community. The deviation of the species richness effect from log-linearity was not significant and was omitted. The results were relatively robust to the order of the terms species richness and presence of particular functional groups, so only the results from the model with species richness tested first are shown. The presence of the four functional groups was tested in the order of their explanatory power in the model. Two- and three-way interactions of functional group effects were small and therefore were omitted from the model. The weeding and seed-addition treatments (c-, c+, and w+) were used to form two contrasts. Only the first of them ("Seed addition"), representing seed addition (c+ and w+) vs. no seed-addition treatments (c-), was included in the model (the contrast between w+ and c+ was not significant). The "Home-away contrast", which represents the main contrast within the total "Invader  $\times$  resident FG" interactions was tested against its deviation ("Other invader-resident FG interactions"). Other error terms are printed in italics. FG = functional group.

Source	Number of species				Biomass			
	df	SS	<i>F</i>	<i>P</i>	df	SS	<i>F</i>	<i>P</i>
Spatial variation	9	51.1	3.01	0.005	9	619241	2.70	0.010
Species richness	1	151.3	80.23	<0.001	1	815930	32.03	<0.001
Legume presence	1	83.7	44.38	<0.001	1	302853	11.89	0.001
Tall herb presence	1	18.7	9.89	0.003	1	85362	3.35	0.072
Grass presence	1	0.1	0.05	0.827	1	31173	1.22	0.273
Small herb presence	1	0.2	0.09	0.771	1	8594	0.34	0.563
<i>Plot</i>	<i>63</i>	<i>118.8</i>	<i>1.57</i>	<i>0.010</i>	<i>63</i>	<i>1604762</i>	<i>0.75</i>	<i>0.907</i>
Invader FG	3	154.1	42.67	<0.001	3	1602127	15.77	<0.001
Home-away contrast	1	145.8	37.94	<0.001	1	2071215	6.50	0.027
Other invader-resident FG interactions	11	42.3	3.19	<0.001	11	3506087	9.41	<0.001
Species richness × Home-away contrast	1	4.5	1.77	0.205	1	15375	0.14	0.710
Species richness × Other invader-resident FG interactions	14	35.2	2.09	0.014	14	1493090	3.15	<0.001
<i>Plot</i> × <i>Invader FG</i>	<i>201</i>	<i>242.0</i>	<i>2.88</i>	<i>&lt;0.001</i>	<i>202</i>	<i>6841052</i>	<i>3.03</i>	<i>&lt;0.001</i>

Seed addition	1	75.4	180.62	<0.001	1	93776	8.40	0.004
Species richness × Seed addition	1	19.8	47.44	<0.001	1	15019	1.35	0.246
Legume presence × Seed addition	1	19.6	46.91	<0.001	1	3215	0.29	0.591
Tall herb presence × Seed addition	1	1.1	2.66	0.104	1	1568	0.14	0.708
Grass presence × Seed addition	1	0.1	0.20	0.652	1	15890	1.42	0.233
Small herb presence × Seed addition	1	0.0	0.09	0.770	1	62645	5.61	0.018
Invader FG × Seed addition	3	13.9	11.07	<0.001	3	181883	5.43	<0.001
Home-away contrast × Seed addition	1	13.6	20.41	<0.001	1	119186	6.65	0.026
Other invader-resident FG interactions × Seed addition	11	7.3	1.59	0.097	11	197138	1.61	0.093
<i>Plot × Invader FG × Subplot</i>	<i>596</i>	<i>248.8</i>	<i>0.57</i>	<i>1.000</i>	<i>595</i>	<i>6639929</i>	<i>0.75</i>	<i>1.000</i>
Year	1	580.2	791.58	<0.001	1	2289985	154.69	<0.001
<i>Plot × Invader FG × Subplot × Year</i>	<i>901</i>	<i>660.4</i>	<i>2.49</i>	<i>&lt;0.001</i>				
<i>Residual</i>	<i>944</i>	<i>278.3</i>			<i>921</i>	<i>13634455</i>	<i>0.65</i>	<i>1.000</i>

TABLE C3. Analysis of variance (ANOVA) of the number of species of external invaders per harvest quadrat. Data exclude the 60-species level. The inclusion of resident biomass as a covariable did not change the significance of the results and was omitted from the model. "Species richness" stands for the  $\log_2$ -transformed sown species-richness of the resident community. The deviation of the species richness effect from log-linearity was not significant and was omitted. The results were relatively robust to the order of the terms species richness and presence of particular functional groups, so only the results from the model with species richness tested first are shown. The presence of the four functional groups was tested in the order of their explanatory power in the model. Two- and three-way interactions of functional group effects were small and were therefore omitted from the model. All error terms are printed in italics.

	<b>df</b>	<b>SS</b>	<b>F</b>	<b>P</b>
Spatial variation	9	10.3663	0.88	0.549
Species richness	1	28.9082	22.03	<0.001
Legume presence	1	10.9671	8.36	0.005
Small herb presence	1	6.0697	4.63	0.035
Tall herb presence	1	0.0013	0.00	0.975
Grass presence	1	0.2808	0.21	0.645
<i>Plot</i>	<i>67</i>	<i>87.9229</i>	<i>4.12</i>	<i>&lt;0.001</i>
Seed addition	1	0.823	2.58	0.112
Species richness × Seed addition	1	0.6031	1.89	0.173
Legume presence × Seed addition	1	0.0001	0.00	0.986
Small herb presence × Seed addition	1	1.2136	3.81	0.055
Tall herb presence × Seed addition	1	0.7482	2.35	0.130
Grass presence × Seed addition	1	0.044	0.14	0.711
<i>Plot × Subplot</i>	<i>76</i>	<i>24.2346</i>	<i>1.18</i>	<i>0.190</i>
Year	1	2.686	9.97	0.002
Species richness × Year	1	1.0648	3.95	0.049



Legume presence × Year	1	2.732	10.14	0.002
Small herb presence × Year	1	2.3659	8.78	0.004
Tall herb presence × Year	1	0.0043	0.02	0.900
Grass presence × Year	1	0.3525	1.31	0.255
Seed addition × Year	1	0.1736	0.64	0.423
<i>Plot × Subplot Year</i>	<i>155</i>	<i>41.7673</i>	<i>0.91</i>	<i>0.713</i>
<i>Residual</i>	<i>160</i>	<i>47.1871</i>		

TABLE C4. Analysis of variance (ANOVA) of the biomass ( $\text{gm}^{-2}$ ) of external invaders per harvest quadrat. Data exclude the 60-species level. The inclusion of resident biomass as a covariable did not change the significance of the results and was omitted from the model. "Species richness" stands for the  $\log_2$ -transformed sown species richness of the resident community. The deviation of the species-richness effect from log-linearity was not significant and was omitted. The results were relatively robust to the order of the terms species richness and presence of particular functional groups, so only the results from the model with species richness tested first are shown. The presence of the four functional groups was tested in the order of their explanatory power in the model. Two- and three-way interactions of functional group effects were small and were therefore omitted from the model. All error terms are printed in italics.

	<b>df</b>	<b>SS</b>	<b>F</b>	<b>P</b>
Spatial variation	9	42165	1.66	0.115
Species richness	1	38314	13.61	<0.001
Grass presence	1	4248	1.51	0.224
Small herb presence	1	3561	1.26	0.265
Legume presence	1	4541	1.61	0.209
Tall herb presence	1	0	0.00	1.000
<i>Plot</i>	<i>67</i>	<i>188639</i>	<i>1.58</i>	<i>0.027</i>

Seed addition	1	1522	0.85	0.359
Species richnesss × Seed addition	1	1535	0.86	0.357
Grass presence × Seed addition	1	31	0.02	0.896
Small herb presence × Seed addition	1	570	0.32	0.574
Legume presence × Seed addition	1	763	0.43	0.515
Tall herb presence × Seed addition	1	4455	2.49	0.118
<i>Plot × Subplot</i>	<i>76</i>	<i>135726</i>	<i>2.61</i>	<i>&lt;0.001</i>
Year	1	5827	8.53	0.004
Species richnesss × Year	1	3751	5.49	0.020
Grass presence × Year	1	230	0.34	0.563
Small herb presence × Year	1	634	0.93	0.337
Legume presence × Year	1	39	0.06	0.811
Tall herb presence × Year	1	2636	3.86	0.051
Seed addition × Year	1	778	1.14	0.288
<i>Plot × Subplot Year</i>	<i>155</i>	<i>105942</i>	<i>0.31</i>	<i>1</i>
<i>Residual</i>	<i>160</i>	<i>353360</i>		

TABLE C5. Analysis of variance (ANOVA) of the total number of species per harvest quadrat and of community biomass ( $\text{gm}^{-2}$ ). Target species were residents in weeded controls (w-), but residents, external and internal invaders in non-weeded subplots (c- and c+). "Species richness" is the sown species richness of the resident community. The weeding and seed-addition treatments (w-, c- and c+) were used to form two contrasts. The first of them ("Invasion") represents weeded controls (w-) vs. invasion treatments (c- and c+), the second ("Seed addition") represents non-weeded treatments without seed addition (c-) vs. with seed addition (c+). Error terms are printed in italics.

Source	Number of species				Biomass			
	df	SS	F	P	df	SS	F	P
Spatial variation	9	1100.7	9.05	<0.001	9	4440201	1.16	0.333
Species richness ( $\log_2$ )	1	3655.3	270.36	<0.001	1	12139477	28.63	<0.001
Species richness (deviation from log-linear)	4	1206.8	22.32	<0.001	4	1651207	0.97	0.428
<i>Plot</i>	<i>67</i>	<i>905.8</i>	<i>3.28</i>	<i>&lt;0.001</i>	<i>67</i>	<i>28408418</i>	<i>5.88</i>	<i>&lt;0.001</i>
Invasion	1	2915.7	706.83	<0.001	1	5018898	69.59	<0.001
Seed addition	1	203.5	49.34	<0.001	1	251564	3.49	0.064
Species richness ( $\log_2$ ) $\times$ Invasion	1	289.2	70.10	<0.001	1	1080842	14.99	<0.001
Species richness (deviation from log-linear) $\times$ Invasion	4	0.8	0.05	0.995	4	445103	1.54	0.193
Species richness ( $\log_2$ ) $\times$ Seed addition	1	40.2	9.75	0.002	1	65241	0.90	0.343
Species richness (deviation from log-linear) $\times$ Seed addition	4	20.2	1.22	0.303	4	256648	0.89	0.472
<i>Plot <math>\times</math> Subplot</i>	<i>150</i>	<i>618.8</i>	<i>0.99</i>	<i>0.522</i>	<i>150</i>	<i>10818315</i>	<i>0.75</i>	<i>0.970</i>
Year	1	663.5	159.32	<0.001	1	8354184	87.12	<0.001
Species richness ( $\log_2$ ) $\times$ Year	1	246.6	59.20	<0.001	1	38361	0.40	0.528
Species richness (deviation from	4	36.3	2.18	0.072	4	1745162	4.55	0.001

log-linear) × Year								
Invasion × Year	1	357.2	85.75	<0.001	1	1586364	16.54	<0.001
Seed addition × Year	1	114.4	27.46	<0.001	1	61793	0.64	0.423
Species richness (log <sub>2</sub> ) × Invasion × Year	1	87.4	20.98	<0.001	1	59669	0.62	0.431
Species richness (deviation from log-linear) × Invasion × Year	4	7.2	0.43	0.787	4	203245	0.53	0.714
Species richness (log <sub>2</sub> ) × Seed addition × Year	1	12.6	3.02	0.084	1	87566	0.91	0.340
Species richness (deviation from log-linear) × Seed addition × Year	4	5.2	0.31	0.868	4	291002	0.76	0.553
<i>Plot × Subplot × Year</i>	<i>224</i>	<i>932.9</i>	<i>2.13</i>	<i>&lt;0.001</i>	<i>224</i>	<i>21480355</i>	<i>1.41</i>	<i>0.005</i>
<i>Residual</i>	<i>242</i>	<i>472.5</i>			<i>242</i>	<i>16501297</i>		

TABLE C6. Analysis of variance (ANOVA) of community biomass, including the effect of observed (=realized) species richness. Target species were residents in weeded controls (w-), but residents, external and internal invaders in non-weeded subplots (c- and c+). The influence of "realized species richness (log<sub>2</sub>-transformed)" on community biomass was tested against the interaction "*Plot × Subplot × Year*". The weeding and seed-addition treatments (w-, c-, and c+) were used to form two contrasts. The first of them ("Invasion") represents weeded controls (w-) vs. non-weeded treatments (c- and c+), the second ("Seed addition") represents non-weeded treatments without seed addition (c-) vs. with seed addition (c+). Error terms are printed in italics.

<b>Source</b>	<b>df</b>	<b>SS</b>	<b>F</b>	<b>P</b>
Spatial variation	9	4085251	6.00	0.307
realized richness ( $\log_2$ )	1	15619722	160.67	<0.001
<i>Plot</i>	<i>72</i>	<i>36869246</i>	<i>6.83</i>	<i>&lt;0.001</i>
Invasion	1	75710	1.01	0.316
Seed addition	1	27015	0.36	0.549
realized richness ( $\log_2$ ) $\times$ Invasion	1	557075	5.73	0.017
realized richness ( $\log_2$ ) $\times$ Seed addition	1	658371	6.77	0.010
<i>Plot <math>\times</math> Subplot</i>	<i>160</i>	<i>11987260</i>	<i>0.77</i>	<i>0.962</i>
Year	1	3874550	39.85	<0.001
realized richness ( $\log_2$ ) $\times$ Year	1	1850417	19.03	<0.001
Invasion $\times$ Year	1	1347	0.01	0.906
Seed addition $\times$ Year	1	15993	0.16	0.685
realized richness ( $\log_2$ ) $\times$ Invasion $\times$ Year	1	563858	5.80	0.017
realized richness ( $\log_2$ ) $\times$ Seed addition $\times$ Year	1	85679	0.88	0.349
<i>Plot <math>\times</math> Subplot <math>\times</math> Year</i>	<i>239</i>	<i>23234778</i>	<i>1.55</i>	<i>&lt;0.001</i>
<i>Residual</i>	<i>233</i>	<i>14571877</i>		

TABLE C7. Analysis of variance (ANOVA) of the community biomass, including the effect of observed (=realized) functional-group proportions. In this analysis, external invaders were excluded because they could not be grouped into the respective functional groups, so target species in this case were residents in weeded controls (w-), but residents and internal invaders in non-weeded subplots (c- and c+). Three outliers with very high biomass were excluded. The realized functional-group proportions were included in the model in the order of their explanatory power and their influence was tested against the "Residual". The weeding and seed-addition treatments (w-, c-, and c+) were used to form two contrasts. The first of them ("Invasion") represents weeded controls (w-) vs. non-weeded treatments (c- and c+), the second ("Seed addition") represents non-weeded treatments without seed addition (c-) vs. with seed addition (c+). Error terms are printed in italics.

<b>Source</b>	<b>df</b>	<b>SS</b>	<b>F</b>	<b>P</b>
Spatial variation	9	2609852	2.10	0.041
Proportion of legumes	1	4847743	80.23	<0.001
Proportion of small herbs	1	1161391	19.22	<0.001
Proportion of grasses	1	1483	0.02	0.876
<i>Plot</i>	<i>72</i>	<i>9961269</i>	<i>2.29</i>	<i>&lt;0.001</i>
Invasion	1	3875505	64.14	<0.001
Seed addition	1	142731	2.36	0.126
Proportion of legumes × Invasion	1	924491	15.30	<0.001
Proportion of small herbs × Invasion	1	41616	0.69	0.408
Proportion of grasses × Invasion	1	256598	4.25	0.041
Proportion of legumes × Seed addition	1	39499	0.65	0.420
Proportion of small herbs × Seed addition	1	9209	0.15	0.697
Proportion of grasses × Seed addition	1	410	0.01	0.934
<i>Residual</i>	<i>147</i>	<i>8882268</i>		