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Supplementary information

Arthropod decline in grasslands and forests is associated with landscape-level drivers

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Arthropod decline in grasslands and forests is associated with drivers at landscape level

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Supplement S1 Detailed model results for aggregated data

Table S1-1 | Results from models for aggregated data, i.e. yearly sums of species biomass, abundances, and number/richness per site. Estimates, z- and p-values and marginal R^2 from linear mixed models for abundance, species number (Poisson errors) and biomass (Gaussian errors) for all arthropods and for arthropods of different trophic levels in 150 grasslands (A), 30 forests (B) and 140 forests (C). Data was recorded annually between 2008 and 2017 for grassland and between 2008 and 2016 for 30 forests and in 2008, 2011 and 2014 for 140 forests. For landscape land-use variables we considered a radius of 1000 m around the sites. Additional models for the radii 250, 500, 1500 and 2000 m showed very similar results, particularly for the effect of year (results not shown). All models included site nested in region as random effect to account for spatial arrangement and temporal repetitions per site. Poisson models included an observation-specific (i.e. one site in one year) random effect to account for potential overdispersion. P-values highlighted in with green are significant ($p \leq 0.05$), p-values highlighted in red are marginally significant ($p < 0.1$).

Note: A significant main effect of *year* indicates a significant change over time; a significant interaction between *year* and one of the land-use variables indicates that the magnitude of the temporal trend was affected by this variable; a significant main effect of land-use variables indicates that the response variable is affected but not its temporal trend. Since all our predictors were standardized prior to modelling, the z- and t-values are directly comparable within each model. For example, z-values of effects of the interactions year*grassland cover and year*arable crop cover on species numbers in grasslands are -1.78 and -2.18. Thus, the effect of grassland cover on the temporal trend in species number has only ~80% of the strength of the effect of arable crop cover.

Species richness refers to species number corrected for abundance[1]. The "species richness" models, thus, included log-transformed abundance as covariate and the observed number of species as response. This approach allows to account for changes in abundance when analyzing trends in the number of species[2]. For grasslands, the temporal trend in species richness was even positive indicating that the decline in species is mainly due to a loss of individuals. This pattern is largely consistent with the more-individuals hypothesis[3]. In forests, the temporal trend in species richness was negative, suggesting an underlying mechanism different to the one in grasslands. One possible explanation is that reduced habitat heterogeneity leads to the loss of certain species but other species are able to compensate losses in abundance.

A) Grassland Predictor		Biomass	Abundance incl. unidentified taxa	Abundance identified taxa	Species number	Species richness	Biomass omnivores	Abundance omnivores	Species number omnivores	Biomass carnivores	Abundance carnivores	Species number carnivores	Biomass herbivores	Abundance herbivores	Species number herbivores	Biomass myceto-detritivores	Abundance myceto-detritivores	Species number myceto-detritivores
Intercept	Estimate	1.338	6.137	4.395	3.118	1.409	0.063	0.175	0.061	0.202	1.774	1.453	1.252	4.225	2.815	0.003	-1.915	-1.363
	z-value	9.001	216.940	20.752	33.991	18.452	2.603	0.472	0.250	7.420	9.925	13.657	7.905	15.916	26.594	4.628	-3.022	-2.792
	p-value	<0.001	<0.001	<0.001	<0.001	<0.001	0.009	0.637	0.802	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	0.005
log(abundance)	Estimate					0.387												
	z-value					44.903												
	p-value					<0.001												
Temperature	Estimate	0.172	0.142	0.188	0.064	-0.010	0.008	0.098	0.055	0.001	0.099	0.043	0.185	0.178	0.065	<0.001	0.291	0.146
	z-value	9.319	6.634	7.439	5.319	-1.346	2.510	2.464	1.971	0.159	4.160	2.441	9.697	6.513	5.191	0.247	3.572	2.679
	p-value	<0.001	<0.001	<0.001	<0.001	0.178	0.012	0.014	0.049	0.874	<0.001	0.015	<0.001	<0.001	<0.001	0.805	<0.001	0.007
Precipitation	Estimate	0.047	0.069	0.032	0.093	0.085	0.010	0.066	0.081	0.023	0.142	0.057	0.033	0.013	0.098	-0.001	0.014	-0.044
	z-value	1.653	2.536	0.826	4.878	6.905	1.872	1.052	1.763	2.386	3.755	1.990	1.143	0.315	4.954	-2.061	0.113	-0.520
	p-value	0.098	0.011	0.409	<0.001	<0.001	0.061	0.293	0.078	0.017	<0.001	0.047	0.253	0.753	<0.001	0.039	0.910	0.603
Year	Estimate	-0.210	-0.216	-0.377	-0.105	0.043	-0.009	-0.280	-0.160	-0.015	-0.048	-0.017	-0.220	-0.417	-0.123	-0.001	-0.481	-0.399
	z-value	-12.608	-11.277	-16.484	-9.701	5.791	-2.972	-8.107	-6.336	-2.526	-2.253	-1.071	-12.819	-16.847	-10.846	-3.321	-6.697	-8.279
	p-value	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	0.012	0.024	0.284	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Local land-use intensity	Estimate	-0.079	-0.021	-0.052	-0.069	-0.048	-0.004	0.079	-0.005	-0.013	-0.030	-0.048	-0.079	-0.066	-0.076	<0.001	0.038	-0.025
	z-value	-3.221	-0.742	-1.808	-4.415	-4.684	-1.093	1.484	-0.149	-1.775	-1.166	-2.541	-3.122	-2.106	-4.484	0.724	0.413	-0.440
	p-value	0.001	0.458	0.071	<0.001	<0.001	0.275	0.138	0.881	0.076	0.244	0.011	0.002	0.035	<0.001	0.469	0.680	0.660
Grassland cover	Estimate	-0.088	-0.066	-0.108	-0.084	-0.044	-0.010	-0.118	-0.068	-0.001	-0.004	-0.014	-0.091	-0.126	-0.106	<0.001	-0.036	-0.016
	z-value	-3.339	-2.170	-3.487	-5.063	-4.083	-2.464	-2.147	-1.942	-0.131	-0.147	-0.715	-3.380	-3.739	-5.839	1.295	-0.418	-0.304
	p-value	0.001	0.030	<0.001	<0.001	<0.001	0.014	0.032	0.052	0.896	0.883	0.474	0.001	<0.001	<0.001	0.195	0.676	0.761
Arable crop cover	Estimate	-0.128	-0.079	-0.134	-0.084	-0.034	-0.005	-0.093	-0.036	-0.030	-0.105	-0.087	-0.124	-0.132	-0.085	<0.001	-0.094	-0.039
	z-value	-4.236	-2.439	-3.763	-4.416	-2.668	-1.083	-1.443	-0.875	-3.246	-3.251	-3.734	-3.985	-3.389	-4.083	-0.378	-0.930	-0.629
	p-value	<0.001	0.015	<0.001	<0.001	0.008	0.279	0.149	0.382	0.001	0.001	<0.001	<0.001	0.001	<0.001	0.705	0.352	0.530
Temperature * precipitation	Estimate	0.050	0.048	0.106	0.023	-0.018	-0.001	-0.053	-0.049	-0.014	0.045	0.009	0.064	0.123	0.030	<0.001	0.138	0.047
	z-value	2.906	2.443	4.524	2.058	-2.482	-0.442	-1.350	-1.698	-2.306	2.030	0.548	3.622	4.852	2.593	0.616	1.538	0.723
	p-value	0.004	0.015	<0.001	0.040	0.013	0.659	0.177	0.090	0.021	0.042	0.584	<0.001	<0.001	0.010	0.538	0.124	0.470
Year * local land-use intensity	Estimate	0.016	-0.019	-0.027	0.014	0.026	<0.001	0.023	0.008	0.005	0.019	0.013	0.016	-0.032	0.016	<0.001	-0.013	0.004
	z-value	0.983	-1.053	-1.243	1.310	3.945	-0.167	0.660	0.286	0.947	0.894	0.843	0.987	-1.356	1.466	-1.129	-0.177	0.085
	p-value	0.325	0.292	0.214	0.190	<0.001	0.868	0.509	0.775	0.344	0.371	0.399	0.324	0.175	0.143	0.259	0.860	0.932
Year * grassland cover	Estimate	-0.026	-0.024	-0.033	-0.021	-0.008	0.002	-0.011	-0.042	0.005	-0.007	<0.001	-0.032	-0.038	-0.024	<0.001	-0.218	-0.150
	z-value	-1.492	-1.185	-1.336	-1.775	-1.108	0.536	-0.312	-1.669	0.882	-0.324	0.019	-1.746	-1.446	-1.952	-1.581	-3.143	-3.313
	p-value	0.136	0.236	0.182	0.076	0.268	0.592	0.755	0.095	0.378	0.746	0.985	0.081	0.148	0.051	0.114	0.002	0.001
Year * Arable crop cover	Estimate	<0.001	-0.010	-0.022	-0.025	-0.018	0.006	-0.009	-0.007	0.019	0.014	0.016	-0.009	-0.034	-0.034	<0.001	-0.078	-0.124
	z-value	-0.022	-0.491	-0.897	-2.179	-2.525	1.749	-0.229	-0.271	3.120	0.608	0.954	-0.475	-1.299	-2.800	-1.667	-1.053	-2.482
	p-value	0.983	0.623	0.370	0.029	0.012	0.080	0.819	0.786	0.002	0.543	0.340	0.635	0.194	0.005	0.096	0.292	0.013
R^2 marginal		0.138	0.101	0.164	0.151	0.677	0.020	0.052	0.035	0.059	0.059	0.041	0.138	0.161	0.163	0.018	0.058	0.054

B) Forest 30 Predictor		Biomass	Abundance incl. unidentified taxa	Abundance identified taxa	Species number	Species richness	Biomass omnivores	Abundance omnivores	Species number omnivores	Biomass carnivores	Abundance carnivores	Species number carnivores	Biomass herbivores	Abundance herbivores	Species number herbivores	Biomass myceto-detritivores	Abundance myceto-detritivores	Species number myceto-detritivores
Intercept	Estimate	2.190		5.610	4.291	2.477	1.166	4.186	2.857	-0.048	3.446	2.939	0.802	4.148	2.630	0.526	4.359	3.114
	z-value	12.788		86.861	98.439	19.379	5.552	41.920	52.811	-0.649	74.627	103.199	10.218	74.507	94.773	1.992	49.376	36.189
	p-value	<0.001		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.516	<0.001	<0.001	<0.001	<0.001	<0.001	0.046	<0.001	<0.001
log(abundance)	Estimate					0.323												
	z-value					14.489												
	p-value					<0.001												
Temperature	Estimate	0.015		-0.098	-0.036	-0.006	0.036	-0.204	-0.022	-0.062	0.003	-0.012	0.081	-0.093	-0.069	-0.074	-0.049	-0.042
	z-value	0.462		-3.059	-2.437	-0.507	0.852	-4.614	-1.173	-1.524	0.085	-0.565	1.872	-2.425	-3.388	-1.403	-1.113	-2.283
	p-value	0.644		0.002	0.015	0.612	0.394	<0.001	0.241	0.127	0.932	0.572	0.061	0.015	0.001	0.161	0.266	0.022
Precipitation	Estimate	-0.155		-0.143	-0.079	-0.032	-0.185	-0.258	-0.117	-0.106	-0.136	-0.097	-0.127	0.045	-0.041	-0.211	-0.210	-0.058
	z-value	-3.140		-3.159	-3.563	-1.937	-2.971	-4.135	-4.022	-1.819	-2.981	-3.208	-2.069	0.831	-1.472	-2.700	-3.254	-2.036
	p-value	0.002		0.002	<0.001	0.053	0.003	<0.001	<0.001	0.069	0.003	0.001	0.039	0.406	0.141	0.007	0.001	0.042
Year	Estimate	-0.130		-0.045	-0.110	-0.095	-0.140	-0.100	-0.149	-0.163	-0.293	-0.198	-0.075	0.277	0.063	-0.200	-0.195	-0.109
	z-value	-3.672		-1.339	-6.935	-8.123	-3.147	-2.142	-7.361	-3.783	-8.828	-8.902	-1.650	6.875	2.899	-3.571	-4.164	-5.508
	p-value	<0.001		0.180	<0.001	<0.001	0.002	0.032	<0.001	<0.001	<0.001	<0.001	0.099	<0.001	0.004	<0.001	<0.001	<0.001
Local land-use intensity	Estimate	-0.007		0.035	-0.011	-0.024	0.053	-0.029	0.017	0.074	0.056	-0.014	-0.205	-0.162	-0.039	0.081	0.172	-0.012
	z-value	-0.093		0.707	-0.300	-0.969	0.503	-0.435	0.399	0.979	1.137	-0.471	-2.977	-2.714	-1.318	0.738	1.795	-0.218
	p-value	0.926		0.480	0.764	0.333	0.615	0.663	0.690	0.327	0.256	0.637	0.003	0.007	0.188	0.461	0.073	0.827
Grassland cover	Estimate	-0.196		-0.050	-0.079	-0.066	-0.112	-0.052	-0.073	-0.078	-0.065	-0.059	-0.108	0.028	-0.104	-0.323	-0.125	-0.077
	z-value	-1.731		-0.738	-1.891	-2.598	-0.732	-0.600	-1.367	-0.971	-1.195	-1.743	-1.340	0.438	-3.163	-1.878	-1.283	-1.075
	p-value	0.084		0.461	0.059	0.009	0.464	0.549	0.172	0.331	0.232	0.081	0.180	0.661	0.002	0.060	0.200	0.282
Arable crop cover	Estimate	0.038		0.016	0.072	0.071	0.153	0.021	0.083	-0.052	-0.004	0.035	-0.084	-0.118	0.053	0.015	0.136	0.099
	z-value	0.506		0.318	1.944	2.870	1.439	0.300	1.835	-0.693	-0.074	1.158	-1.204	-1.973	1.800	0.132	1.426	1.762
	p-value	0.613		0.751	0.052	0.004	0.150	0.764	0.066	0.488	0.941	0.247	0.229	0.048	0.072	0.895	0.154	0.078
Temperature * precipitation	Estimate	0.092		0.065	0.014	-0.009	0.096	0.114	0.017	0.064	0.025	0.006	0.066	0.096	0.013	0.053	0.018	0.024
	z-value	2.801		2.039	0.955	-0.759	2.313	2.581	0.861	1.583	0.790	0.254	1.525	2.538	0.640	1.017	0.400	1.261
	p-value	0.005		0.041	0.340	0.448	0.021	0.010	0.389	0.113	0.429	0.800	0.127	0.011	0.522	0.309	0.689	0.207
Year * local land-use intensity	Estimate	-0.039		-0.024	-0.001	0.008	-0.031	-0.027	-0.005	-0.074	-0.018	-0.009	0.028	0.009	<0.001	-0.044	-0.026	0.012
	z-value	-1.292		-0.821	-0.037	0.765	-0.803	-0.680	-0.260	-1.990	-0.609	-0.448	0.716	0.244	0.026	-0.918	-0.633	0.714
	p-value	0.196		0.412	0.970	0.444	0.422	0.496	0.795	0.047	0.543	0.654	0.474	0.807	0.979	0.359	0.527	0.475
Year * grassland cover	Estimate	-0.018		-0.004	0.010	0.010	0.012	-0.019	0.022	-0.134	0.042	0.020	0.040	-0.019	0.015	-0.060	-0.068	-0.003
	z-value	-0.560		-0.113	0.660	0.895	0.293	-0.437	1.076	-3.397	1.330	0.910	0.947	-0.507	0.699	-1.164	-1.552	-0.157
	p-value	0.576		0.910	0.510	0.371	0.769	0.662	0.282	0.001	0.183	0.363	0.344	0.612	0.484	0.244	0.121	0.875
Year * Arable crop cover	Estimate	0.015		-0.012	0.008	0.012	0.046	-0.009	-0.002	-0.020	-0.002	0.006	0.015	-0.025	0.029	-0.023	0.036	<0.001
	z-value	0.489		-0.404	0.572	1.130	1.186	-0.228	-0.090	-0.543	-0.061	0.319	0.368	-0.707	1.586	-0.479	0.884	0.006
	p-value	0.625		0.686	0.567	0.258	0.235	0.820	0.929	0.587	0.952	0.750	0.713	0.480	0.113	0.632	0.377	0.995
R² marginal		0.233		0.150	0.328	0.857	0.151	0.226	0.313	0.175	0.310	0.339	0.240	0.267	0.209	0.224	0.241	0.201

C) Forest 140		**Biomass**	**Abundance incl. unidentified taxa**	**Abundance identified taxa**	**Species number**	**Species richness**	**Biomass omnivores**	**Abundance omnivores**	**Species number omnivores**	**Biomass carnivores**	**Abundance carnivores**	**Species number carnivores**	**Biomass herbivores**	**Abundance herbivores**	**Species number herbivores**	**Biomass myceto-detritivores**	**Abundance myceto-detritivores**	**Species number myceto-detritivores**
Predictor																		
Intercept	Estimate	1.983		5.406	4.065	1.805	0.911	4.021	2.652	-0.392	3.113	2.625	0.833	4.021	2.505	0.214	4.022	2.867
	z-value	8.788		28.137	54.720	18.706	4.142	15.109	30.128	-3.096	26.520	123.058	5.535	113.928	68.395	0.599	15.098	22.622
	p-value	0.000		0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.549	0.000	0.000
log(abundance)	Estimate					0.418												
	z-value					24.297												
	p-value					0.000												
Temperature	Estimate	0.004		-0.253	-0.069	0.029	-0.028	-0.454	-0.048	-0.094	-0.115	-0.009	0.177	0.023	-0.118	-0.132	-0.301	-0.092
	z-value	0.080		-6.062	-3.379	2.288	-0.608	-8.464	-2.297	-2.238	-2.866	-0.390	3.315	0.551	-5.114	-2.016	-6.034	-4.045
	p-value	0.936		0.000	0.001	0.022	0.543	0.000	0.022	0.025	0.004	0.697	0.001	0.582	0.000	0.044	0.000	0.000
Precipitation	Estimate	-0.063		0.101	-0.073	-0.109	-0.126	-0.022	-0.052	0.011	-0.026	-0.129	-0.082	0.084	-0.074	-0.142	-0.023	-0.050
	z-value	-1.030		1.705	-2.587	-6.570	-1.990	-0.289	-1.731	0.198	-0.445	-4.693	-1.157	1.823	-1.818	-1.596	-0.327	-1.524
	p-value	0.303		0.088	0.010	0.000	0.047	0.772	0.083	0.843	0.656	0.000	0.247	0.068	0.069	0.110	0.743	0.127
Year	Estimate	-0.131		0.062	-0.096	-0.121	-0.228	-0.065	-0.132	-0.158	-0.360	-0.244	-0.051	0.406	0.133	-0.124	-0.136	-0.126
	z-value	-4.131		2.115	-6.776	-13.074	-7.069	-1.681	-8.482	-5.282	-12.575	-12.240	-1.317	12.584	8.848	-2.730	-3.974	-7.452
	p-value	0.000		0.034	0.000	0.000	0.000	0.093	0.000	0.000	0.000	0.000	0.188	0.000	0.000	0.006	0.000	0.000
Local land-use intensity	Estimate	0.120		0.015	0.052	0.049	0.201	-0.022	0.071	0.124	0.115	0.059	0.012	-0.067	0.029	0.072	0.106	0.045
	z-value	2.811		0.458	2.393	3.683	4.126	-0.523	2.805	3.195	3.400	2.650	0.257	-1.795	1.330	1.139	2.112	1.625
	p-value	0.005		0.647	0.017	0.000	0.000	0.601	0.005	0.001	0.001	0.008	0.797	0.073	0.184	0.255	0.035	0.104
Grassland cover	Estimate	-0.147		-0.064	-0.040	0.000	-0.138	-0.043	-0.053	-0.096	-0.055	-0.023	-0.170	-0.062	-0.039	-0.069	-0.091	-0.049
	z-value	-2.360		-1.313	-1.222	0.011	-1.951	-0.680	-1.347	-1.748	-1.055	-0.836	-2.544	-1.326	-0.660	-0.754	-1.184	-1.160
	p-value	0.018		0.189	0.222	0.991	0.051	0.497	0.178	0.080	0.291	0.403	0.011	0.185	0.510	0.451	0.236	0.246
Arable crop cover	Estimate	0.011		0.036	0.033	0.019	0.019	-0.044	0.031	-0.025	0.018	0.022	-0.037	0.022	0.042	0.032	0.065	0.033
	z-value	0.263		1.160	1.574	1.482	0.394	-1.096	1.304	-0.662	0.551	1.031	-0.824	0.592	1.956	0.537	1.349	1.242
	p-value	0.793		0.246	0.115	0.138	0.693	0.273	0.192	0.508	0.582	0.302	0.410	0.554	0.050	0.591	0.177	0.214
Temperature * precipitation	Estimate	0.205		0.120	0.075	0.012	0.071	0.031	0.068	0.170	0.153	0.111	0.323	0.320	0.085	0.191	0.002	0.048
	z-value	4.105		2.664	3.353	0.817	1.391	0.534	2.845	3.634	3.532	4.063	5.432	6.897	3.974	2.652	0.045	1.830
	p-value	0.000		0.008	0.001	0.414	0.164	0.593	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.008	0.964	0.067
Year * local land-use intensity	Estimate	-0.016		-0.045	-0.005	0.015	-0.032	-0.067	-0.019	-0.007	0.002	-0.006	0.056	0.004	0.015	-0.099	-0.046	-0.009
	z-value	-0.483		-1.431	-0.349	1.592	-0.923	-1.627	-1.143	-0.228	0.077	-0.284	1.347	0.115	0.972	-2.036	-1.257	-0.482
	p-value	0.629		0.152	0.727	0.111	0.356	0.104	0.253	0.819	0.938	0.776	0.178	0.908	0.331	0.042	0.209	0.630
Year * grassland cover	Estimate	0.107		0.124	0.085	0.034	0.111	0.079	0.079	0.042	0.108	0.129	0.120	0.081	0.046	0.107	0.104	0.072
	z-value	2.988		3.720	5.216	3.090	3.063	1.805	4.346	1.259	3.316	5.751	2.770	2.244	2.421	2.093	2.633	3.626
	p-value	0.003		0.000	0.000	0.002	0.002	0.071	0.000	0.208	0.001	0.000	0.006	0.025	0.015	0.036	0.008	0.000
Year * Arable crop cover	Estimate	-0.005		-0.040	-0.003	0.014	0.026	-0.053	0.001	-0.069	-0.044	-0.012	0.001	0.007	-0.006	-0.060	-0.048	0.006
	z-value	-0.153		-1.300	-0.177	1.437	0.772	-1.307	0.043	-2.207	-1.453	-0.571	0.016	0.204	-0.370	-1.260	-1.347	0.353
	p-value	0.878		0.193	0.860	0.158	0.440	0.191	0.966	0.027	0.146	0.568	0.987	0.838	0.711	0.208	0.178	0.724
R^2 marginal		0.135		0.207	0.251	0.754	0.161	0.224	0.218	0.163	0.356	0.406	0.178	0.362	0.343	0.092	0.146	0.174

Supplement S2 Details on effects of weather and climatic change on arthropod numbers

Effects of weather on arthropod numbers:

Our models showed clear but differing effects of weather conditions on arthropod numbers in both grasslands and forests (Table S1-1; Extended Data Figure S 1): both, winter temperature and precipitation during the growing period, had positive effects in grasslands but negative effects in forests. More research is required to gain a deeper mechanistic understanding of these patterns. Yet, possible explanations are that arthropods in grasslands suffer more from direct mortality due to frost and from lower plant biomass due to summer drought[4] than arthropods in forests; in contrast, arthropods in forests may be more susceptible to pathogens during warm winter and wet summer conditions[5] and benefit from reduced host resistance when precipitation during the growing period is low[6].

To evaluate if weather affected our trend estimates, we reran our main models (Table S1-1) excluding weather variables as predictors. These results indicate that models including weather variables explained more variation in arthropod numbers than models without weather variables (Table S2-1). When weather variables were included, estimated trends were similar or stronger in grasslands and similar or slightly weaker in forests (Table S2-1). This suggests that our weather variables improved the explanatory power of the models and in some cases, helped to detect arthropod trends by reducing variation.

Table S2-1 | Results from models with and without weather variables as predictor

Z-/t- and p-values for effects of *year* and marginal R^2 from (generalized) linear mixed models for abundance, species number (Poisson errors) and biomass (Gaussian errors) for all arthropods from models which included year, local and landscape land-use intensity as predictors but no weather variables (A) and from our full models which included weather variables (B; Table S1-1). The number of independent samples in each model was 1406 and 266 for grasslands and forest, respectively.

	A) Models without weather variables			**B) Models with weather variables**		
	z-/t-value	**p-value**	**R^2 marginal**	**z-/t-value**	**p-value**	**R^2 marginal**
Grassland						
Biomass	-9.893	< 0.001	0.090	-12.608	< 0.001	0.138
Abundance	-14.818	< 0.001	0.135	-16.484	< 0.001	0.164
Species number	-9.299	< 0.001	0.114	-9.701	< 0.001	0.151
Forest 30 sites						
Biomass	-3.228	0.001	0.147	-3.672	< 0.001	0.233
Abundance	-2.101	0.036	0.063	-1.339	0.180	0.150
Species number	-7.974	< 0.001	0.277	-6.935	< 0.001	0.328

Possible effects of climatic change on arthropod trends:

We observed changes in climatic conditions over the course of our study, i.e. higher winter temperature and lower precipitation during the growing period (Extended Data Figure S7). Based on our model results (Table S1-1; Extended Data Figure S 1), both positive and negative effects on arthropod numbers may be expected from these climatic changes. In grasslands, increasing winter temperatures may be beneficial for arthropods, but lower precipitation during the growing period may be detrimental. In forests, increasing precipitation may be beneficial, but higher winter temperature may be detrimental. We are currently not able to quantify the net effect of these climatic changes on arthropod numbers and thus, if and how much the observed trends in arthropod numbers were affected by them. If temperatures will increase and precipitation decrease in Central Europe as predicted due to climate change[7], this may have negative effects on arthropods in both forests and grasslands.

Supplement S3 Details on the robustness of temporal trends

A) Robustness of trend estimates

To evaluate the robustness of the observed temporal trends in arthropod numbers, we conducted several additional analyses. In addition to the estimated percentage declines predicted by our models which included weather and land-use variables as covariates (Supplementary Table S1-1), we compared arthropod numbers at each site between the first and last, and between the first two and last two years of our study and calculated means and standard deviations. These alternative trend estimates support overall trends found in our models but suggest weaker declines in grasslands compared to the trend estimates from our models (Supplementary Table S3-1). In forests, alternative trend estimates suggest, e.g., stronger declines in abundance, similar declines in species number and weaker declines in biomass. In the main text, we present trend estimates based on our models since they included weather conditions and land-use variables as covariates.

Table S3-1 | Different estimates of temporal trends in arthropod biomass, species number and abundance.

Estimated percentage of declines over the observation period in arthropod abundance (all individuals), abundance of specimen identified to species level, species number and total biomass, calculated either based on fitted models (Supplementary Table S1-1, coefficient of “year”; $n_{grassland}$ = 1406, n_{forest} = 266), on raw data from first (2008) and last study year (2016 in forests and 2017 in grasslands; $n_{grassland}$ = 138, n_{forest} = 29), or on raw data pooled for the first and last two study years to reduce potential effects on annual fluctuations ($n_{grassland}$ = 99, n_{forest} = 29). Results for forests refer to those sites that were sampled annually.

	Based on model coefficients for the fixed effect "year", including data from all years		Based on raw data of first vs. last year				Based on raw data of first two vs. last two years			
	Forest	**Grassland**	**Forest**		**Grassland**		**Forest**		**Grassland**	
			Mean	SD	Mean	SD	Mean	SD	Mean	SD
Abundance all	NA	-57.9	NA	NA	-37.7	72.5	NA	NA	NA	NA
Abundance identified taxa	-16.6	-77.9	-33.7	33.9	-66.9	35.0	-4.4	39.3	-54.6	42.2
Species number	-35.6	-34.4	-31.6	22.6	-26.6	35.4	-21.3	16.1	-16.1	37.5
Biomass	-40.5	-67.1	-27.4	62.9	-49.7	58.0	-9.8	49.0	-35.6	73.6

B) Contribution of individual years to overall trends

We tested whether particular years had a strong influence on the overall conclusions by repeating our models and excluding data from one year each time. Both weaker and stronger trends were found when single years were excluded, but trends were largely similar to those found in models that included all years (Extended Data Figure S2). The only single year with a notable effect on overall trends was the year 2008, since declines were strongest from 2008 to 2010, particularly in grasslands.

Because this approach suffers from reduced statistical power when part of the data is excluded, we fitted 100 models for each main response in grasslands and forests in which the order of years was randomized in the data each time. The histograms of z-values indicate that the observed trends differ strongly from random (Extended Data Figure S2). This means that significant trends can only be found when years are ordered correctly which suggests that a step-wise decline over several years is driving the trends.

In contrast to our analyses on alpha diversity level which assess statistical significance of temporal trends only for a series of years, our analysis of gamma diversity allows to assess significance for comparison of two individual years since non-overlapping confidence intervals derived from bootstrapping indicate significant differences[8]. In grasslands, gamma diversity declined continuously from 2008 to 2012, then increased slightly and declined again until 2016 (Figure 1). In forests, gamma diversity showed a relatively continuous decline from 2008 to 2016 despite some fluctuations (Figure 1). This confirms that a step-wise decline over several years has occurred.

Most of the decline, particularly in grasslands, appears to have happened from 2008 to 2010 which raises the concern whether 2008 is a reliable starting point for the time-series analysis. To address this case, we discuss four questions:

i. **Are the observed patterns part of a longer-term trend?**

   When comparing the temporal patterns between 2008 and 2016 reported here (Figure 1) and by Hallmann et al.[9], several similarities can be observed: arthropod numbers declined from 2008 to 2010 in both datasets, followed by an increase in 2011 which is more pronounced in Hallmann et al.´s data but also observable in our data, particularly in forests. After 2011, arthropod numbers again declined in both data sets until 2016 when the data series of Hallmann et al. ended. This match in temporal patterns in both time series suggests that our results are indeed part of a longer-term trend in arthropod numbers, which has taken place since at least the early 1990s[9]. Note that differences between years in arthropod biomass from Hallmann et al.[9] should be interpreted with caution considering that sampling locations differed between years.

ii. **Can high arthropod numbers in 2008 be attributed to outstanding weather conditions?**

   Winter temperatures were higher and precipitation during the growing period lower in 2008 than in the following two years. Weather conditions in 2014-2016, however, were similar to those in 2008. This suggests that high arthropod numbers in 2008 were not solely caused by certain weather conditions.

iii. **Can declines in arthropod numbers be associated with scientific activities or research-related changes in management?**

Since the sites of the Biodiversity Exploratories are managed by landowners or tenant farmers, not by the scientific consortium, there was no change in type or intensity of land use at the sites due to the start of the scientific monitoring in 2008. The number of site visits by scientists is reduced to a minimum and the activities of different research groups are well coordinated and take place in different areas within the site, precisely marked on plotcharts which each researcher has to follow (each researcher has to take the shortest way to the subplot without affecting other subplots), to avoid disturbance. The areas allocated for insect sampling are located in the site corners (forests) or along the site borders (grasslands), where no other activities are carried out. (Note that all sites are part of larger management units and thus, there is no change in vegetation structure or land use at the site border that could cause edge effects.) The number of research groups conducting field work was relatively stable over our study period. Although we cannot completely rule out that scientific activities may have had some effects on the local communities, it is unlikely that the strong decrease in arthropod numbers observed should be only a local phenomenon due to research activities, particularly if considering that the observed patterns match those reported from different locations[9].

iv. **Were there changes in land use at landscape level in 2008 or shortly before that could explain why declines were stronger in earlier than in later years?**

In 2007, the Common Agricultural Policy of the European Union suspended the compulsory site-aside of agricultural area[10]. In Germany, this led to a decrease in fallows from 650,000 ha in 2007 to 310,000 ha in 2008[11]. This change in land cover may have had negative effects on arthropod numbers. However, further data on land use at landscape scale including information on, e.g., pesticide use or high-resolution habitat availability, is lacking. This limits our ability to quantify effects of land-use at landscape scale and to separate short-term from long-term effects. The longer time-series of Hallmann et al.[9] indicates that there were several periods of stronger declines and periods of rather stable insect biomass over the past 30 years. In Hallmann et al.'s study, insect biomass declined more and more over time and never reached levels of the early 1990s, despite some periods of rather stable numbers. Our patterns are similar although only one period of strong decline was observed due to the shorter length of the time series. This suggests that the observed declines are part of a longer-term process or a series of events and not caused by a single event or change in land use around 2008.

v. **Can high arthropod numbers in 2008 be caused by site-selection bias?**

If site selection favored sites with high densities of focal species, time-series studies are likely to detect population declines for statistical reasons, even if there are no real declines[12]. For our study, sites were chosen which represented gradients of land-use intensity. Arthropod numbers, but not their temporal trends, were affected by local land-use intensity (Supplementary Table S1-1). This indicates that the observed trends and the high arthropod numbers in 2008 are not a result of site-selection bias.

C) Changes in personnel conducting sweep-netting

Different people conducted sweep-netting in each of the tree regions due to logistical ease, but within regions personnel were kept as constant as possible. We tried to reduce the observer bias as much as possible by standardizing sweep-netting, i.e. the same number of double sweeps was done at each site each time and the same transect length was covered within the same amount of time. Personnel conducting the sweep-netting were trained comprehensively. Changes in personnel conducting sweep-netting were reduced as much as possible, but could not be omitted completely: one change in Schwäbische Alb and Hainich regions in 2009; two changes in Schorfheide region in 2009 and 2010. While we cannot rule out that changes of observers might have contributed somehow to differences between 2008 and 2009, two arguments suggest that the overall trends are not caused by changes in personnel. First, grassland arthropods declined in all three regions, but it is unlikely that the subsequent observers were sampling less efficiently than their predecessors in all three regions. Second, the largest portion of the decline in grasslands happened between 2008 and 2010, but at least two regions were sampled by the same person in 2009 and 2010. Overall, the observer bias is much more likely to contribute to differences between regions (which are accounted for in our models by including region as random effect) rather than to the effect of year.

D) Detailed model results for non-aggregated data

Detected temporal trends in arthropod numbers from models with data of individual sampling dates not aggregated per year (Table S3-2), were consistent with model results for data aggregated per site and year (Table S1-1).

Table S3-2 | Results from models for non-aggregated data. Results from generalized additive mixed models with data at the level of individual observations (i.e., two collections per year for grasslands, n = 2819, and five collections per year for forests, n = 1634) which could account for seasonal differences and weather conditions at the time of sampling. For grasslands, fixed effects included mean winter temperature, precipitation during the growing season and their interaction, mean temperature and precipitation on the day of sampling, Julian date of the day of sampling, local land-use intensity and landscape-level land-use intensity (cover of arable fields and cover of grassland within a radius of 1000 m), as well as interactions between year and local land-use intensity and between year and landscape-level land-use intensity. For forest data from 30 sites, fixed effects included mean winter temperature, mean temperature and precipitation during sampling period, length of sampling period [days], Julian date of the day when traps were emptied, local land-use intensity and landscape-level land-use intensity (cover of arable fields and cover of grassland within a radius of 1000 m), as well as interactions between year and local land-use intensity and between year and landscape-level land-use intensity. Models included site nested in region as random effect to account for the nested design and the repeated measure at site level. Poisson models included a site-specific random effect to account for potential overdispersion. P-values highlighted in green are significant ($p < 0.05$), p-values highlighted in red are marginally significant ($p < 0.1$).

	Biomass		Abundance incl. unidentified taxa		Abundance identified taxa		Species number	
A) Grassland	z-value	p-value	z-value	p-value	z-value	p-value	z-value	p-value
Intercept	0.050	0.960	112.679	<0.001	13.101	<0.001	22.566	<0.001
Winter temperature	7.059	<0.001	4.467	<0.001	6.867	<0.001	4.647	<0.001
Precipitation growing season	-0.967	0.334	1.059	0.290	-1.551	0.121	1.882	0.060
Temperature sampling	3.470	0.001	4.921	<0.001	6.324	<0.001	5.398	<0.001
Precipitation sampling	0.545	0.585	-0.592	0.554	1.352	0.176	1.567	0.117
Year	-11.114	<0.001	-10.117	<0.001	-14.967	<0.001	-9.359	<0.001
Local land-use intensity	-4.233	<0.001	-0.688	0.492	-2.462	0.014	-4.271	<0.001
Arable crop cover	-4.907	<0.001	-3.616	<0.001	-4.297	<0.001	-4.727	<0.001
Grassland cover	-4.419	<0.001	-2.876	0.004	-4.374	<0.001	-5.575	<0.001
Winter temperature * precipitation growing period	0.704	0.482	2.132	0.033	2.800	0.005	0.354	0.723
Year * local land-use intensity	0.004	0.996	-1.613	0.107	-1.648	0.099	0.772	0.440
Year * Arable crop cover	1.739	0.082	0.447	0.655	1.214	0.225	-0.747	0.455
Year * grassland cover	-0.052	0.959	-0.663	0.508	-0.173	0.863	-0.725	0.469
	Chi.sq	p-value	Chi.sq	p-value	Chi.sq	p-value	Chi.sq	p-value
s(Julian date of sampling)	36.400	<0.001	35.680	<0.001	243.300	<0.001	171.200	<0.001

	Biomass		Abundance incl. unidentified taxa	Abundance identified taxa		Species number	
B) Forest (30)	z-value	p-value		z-value	p-value	z-value	p-value
Intercept	-0.029	0.977		50.880	<0.001	60.456	<0.001
Winter temperature	-0.401	0.688		-2.570	0.010	-3.003	0.003
Temperature sampling	7.277	<0.001		7.272	<0.001	7.960	<0.001
Precipitation sampling	-3.863	<0.001		-3.290	0.001	-3.103	0.002
Length of sampling period	8.707	<0.001		9.565	<0.001	10.037	<0.001
Year	-5.430	<0.001		-1.286	0.198	-4.621	<0.001
Local land-use intensity	2.159	0.031		2.465	0.014	1.034	0.301
Arable crop cover	-0.308	0.758		0.774	0.439	1.512	0.131
Grassland cover	-1.192	0.234		-0.849	0.396	-1.658	0.097
Year * local land-use intensity	-2.950	0.003		-1.987	0.047	-0.820	0.412
Year * Arable crop cover	1.165	0.244		-0.371	0.711	0.273	0.785
Year * grassland cover	0.069	0.945		1.113	0.266	-0.050	0.960
	Chi.sq	p-value		Chi.sq	p-value	Chi.sq	p-value
s(Julian date of sampling)	289.200	<0.001		1939.000	<0.001	2426.000	<0.001

E) <u>Region-specific arthropod trends</u>

In grasslands, arthropod measures at site level (i.e. alpha diversity) declined significantly or marginally significantly in all three regions, except for species number in Schorfheide (Table S3-3). Similarly, gamma diversity decreased clearly over time in Schwäbische Alb and Hainich but not in Schorfheide (Figure S3-1). In forests, significant and marginally significant declines in alpha diversity were observed in Hainich (species number) and Schorfheide (biomass and abundance), but not in Schwäbische Alb (Table S3-3). Gamma diversity decreased over time in all three regions, but least in Schwäbische Alb (Figure S3-1). This indicates that arthropod declines occurred in all three regions in both forests and grasslands, although not all measures of arthropod diversity declined in all regions.

Table S3-3: Region-specific trends in alpha diversity of arthropods. Z-/t- and p-values for effects of *year* from (generalized) linear mixed models for abundance, species number (Poisson errors) and biomass (Gaussian errors) for all arthropods fitted specifically for each of the three regions (independent number of samples: $n_{grassland} = 1406$, $n_{forest} = 266$).

	Schwäbische Alb z-/t-value	p-value	Hainich z-/t-value	p-value	Schorfheide z-/t-value	p-value
Grassland						
Biomass	-3.349	0.001	-8.465	< 0.001	-3.852	< 0.001
Abundance	-5.358	< 0.001	-12.006	< 0.001	-5.819	< 0.001
Species number	-1.802	0.072	-1.408	< 0.001	-1.185	0.236
Forest (30 sites)						
Biomass	-1.071	0.284	-1.228	0.220	-2.252	0.024
Abundance	0.354	0.724	-0.990	0.322	-1.793	0.073
Species number	-0.950	0.342	-2.888	0.004	-1.619	0.106

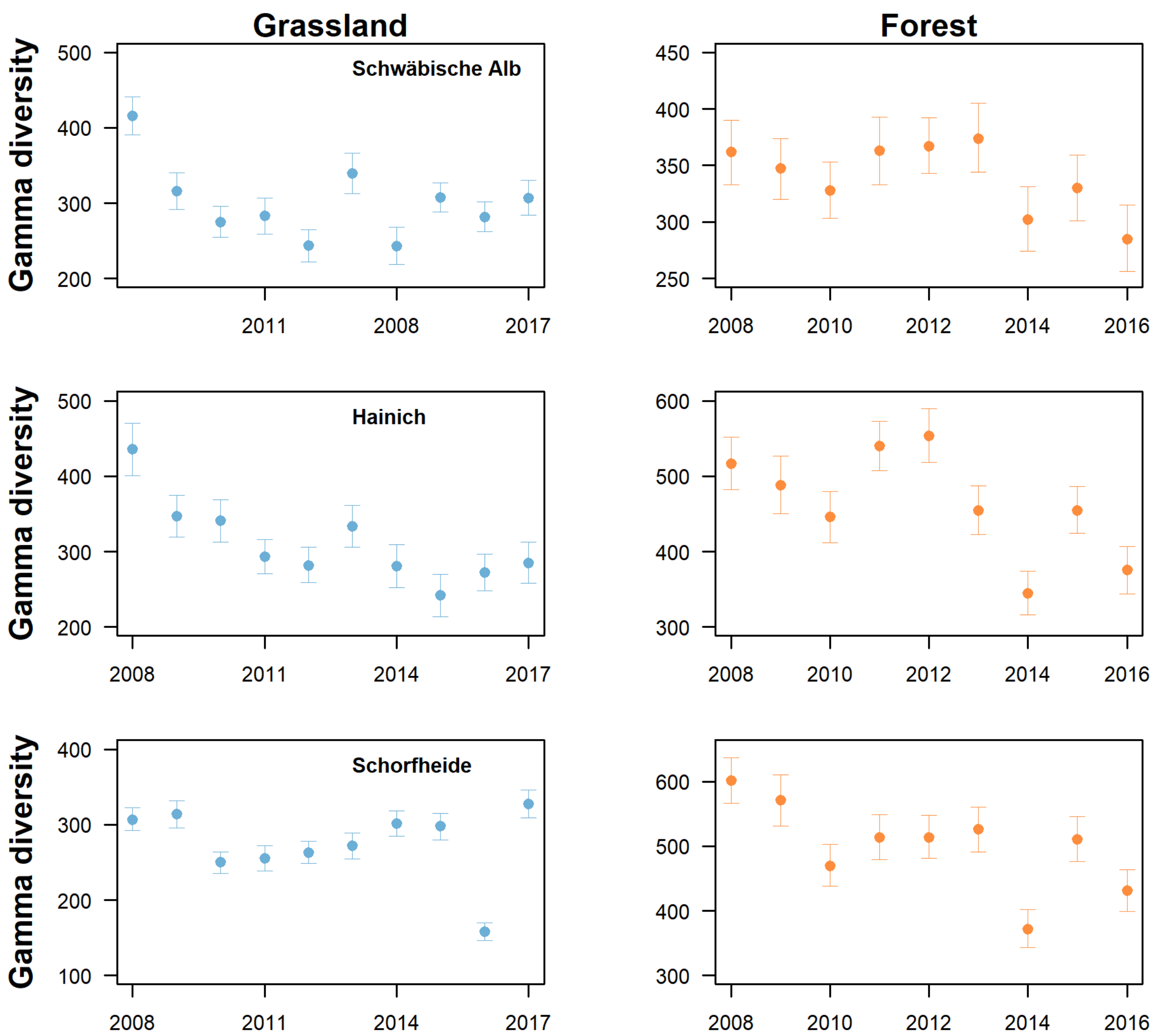

Figure S3-1: Region-specific trends in gamma diversity of arthropods. Estimated gamma diversity, i.e. the total number of species across all grassland or forest sites, for each of the three study regions over time. Gamma diversity was calculated as incidence-based bias-corrected diversity estimates (Chao's BSS[13], see Methods) for q = 0 (q=0 equals species richness). This approach accounts for slight differences in site numbers between years caused by limited accessibility or failure of traps. Dots represent mean values and errors bars represent confidence intervals derived from bootstrapping (n=200). Note that non-overlapping confidence intervals indicate significant difference between two sampling years[8].

Supplement S4 Details on species loss at gamma diversity level relative to species´ frequency

We calculated gamma diversity separately for each year as incidence-based bias-corrected diversity estimates (Chao's BSS[13]) based on species´ frequencies, i.e. the number of sites where a species occurs. This approach accounts for slight differences in site numbers between years caused by limited accessibility or failure of traps. Gamma diversity was calculated from q=0 to q=2. With increasing order q, the more frequent species are more strongly weighted (q=0 equals species richness, q=1 equals the exponential of Shannon entropy and q=2 equals the inverse of Simpson diversity). Confidence intervals were derived by bootstrapping (n=200). Note that non-overlapping confidence intervals indicate significant difference[8]. Gamma diversity in both grasslands and forests was significantly lower in later than in early years for q = 0, i.e. if all species were weighted equally (Figure 1). When widespread species were weighted more strongly (q=1, 2), gamma diversity declined only in forests but remained at a similar level in grasslands (Extended Data Figure S3). This indicates that species loss concerned species irrespective of their frequency in forests, but mostly less widespread species in grasslands.

Supplement S5 Abundance changes of dominant species

Table S5-1 | List of the most abundant species in forests and grasslands with changes in abundance.

Change in abundance of the most dominant (most abundant) species in 30 forests and 150 grasslands from the first two (2008/09) to the last two study years (forests: 2015/16; grasslands: 2016/17). List includes all species that ranked among the 20 most abundant species in either one or both of the two time intervals. While almost all dominant species declined in grasslands, some species increased or maintained abundances in forests. These species are herbivores and bark beetles including native (*Meligethes aeneus, Xyloterus domesticus, Rhynchaenus fagi*) as well as invasive (*Xyleborus germanus*) potential pest species.

Forests					Grasslands				
Species	**Total abundance**	**Rank 2008/09**	**Rank 2015/16**	**Change in abundance from 2008/09 to 2015/16 in individuals**	**Species**	**Total abundance**	**Rank 2008/09**	**Rank 2016/17**	**Change in abundance from 2008/09 to 2016/17 in individuals**
Cortinicara gibbosa	5089	1	3	-535	*Macrosteles laevis*	30333	1	3	-17402
Athous subfuscus	2666	2	7	-390	*Arthaldeus pascuellus*	10593	2	1	-4625
Dalopius marginatus	2282	3	6	-225	*Leptopterna dolabrata*	10758	3	2	-4264
Meligethes aeneus	5446	4	4	66	*Macrosteles cristatus*	5312	4	9	-3171
Rhynchaenus fagi	5217	5	2	1188	*Errastunus ocellaris*	4144	5	20	-2263
Sciodrepoides watsoni	537	6	81	-299	*Meligethes aeneus*	7019	6	4	-1432
Anobium costatum	1588	7	17	-122	*Trigonotylus caelestialium*	8100	7	6	-1498
Quedius xanthopus	782	8	41	-251	*Psammotettix confinis*	3762	8	11	-1556
Hylurgops palliatus	1900	9	16	-88	*Deltocephalus pulicaris*	4716	9	7	-1352
Ectinus aterrimus	528	10	66	-265	*Notostira erratica*	2396	10	30	-1403
Athous vittatus	1351	11	9	41	*Megaloceroea recticornis*	2598	11	13	-1076
Xyloterus domesticus	8490	12	5	404	*Leptopterna ferrugata*	1981	12	40	-1355
Xyleborus germanus	3395	13	1	1583	*Notostira elongata*	2345	13	16	-1140
Cychramus variegatus	1125	14	12	9	*Longitarsus pratensis*	3199	14	12	-914
Micrambe abietis	2243	15	15	22	*Plagiognathus chrysanthemi*	2916	15	5	-311
Vincenzellus ruficollis	411	16	56	-155	*Cicadula quadrinotata*	2943	16	14	-879
Hedobia imperialis	296	17	93	-167	*Amblytylus nasutus*	2036	17	8	-471
Hylastes cunicularius	712	18	24	-78	*Euscelis incisus*	2613	18	10	-429
Cartodere nodifer	381	19	21	-12	*Philaenus spumarius*	2010	19	19	-618
Psallus varians	416	20	18	12	*Psammotettix helvolus*	2004	20	21	-592
Epuraea melanocephala	811	23	20	33	*Javesella pellucida*	4114	27	17	-276
Serica brunnea	536	29	13	131	*Chorthippus parallelus*	1123	41	15	110
Trixagus dermestoides	461	33	14	139					
Phyllobius argentatus	627	128	8	315					
Ceutorhynchus pallidactylus	204	134	19	135					
Corticarina lambiana	437	159	10	259					
Ernoporicus fagi	337	189	11	250					

Supplement S6 Temporal trends in plant communities and correlations between temporal trends of plant and arthropod communities

To analyze changes in number of plant species and community weighted means of Ellenberg indicator values for light (L), moisture (M) and nutrients (N) we fitted linear mixed models with year, mean winter temperature, precipitation during the growing period and the interaction of both weather variables as fixed effects and site nested in region as random effect. Species number in grasslands and forests and M and L in forests were log-transformed prior to analyses to achieve normal distribution.

In grasslands (150 sites), plant species number and L increased (z-/t-value = 11.15 and 7.18, p-value <0.001 and <0.001, respectively), while N and M decreased over time (z-/t-value = -5.99 and -6.86, p-value <0.001 and <0.001, respectively). In forests (30 sites), plant species number and N increased over time (z-/t-value = 6.13 and 2.35, p-value <0.001 and 0.012, respectively). For the response variables with significant temporal trends, we derived site-specific estimates for *year* and calculated correlations with site-specific estimates for *year* for arthropod biomass, abundance and species numbers to test whether temporal trends in arthropods and plants were correlated. None of the correlations between temporal trends in arthropods and plants were significant with R ranging between -0.14 and 0.13.

This indicates that although plant communities at our sites changed over the course of our study, these changes did not explain the temporal trends observed in arthropod numbers.

Supplement S7 Comparison of weak and strong dispersers

Table S7-1 | Model results for weak and strong dispersers Results (z-/t- and p-values) from linear mixed models for abundance, species number (Poisson errors) and biomass (Gaussian errors) of arthropods with weak and strong dispersal ability (see methods) in 150 grasslands (A) and 30 forests (B). To test whether temporal trends and their drivers differed between both dispersal groups, the respective response variable included values for each group per site and year. The factor "dispersal group" (weak or strong disperser) was included as fixed effect. Effects of year and the interactions of year and local land-use intensity, year and arable field cover, and year and grassland cover were estimated for both dispersal guilds specifically (exemplary R code: *response ~ dispersal_guild + dispersal_guild : (year * local_landuse) + dispersal_guild : (year * arable_crop_cover) + dispersal_guild : (year * grassland_cover) + winter_temp*precipitation*). In additional models, we tested whether these effects differed significantly between dispersal groups by including the three three-way interaction between dispersal guild, year and one of the three land-use variables (exemplary R code: *response ~ dispersal_guild * year * local_landuse + dispersal_guild * year * arable_crop_cover + dispersal_guild * year * grassland_cover + winter_temp *precipitation*). Significant effects ($p < 0.05$) are indicated by green shading and marginal significant effects ($p < 0.1$) by red shading. Significant ($p < 0.05$) differences between dispersal groups are indicated by bold typesetting. All models included site nested in region as random effect to account for spatial arrangement and temporal repetitions per site. Poisson models included an observation-specific random effect to account for potential overdispersion.

The same analyses were conducted for weak and strong dispersers among herbivores and carnivores. For omnivores (30 species in forests and 20 in grasslands) and myceto-detritivores (23 species in forests and 4 in grasslands), the number of weak disperser species was too low for a meaningful analysis. In grasslands, herbivores showed similar patterns as all arthropods and dispersal guilds among carnivores did not respond significantly different. In forests, the overall decline in strong dispersers and the overall decline in species number of weak dispersers corresponds to declines of the same dispersal groups among carnivores. Overall increases in abundance and biomass of weak dispersers correspond to increases of weak dispersers of both herbivores and carnivores.

A) Grassland	**Dispersal group**	**Biomass**		**Abundance**		**Species number**		**Biomass herbivores**		**Abundance herbivores**		**Species number herbivores**		**Biomass carnivores**		**Abundance carnivores**		**Species number carnivores**	
		z-value	**p-value**	**z-value**	**p-value**	**z-value**	**p-value**	**z-value**	**p-value**	**z-value**	**p-value**	**z-value**	**p-value**	**z-value**	**p-value**	**z-value**	**p-value**	**z-value**	**p-value**
(Intercept)		2.613	0.01	19.791	<0.001	31.932	<0.001	16.509	<0.001	15.078	<0.001	24.790	<0.001	24.094	<0.001	11.424	<0.001	10.439	<0.001
Dispersal group - weak vs. strong		-25.234	<0.001	-46.786	<0.001	-79.992	<0.001	-6.475	<0.001	-28.449	<0.001	-43.942	<0.001	-32.204	<0.001	-37.970	<0.001	-34.787	<0.001
Winter temperature		10.182	<0.001	10.183	<0.001	7.529	<0.001	5.492	<0.001	8.923	<0.001	7.533	<0.001	1.861	0.06	2.876	<0.001	5.299	<0.001
Precipitation		2.797	0.01	3.144	<0.001	6.498	<0.001	2.292	0.02	1.310	0.19	6.018	<0.001	2.267	0.02	2.441	0.01	4.243	<0.001
Frost * precipitation		2.989	<0.001	3.921	<0.001	2.032	0.04	4.155	<0.001	5.278	<0.001	3.230	<0.001	1.103	0.27	0.740	0.46	2.775	0.01
Year	**strong**	-10.431	<0.001	-14.836	<0.001	-10.217	<0.001	-8.803	<0.001	**-16.941**	<0.001	-11.484	<0.001	-1.697	0.09	-1.111	0.27	-1.754	0.08
	weak	-9.246	<0.001	-12.153	<0.001	-7.604	<0.001	-9.520	<0.001	**-11.251**	<0.001	-8.204	<0.001	-0.959	0.34	-0.576	0.56	-2.078	0.04
Local land-use intensity	**strong**	-2.921	<0.001	**-0.510**	0.61	**-3.220**	<0.001	-2.393	0.02	**-0.953**	0.34	-3.911	<0.001	**-1.571**	0.12	**-0.859**	0.39	**0.460**	0.65
	weak	-3.122	<0.001	**-5.951**	<0.001	**-6.624**	<0.001	-2.869	<0.001	**-4.465**	<0.001	-4.514	<0.001	**-4.805**	<0.001	**-4.736**	<0.001	**-4.764**	<0.001
Arable crop cover	**strong**	**-1.895**	0.06	**-1.429**	0.15	**-2.596**	0.01	**-1.540**	0.12	-1.958	0.05	-3.367	<0.001	-1.853	0.06	**-1.667**	0.10	**-1.076**	0.28
	weak	**-4.324**	<0.001	**-3.550**	<0.001	**-4.837**	<0.001	**-3.519**	<0.001	-2.961	<0.001	-3.755	<0.001	-3.381	<0.001	**-6.289**	<0.001	**-5.384**	<0.001
Grassland cover	**strong**	-3.056	<0.001	-2.316	0.02	-4.539	<0.001	-2.621	0.01	-2.945	<0.001	-5.762	<0.001	-0.932	0.35	-0.061	0.95	-<0.0017	0.99
	weak	-1.628	0.10	-3.077	<0.001	-1.884	0.06	-2.998	<0.001	-4.259	<0.001	-4.141	<0.001	-1.361	0.17	-1.715	0.09	-0.732	0.46
Year * local land-use intensity	**strong**	**-0.870**	0.38	-1.921	0.05	0.987	0.32	-0.558	0.58	-2.194	0.03	1.403	0.16	0.458	0.65	-0.034	0.97	0.042	0.97
	weak	**2.685**	0.01	0.859	0.39	1.787	0.07	2.260	0.02	1.783	0.07	1.739	0.08	0.986	0.32	2.046	0.04	1.986	0.05
Year * arable crop cover	**strong**	**0.886**	0.38	-0.435	0.66	-1.457	0.15	**0.333**	0.74	-0.924	0.36	-1.960	0.05	1.732	0.08	1.091	0.28	0.997	0.32
	weak	**-2.631**	0.01	-1.799	0.07	-2.834	<0.001	**-3.241**	<0.001	-1.986	0.05	-2.868	<0.001	0.441	0.66	0.057	0.95	-0.394	0.69
Year * grassland cover	**strong**	-0.857	0.39	-0.906	0.36	-1.702	0.09	-0.480	0.63	-1.085	0.28	-1.754	0.08	0.012	0.99	0.317	0.75	0.089	0.93
	weak	-1.415	0.16	-2.159	0.03	-1.341	0.18	-1.894	0.06	-2.472	0.01	-1.910	0.06	0.237	0.81	-0.796	0.43	-1.532	0.13

B) Forest (30)	Dispersal group	Biomass		Abundance		Species number		Biomass herbivores		Abundance herbivores		Species number herbivores		Biomass carnivores		Abundance carnivores		Species number carnivores	
		z-value	p-value	z-value	p-value	z-value	p-value	z-value	p-value	z-value	p-value	z-value	p-value	z-value	p-value	z-value	p-value	z-value	p-value
(Intercept)		34.828	<0.001	63.452	<0.001	102.799	<0.001	42.037	<0.001	56.887	<0.001	90.110	<0.001	20.229	<0.001	70.887	<0.001	101.737	<0.001
Dispersal group - weak vs. strong		-62.192	<0.001	-50.524	<0.001	-81.226	<0.001	-32.066	<0.001	-45.724	<0.001	-39.718	<0.001	-21.611	<0.001	-42.396	<0.001	-44.833	<0.001
Winter temperature		0.416	0.68	-1.726	0.08	-2.446	0.01	-0.675	0.50	-3.145	<0.001	-3.427	<0.001	-1.384	0.17	-0.156	0.88	-0.657	0.51
Precipitation		-1.965	0.05	-2.418	0.02	-3.536	<0.001	-0.528	0.60	0.017	0.99	-1.417	0.16	-0.825	0.41	-2.069	0.04	-3.243	<0.001
Frost * precipitation		1.674	0.09	0.965	0.33	1.168	0.24	1.588	0.11	2.479	0.01	0.678	0.50	-0.024	0.98	0.461	0.64	0.299	0.77
Year	strong	**-3.429**	<0.001	**-1.850**	0.06	**-7.402**	<0.001	**0.159**	0.87	**5.582**	<0.001	2.348	0.02	**-1.985**	0.05	**-8.411**	<0.001	**-9.493**	<0.001
	weak	**5.437**	<0.001	**3.753**	<0.001	**-1.118**	0.26	**6.555**	<0.001	**7.435**	<0.001	2.727	0.01	**1.761**	0.08	**1.381**	0.17	**-1.251**	0.21
Local land-use intensity	strong	-0.041	0.97	**0.889**	0.37	-0.223	0.82	**-1.299**	0.19	-1.947	0.05	-1.050	0.29	0.448	0.65	1.213	0.22	-0.473	0.64
	weak	-1.125	0.26	**-2.932**	<0.001	-1.673	0.09	**-3.258**	<0.001	-2.584	0.01	-1.753	0.08	-1.205	0.23	-0.038	0.97	-0.014	0.99
Arable crop cover	strong	**1.285**	0.20	0.029	0.98	1.997	0.05	-0.289	0.77	-1.557	0.12	1.630	0.10	**0.769**	0.44	0.300	0.76	1.331	0.18
	weak	**-1.323**	0.19	0.360	0.72	1.768	0.08	0.040	0.97	-1.496	0.13	1.395	0.16	**-1.655**	0.10	-1.565	0.12	-0.261	0.79
Grassland cover	strong	-2.169	0.03	**-0.377**	0.71	**-1.891**	0.06	-0.861	0.39	**0.825**	0.41	-2.939	<0.001	**-0.388**	0.70	**-1.299**	0.19	**-1.562**	0.12
	weak	-2.465	0.01	**-5.837**	<0.001	**-2.997**	<0.001	-1.717	0.09	**-2.860**	<0.001	-2.450	0.01	**-4.702**	<0.001	**-3.908**	<0.001	**-2.775**	0.01
Year * local land-use intensity	strong	**-0.606**	0.54	-0.484	0.63	0.111	0.91	0.246	0.81	0.847	0.40	0.273	0.79	-0.529	0.60	-0.510	0.61	-0.513	0.61
	weak	**-3.407**	<0.001	-1.226	0.22	-0.688	0.49	-2.481	0.01	-4.631	<0.001	-0.606	0.54	-0.400	0.69	0.285	0.78	0.504	0.61
Year * arable crop cover	strong	0.432	0.67	-0.267	0.79	0.403	0.69	0.115	0.91	-0.774	0.44	1.399	0.16	0.250	0.80	**0.513**	0.61	0.398	0.69
	weak	-0.242	0.81	-0.434	0.66	0.589	0.56	1.486	0.14	1.514	0.13	0.869	0.39	-0.658	0.51	**-2.463**	0.01	-0.356	0.72
Year * grassland cover	strong	-0.469	0.64	**0.497**	0.62	0.595	0.55	-0.004	1.00	-0.087	0.93	0.760	0.45	-0.717	0.47	1.552	0.12	0.979	0.33
	weak	-1.707	0.09	**-2.169**	0.03	0.874	0.38	-1.703	0.09	-2.114	0.03	0.119	0.91	-2.458	0.01	-1.007	0.31	0.461	0.64

Supplement S8 Temporal changes in local land-use intensity.

Local land-use intensity was recorded annually in grasslands and twice in forests. The first forest inventory was conducted between 2009 and 2011 and the second inventory five years after the first inventory at all sites. Linear-mixed models with year as fixed effect and site nested in region as random effect revealed a marginally significant decrease in local land-use intensity in grasslands (z-value = -1.93, p-value = 0.05) and a significant decrease in forests (z-value = -5.183, p-value = <0.001).

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