

Dyderski M.K., Bury S., Pawlik, L, Bodziarczyk, J., Godziek, J., 2025. Twenty years of temperate montane forest progression in the oldest Polish national park

Table S1 Naslund non-linear models of tree height used for imputing missing values. In these models, we used DBH as a predictor, accounting for plot-specific dependency as a random effect, except *Picea abies*, where the model with random effects did not reach a convergence due to the small number of plots (n=9) with this species. Model formula: $h(d) = bh + \frac{a^2}{(a+bd)^2}$, where h – tree height [m], bh – breast height (here 1.3 m), d – diameter at breast height [cm], a, b – model parameters.

Species	Variable	Estimate	SE	t	p	RE SD
<i>F. sylvatica</i> n=269, EE=2.12	a	1.7855	0.1050	17.001	<0.001	0.4356
	b	0.1659	0.0050	33.399	<0.001	0.0207
<i>P. abies</i> n=50, EE=2.22	a	2.2691	0.2083	9.0130	<0.001	-
	b	0.1332	0.0063	21.106	<0.001	-
<i>A. alba</i> n=383, EE=1.99	a	1.9921	0.0934	21.330	<0.001	0.4105
	b	0.1506	0.0031	48.085	<0.001	0.0140

SE – standard error of estimate, t-test statistic, p – p-value, RE SD – random effect standard deviation, EE – estimation error

Table S2 Linear mixed-effects models of *A. alba* and *F. sylvatica* dynamics. Abbreviations: SE – standard error, df – degrees of freedom, t – t value, Pr(>|t|) – p-value, AICc – Akaike's Information Criterion, corrected for small sample size, AICc₀ – AICc of null (intercept and random effects only) model, RE SD – random effect standard deviation, R²_m – marginal coefficient of determination, R²_c – conditional coefficient of determination.

Response	Variable	Estimate	SE	df	t	Pr (> t)
<i>Fagus</i> increment plot RE SD=12.780 date RE SD<0.001 AICc=711.4, AICc ₀ =745.1 R ² _m =0.391; R ² _c =0.770	(Intercept)	38.337	15.324	41.807	2.502	0.016
	Aspect (transformed)	2.275	2.999	37.679	0.759	0.453
	Basal area [m ² ha ⁻¹]	0.520	0.216	48.346	2.402	0.020
	Stand composition (PC1)	7.616	2.920	40.856	2.608	0.013
	Topographic Position Index	-3.351	4.805	37.571	-0.698	0.490
	Topographic Wetness Index	-1.292	2.057	37.574	-0.628	0.534
	Winter temperature [°C]	14.855	4.615	56.014	3.219	0.002
<i>Fagus</i> mortality plot RE SD=1.847 date RE SD<0.001 AICc=519.2, AICc ₀ =534.3 R ² _m =0.208; R ² _c =0.333	(Intercept)	1.450	2.529	30.945	0.574	0.570
	Stand composition (PC1)	2.935	0.676	41.266	4.341	<0.001
	Aspect (transformed)	-1.223	0.681	40.091	-1.797	0.080
	Winter temperature [°C]	-0.928	1.174	39.611	-0.790	0.434
<i>Fagus</i> recruitment plot RE SD<0.001 date RE SD=1.235 AICc=496.1, AICc ₀ =496.1 R ² _m =0.000; R ² _c =0.093	(Intercept)	1.276	0.965	1.000	1.322	0.412
<i>Abies</i> increment plot RE SD=7.73 date RE SD=7.136 AICc=680.75 AICc ₀ =724.4 R ² _m =0.436; R ² _c =0.755	(Intercept)	0.864	12.011	19.115	0.072	0.943
	Stand composition (PC1)	-12.672	2.046	38.931	-6.193	<0.001
	Aspect (transformed)	3.039	2.081	37.250	1.460	0.153
	Basal area [m ² ha ⁻¹]	0.495	0.157	41.752	3.153	0.003
	Topographic Wetness Index	-0.245	1.427	37.155	-0.172	0.865
	Topographic Position Index	0.031	3.334	37.176	0.009	0.993
	Winter temperature [°C]	-1.431	3.605	37.816	-0.397	0.694

Response	Variable	Estimate	SE	df	t	Pr (> t)
<i>Abies</i> mortality	(Intercept)	-6.227	8.339	35.862	-0.747	0.460
plot RE SD=4.563	Basal area [m ² ha ⁻¹]	0.575	0.150	41.010	3.825	<0.001
date RE SD=0.343	Stand composition (PC1)	-2.489	1.951	38.883	-1.276	0.210
AICc=698.1, AICc ₀ =716.3	Aspect (transformed)	0.860	1.986	37.889	0.433	0.667
R ² _m =0.197; R ² _c =0.298	Topographic Position Index	-1.769	2.694	37.846	-0.657	0.515
	Winter temperature [°C]	1.296	3.315	33.705	0.391	0.698
<i>Abies</i> recruitment	(Intercept)	-2.238	4.737	33.216	-0.472	0.640
plot RE SD<0.001	Stand composition (PC1)	-0.505	1.215	83.158	-0.415	0.679
date RE SD=1.933	Topographic Position Index	0.133	1.705	83.001	0.078	0.938
AICc=635.9, AICc ₀ =639.0	Winter temperature [°C]	-2.180	2.211	83.144	-0.986	0.327
R ² _m =0.019; R ² _c =0.064						

Table S3 Generalized linear mixed-effects models of *A. alba* and *F. sylvatica* dynamics. Abbreviations: SE – standard error, z – z value, Pr(>|z|) – p-value, AICc – Akaike’s Information Criterion, corrected for small sample size, AICc₀ – AICc of null (intercept and random effects only) model, RE SD – random effect standard deviation, ZI – zero-inflation component.

Response	Variable	Estimate	SE	z	Pr (> z)
Relative <i>Fagus</i> increment	(Intercept)	0.369	1.178	0.314	0.754
plot RE SD=0.713	Summer precipitation [mm]	0.552	0.149	3.702	<0.001
date RE SD<0.001	ZI: (Intercept)	-0.009	0.003	-2.609	0.009
AICc=-204.8, AICc ₀ =-189.3					
Relative <i>Fagus</i> mortality	(Intercept)	-3.218	0.565	-5.699	<0.001
plot RE SD=0.786	Aspect (transformed)	0.094	0.178	0.528	0.597
date RE SD<0.001	Stand composition (PC1)	0.615	0.162	3.798	<0.001
AICc=-19.3, AICc ₀ =-13.2	Slope [°]	0.012	0.015	0.812	0.417
	ZI: (Intercept)	-2.054	0.336	-6.116	<0.001
Relative <i>Fagus</i> recruitment	(Intercept)	-4.176	0.216	-19.360	<0.001
plot RE SD<0.001	ZI: (Intercept)	0.560	0.222	2.525	0.012
date RE SD<0.001					
AICc=-81.5, AICc ₀ =-81.5					
Relative <i>Abies</i> increment	(Intercept)	-2.025	0.279	-7.272	<0.001
plot RE SD=0.183	Basal area [m ² ha ⁻¹]	-0.019	0.009	-2.165	0.030
date RE SD=0.429	Stand composition (PC1)	-1.015	0.153	-6.632	<0.001
AICc=-161.7, AICc ₀ =-133.0	ZI: (Intercept)	-1.753	0.300	-5.833	<0.001
Relative <i>Abies</i> mortality	(Intercept)	-2.593	0.166	-15.580	<0.001
plot RE SD=0.004	ZI: (Intercept)	-0.274	0.215	-1.275	0.202
date RE SD=0.001					
AICc=-39.0, AICc ₀ =-39.0					
Relative <i>Abies</i> recruitment	(Intercept)	-2.235	0.160	-13.990	<0.001
plot RE SD<0.001	ZI: (Intercept)	-1.753	0.300	-5.833	<0.001
date RE SD<0.001					
AICc=-6.0, AICc ₀ =-6.0					

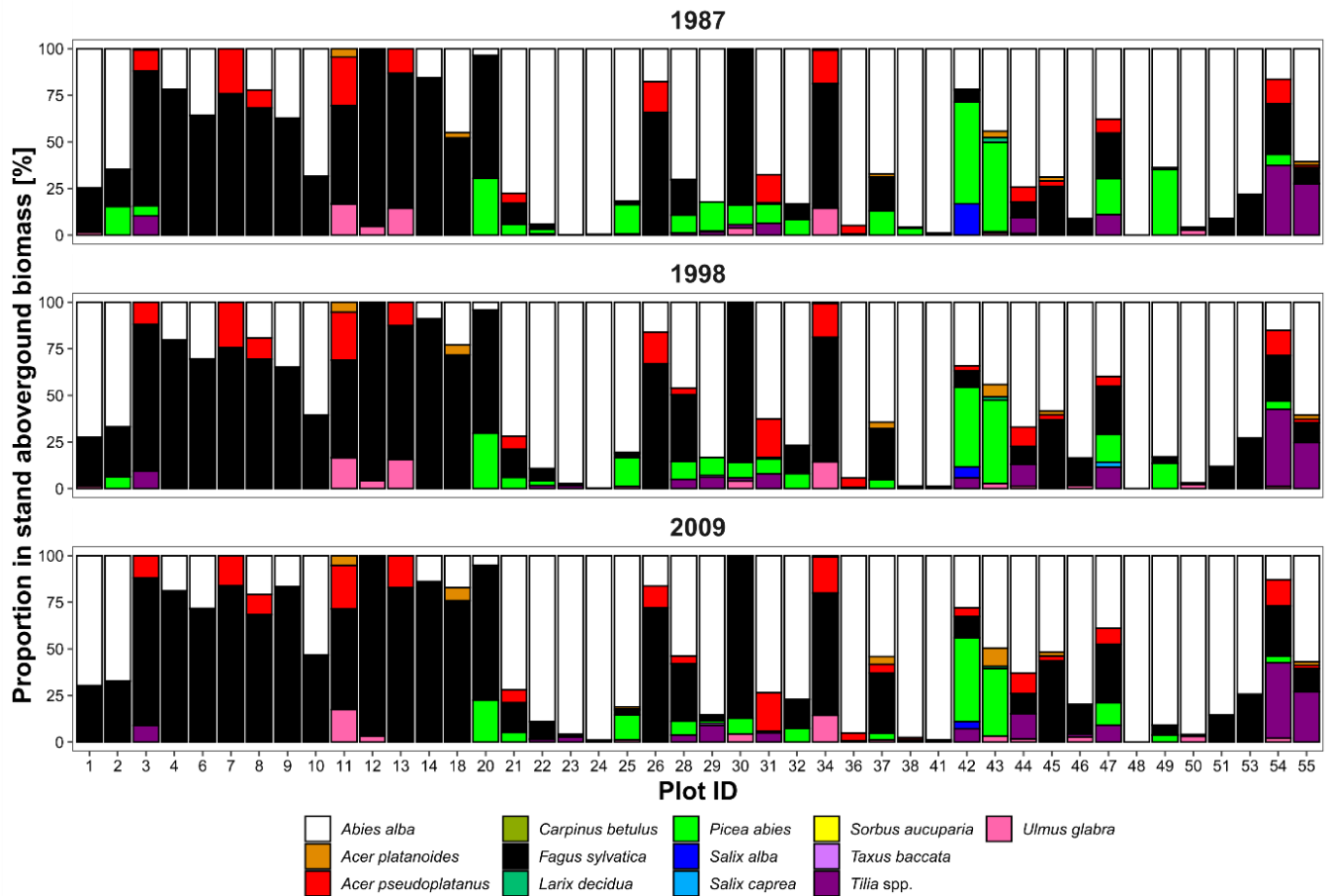


Fig S1 The proportion of tree species in stand aboveground biomass within each study plot across sampling dates.

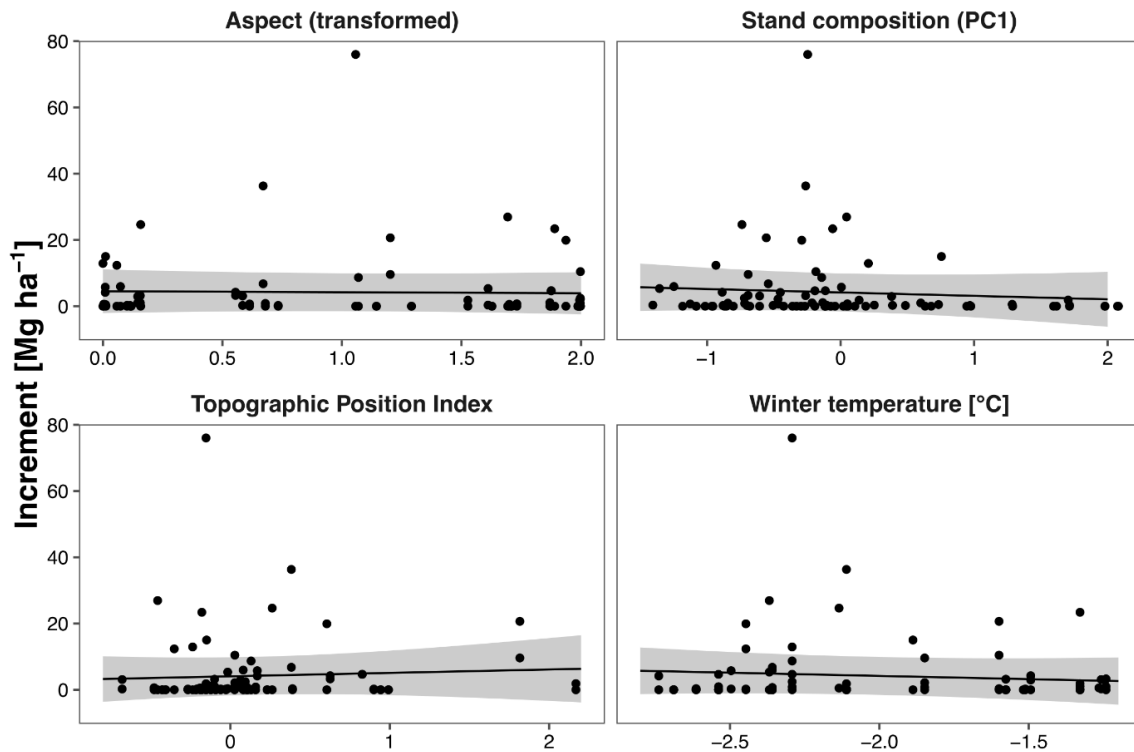


Fig S2 Relationships between predictors and stand absolute recruitment. Lines and ribbons indicated marginal responses and 95% confidence intervals, calculated from linear mixed-effects models (Table R3).

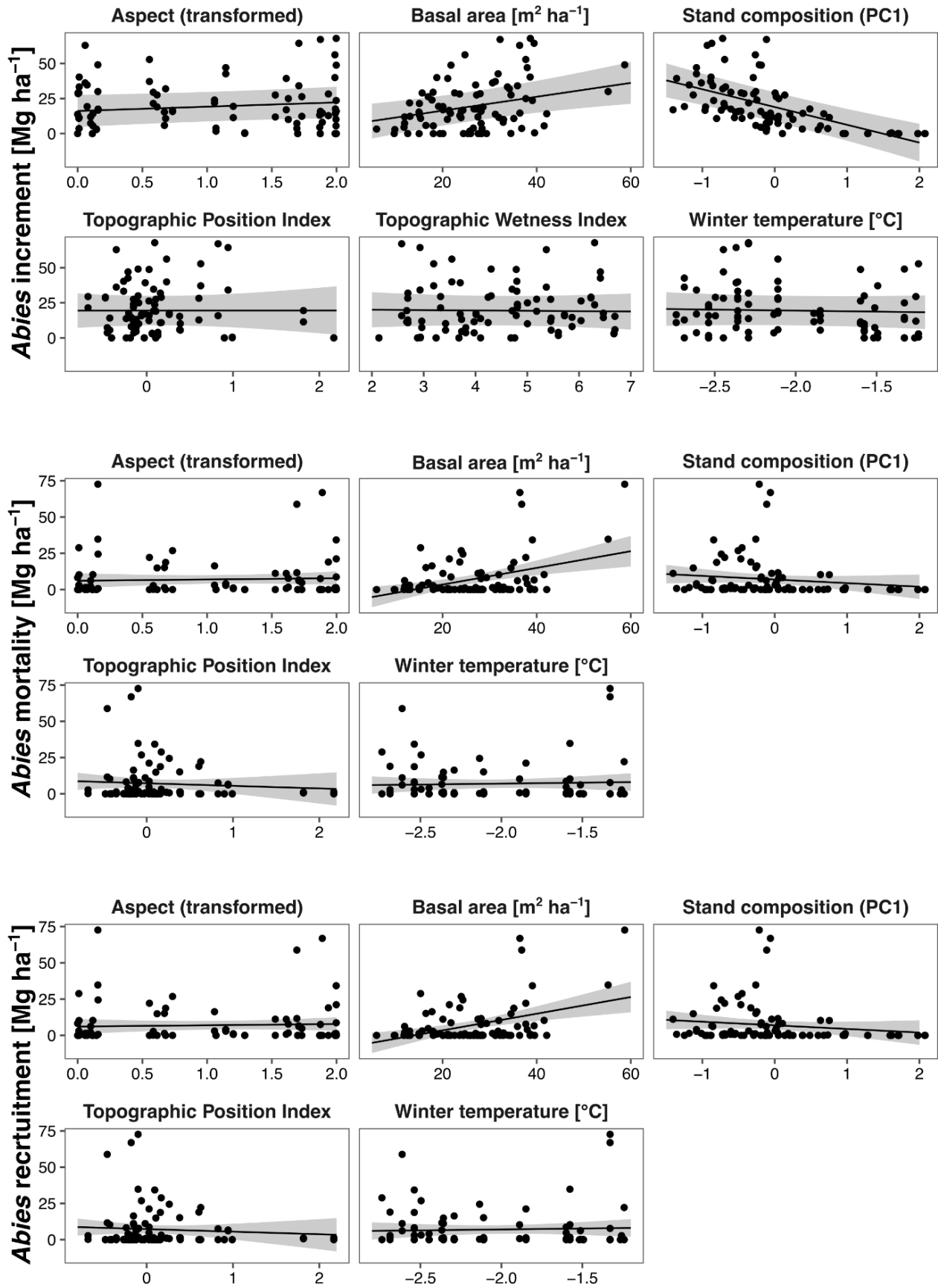


Fig S3 Relationships between predictors and *A. alba* absolute increment, recruitment, and mortality. Lines and ribbons indicated marginal responses and 95% confidence intervals, calculated from linear mixed-effects models (Table S2).

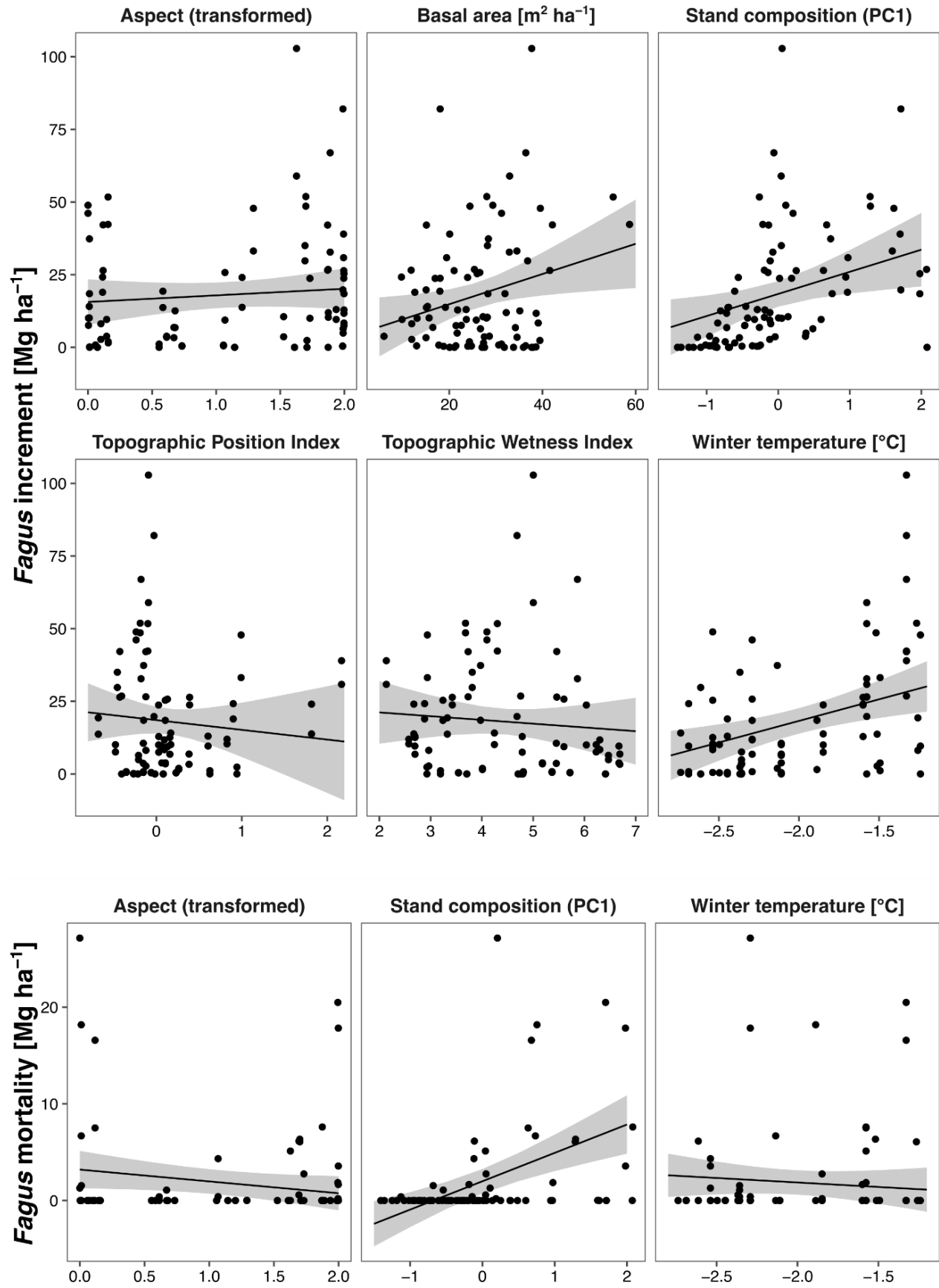


Fig S4 Relationships between predictors and *F. sylvatica* absolute increment and mortality. Lines and ribbons indicated marginal responses and 95% confidence intervals, calculated from linear mixed-effects models (Table S2).

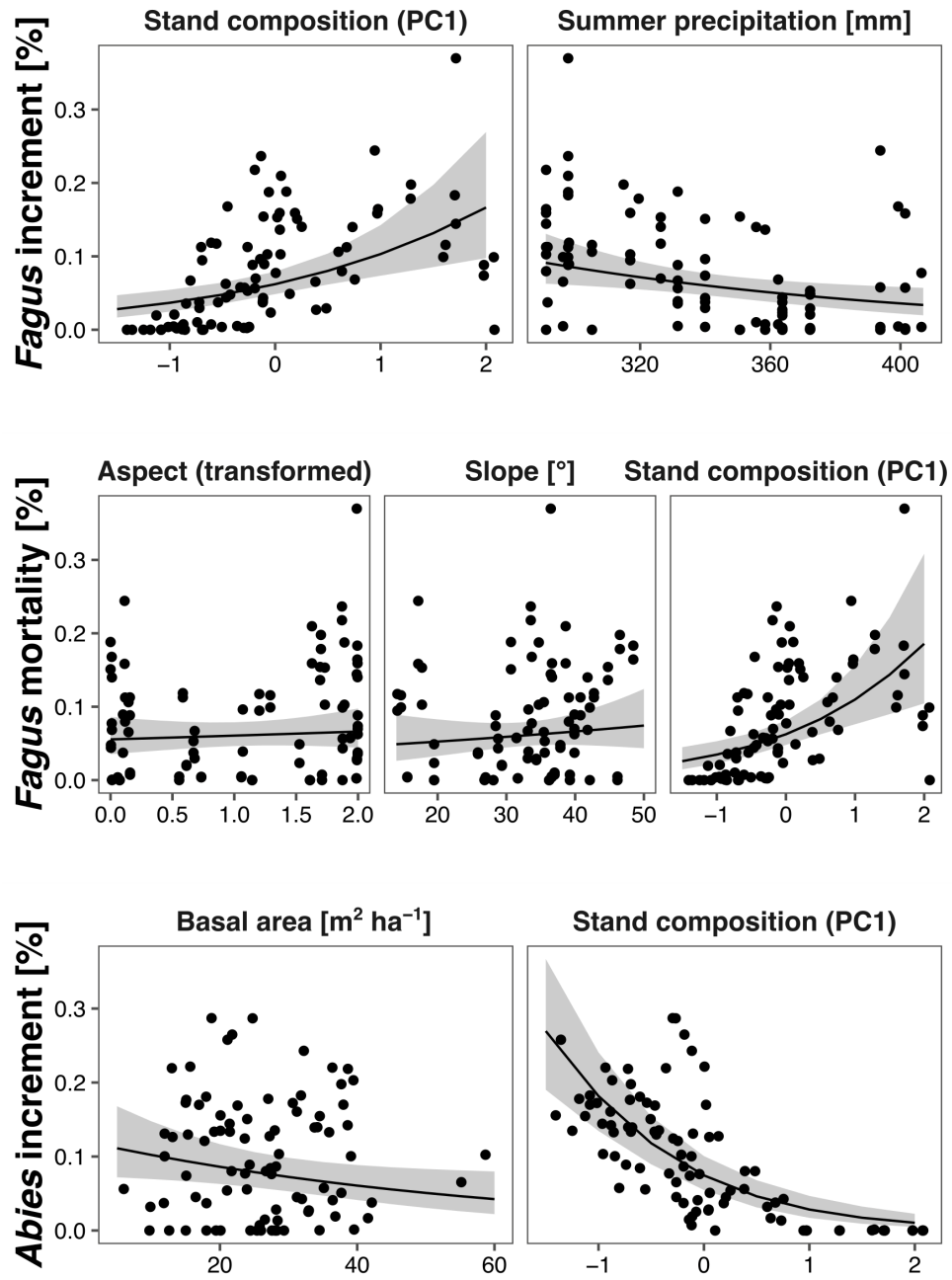


Fig S5: Relationships between predictors and species-specific relative increment and mortality. Lines and ribbons indicated marginal responses and 95% confidence intervals, calculated from generalized linear mixed-effects models assuming Beta distributions (Table S3).