Versace S, Garfì V, Dalponte M, Di Febbraro M, Frizzera L, Gianelle D, Tognetti R (2020).
Species interactions in pure and mixed-species stands of silver fir and European beech in Mediterranean mountains
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Supplementary Material

Appendix 1 - Additional information on the model selection.

The independent variables initially used in the models (silver fir mixed-pure and European beech mixed-pure) were 12. VIF function has identified only the variables with a low multicollinearity. In particular, for the models of silver fir in mixed-species and pure stands five variables were identified: *CI, DBH*^{2}*, age, soil_depth* and *solpe*. For European beech mixed-pure model, instead, six variables were identified: *CI, DBH*^{2}*, age, soil_depth, solpe* and *BA*. However, VIF function identified one variable for interactions (CI_{2011}*_intra* or CI_{2011}*_inter*) and one variable for the basal area occupied by competitors of the subject tree (BA_{beech} or BA_{fir}). Therefore, to understand which of these variables (CI_{2011}*_intra* or CI_{2011}*_inter* and BA_{beech} or BA_{fir}) explained the basal area increment of the two species the most, several models were developed. The subsequent variable selection process was carried out using AIC. This selection consisted in identifying all possible combinations, until obtaining only the variables with high explanatory power. In the models of silver fir (intra- and inter-specific interactions), variables *age* and *soil_depth* were removed (Table S2). In the models of European beech (intra- and inter-specific interactions), the variable *slope* was removed (Table S3). The final models were developed according to lower AIC values, i.e., the sixth model (for silver fir) and the third model (for European beech).

Fig. S1 - Residuals vs. predicted log-transformed BAI of growth models in Tab. 4 and Tab. 5. Panel (a) and (b) indicate intra-and inter-specific interaction models for silver fir mixed-pure, in Molise and Calabria, in respectively; (c) and (d) indicate intra-and inter-specific interaction models for European beech mixed-pure, in Molise and Calabria, respectively.

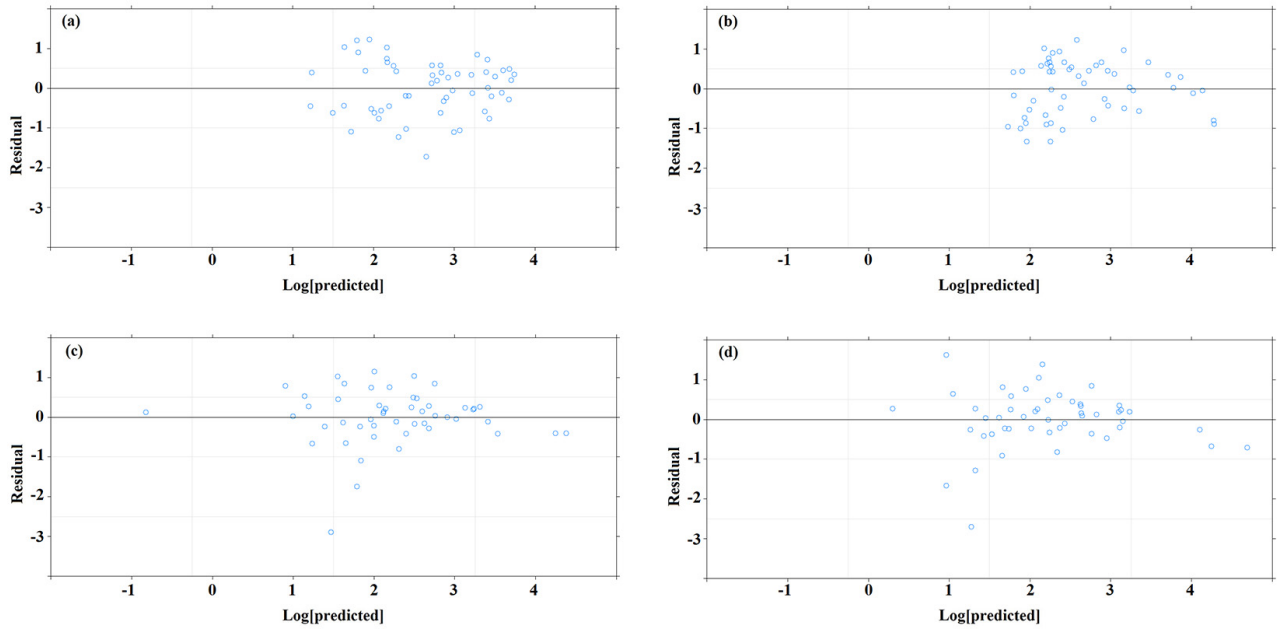
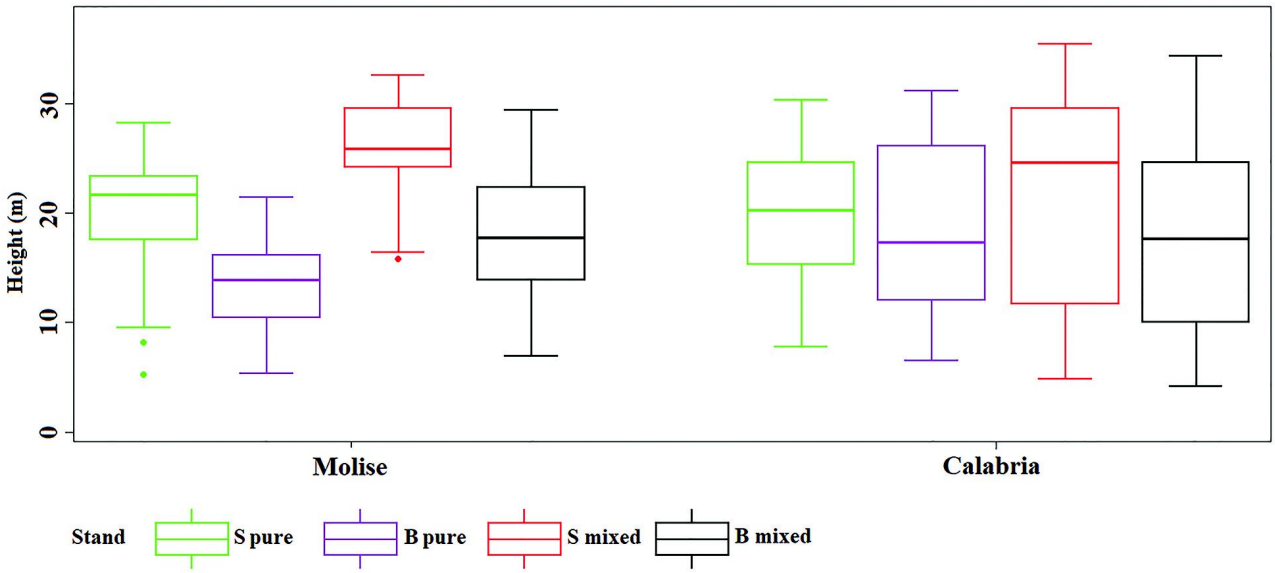


Fig. S2 - Height of all European beech and silver fir trees. Stands refer to S (silver fir) and B (European beech) in mixed-species and pure stands, in Molise and Calabria.



Tab. S1 - Optimal search radii selected on the basis of the best values of linear regression models, considering all sampled trees. (CV): Constancy of variances ($p > 0.05$); (r^2): adjusted r^2; (p): significance of the correlation ($p < 0.1$); (n) number of sampled trees; R (m): optimal radius.

Sites	Stands	CV	r^2	p	n	R (m)
Molise	$beech_{pure}$	3.41	0.42	<0.01	29	7
	$beech_{mixed}$	0.56	0.57	<0.01	19	9
Calabria	$beech_{pure}$	2.66	0.55	<0.01	15	7

Tab. S2 - Comparisons between different variables of silver fir mixed-pure in linear mixed models. (BAI_{5years}): 5-years basal area increment; (DBH^2): diameter at breast height squared (cm^2); (Age): tree age (years); (Soil_depth): depth of soils; (CI_{2011}_intra, CI_{2011}_inter): intra- and inter-specific interactions; (Slope): slope of the soil; (mix-pure): type of stands (pure and mixed-species).

Model Group	Model name	Equation	AIC
Models form of intra-specific interactions	Mixed-effect 1	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2+ age + soil_depth + slope + mix-pure	122.9149
	Mixed-effect 2	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2+ age + soil_depth + mix-pure	122.8869
	Mixed-effect 3	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2+ age + slope + mix-pure	122.3259
	Mixed-effect 4	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2 + soil_depth + slope + mix-pure	121.0298
	Mixed-effect 5	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2 + soil_depth + mix-pure	121.469
	Mixed-effect 6	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2 + slope + mix-pure	120.3979*
	Mixed-effect 7	Log (BAI_{5years}) = CI_{2011}_intra + age + soil_depth + slope + mix-pure	124.9169
	Mixed-effect 8	Log (BAI_{5years}) = CI_{2011}_intra + age + soil_depth + mix-pure	125.5165
	Mixed-effect 9	Log (BAI_{5years}) = CI_{2011}_intra + age + slope + mix-pure	123.558
	Mixed-effect 10	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2 + age + mix-pure	122.7611
	Mixed-effect 11	Log (BAI_{5years}) = CI_{2011}_intra + age + mix-pure	124.467
	Mixed-effect 12	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2 + mix-pure	121.8196
Models form of inter-specific interactions	Mixed-effect 1	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2+ age + soil_depth + slope + mix-pure	128.0722
	Mixed-effect 2	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2+ age + soil_depth + mix-pure	127.9695
	Mixed-effect 3	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2+ age + slope + mix-pure	127.353
	Mixed-effect 4	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2 + soil_depth + slope + mix-pure	126.3348
	Mixed-effect 5	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2 + soil_depth + mix-pure	126.0913
	Mixed-effect 6	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2 + slope + mix-pure	125.4927*
	Mixed-effect 7	Log (BAI_{5years}) = CI_{2011}_inter + age + soil_depth + slope + mix-pure	134.8332
	Mixed-effect 8	Log (BAI_{5years}) = CI_{2011}_inter + age + soil_depth + mix-pure	135.1863
	Mixed-effect 9	Log (BAI_{5years}) = CI_{2011}_inter + age + slope + mix-pure	133.4529
	Mixed-effect 10	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2 + age + mix-pure	127.7808
	Mixed-effect 11	Log (BAI_{5years}) = CI_{2011}_inter + age + mix-pure	134.2147
	Mixed-effect 12	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2 + mix-pure	126.3028

Tab. S3 - Comparisons between different variables of European beech mixed-pure in linear mixed models. (BAI_{5years}): 5-years basal area increment; (DBH^2): diameter at breast height squared (cm^2); (Age): tree age (years); (Soil_depth): depth of soils; (CI_{2011}_intra, CI_{2011}_inter): intra- and inter-specific interactions; (Slope): slope of the soil; (mix-pure): type of stands (pure and mixed-species).

Model Group	Model name	Equation	AIC
Models form of intra-specific interactions	Mixed-effect 1	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2+ age + soil_depth + slope + BA_{beech} + mix-pure	120.1024
	Mixed-effect 2	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2+ age + soil_depth + slope + mix-pure	119.7852
	Mixed-effect 3	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2+ age + soil_depth + BA_{beech} + mix-pure	118.2059*
	Mixed-effect 4	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2+ age + slope + BA_{beech} + mix-pure	127.6359
	Mixed-effect 5	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2+ age + soil_depth + mix-pure	118.2239
	Mixed-effect 6	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2+ age + slope + mix-pure	128.0337
	Mixed-effect 7	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2+ age + BA_{beech} + mix-pure	125.7382
	Mixed-effect 8	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2 + age + mix-pure	126.3345
	Mixed-effect 9	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2 + BA_{beech} + mix-pure	124.7535
	Mixed-effect 10	Log (BAI_{5years}) = CI_{2011}_intra + age + BA_{beech} + mix-pure	132.6542
	Mixed-effect 11	Log (BAI_{5years}) = CI_{2011}_intra + age + mix-pure	136.0475
	Mixed-effect 12	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2 + mix-pure	125.1649
	Mixed-effect 13	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2+ age + soil_depth + slope + BA_{fir} + mix-pure	120.5088
	Mixed-effect 14	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2+ age + soil_depth + BA_{fir} + mix-pure	119.5608
	Mixed-effect 15	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2+ age + slope + BA_{fir} + mix-pure	124.3575
	Mixed-effect 16	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2+ age + BA_{fir} + mix-pure	124.4589
	Mixed-effect 17	Log (BAI_{5years}) = CI_{2011}_intra + DBH^2 + BA_{fir} + mix-pure	122.5345
	Mixed-effect 18	Log (BAI_{5years}) = CI_{2011}_intra + age + BA_{fir} + mix-pure	136.1465
Models form of inter-specific interactions	Mixed-effect 1	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2+ age + soil_depth + slope + BA_{beech} + mix-pure	125.3302
	Mixed-effect 2	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2+ age + soil_depth + slope + mix-pure	131.8086
	Mixed-effect 3	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2+ age + soil_depth + BA_{beech} + mix-pure	123.4531*
	Mixed-effect 4	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2+ age + slope + BA_{beech} + mix-pure	133.8026
	Mixed-effect 5	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2+ age + soil_depth + mix-pure	129.9266
	Mixed-effect 6	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2+ age + slope + mix-pure	140.9954
	Mixed-effect 7	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2+ age + BA_{beech} + mix-pure	131.8026
	Mixed-effect 8	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2 + age + mix-pure	139.204
	Mixed-effect 9	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2 + BA_{beech} + mix-pure	131.6319
	Mixed-effect 10	Log (BAI_{5years}) = CI_{2011}_inter + age + BA_{beech} + mix-pure	139.6995
	Mixed-effect 11	Log (BAI_{5years}) = CI_{2011}_inter + age + mix-pure	157.0247
	Mixed-effect 12	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2 + mix-pure	138.4801
	Mixed-effect 13	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2+ age + soil_depth + slope + BA_{fir} + mix-pure	130.65
	Mixed-effect 14	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2+ age + soil_depth + BA_{fir} + mix-pure	129.374
	Mixed-effect 15	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2+ age + slope + BA_{fir} + mix-pure	135.8036
	Mixed-effect 16	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2+ age + BA_{fir} + mix-pure	135.715
	Mixed-effect 17	Log (BAI_{5years}) = CI_{2011}_inter + DBH^2 + BA_{fir} + mix-pure	134.218
	Mixed-effect 18	Log (BAI_{5years}) = CI_{2011}_inter + age + BA_{fir} + mix-pure	150.6062

Tab. S4 - Parameter estimates for intra-specific interaction models (model 6 for silver fir and model 3 for European beech) fitted through the likelihood criterion (ML). (DBH^2): diameter at breast height squared (cm^2); (*Age*): tree age (years); (*Soil_depth*): depth of soils; (CI_{2011}_*intra*): intra-specific interactions; (*Slope*): slope of the terrain; (BA_{beech}): basal area occupied by competitors of European beech; (*mix-pure*): type of stands (pure and mixed-species).

Silver fir mixed-pure				**European beech mixed-pure**			
Fixed effects	**Est.**	**SE**	**p**	**Fixed effects**	**Est.**	**SE**	**p**
CI_{2011}_*intra*	-0.443	0.191	0.024	CI_{2011}_*intra*	-0.457	0.161	0.007
DBH^2	0.277	0.141	0.055	DBH^2	0.616	0.134	<0.001
Slope	0.164	0.087	0.065	*Age*	0.135	0.104	0.199
mix-pure	-0.098	0.294	0.739	*Soil_depth*	-0.510	0.149	0.001
				BA_{beech}	-0.243	0.374	0.161
				mix-pure	-0.017	0.374	0.964
Random effects				**Random effects**			
Name	**Variance**	**Std. Dev.**		**Name**	**Variance**	**Std. Dev.**	
Plot (intercept)	0.00	0.00		Plot (intercept)	0.00	0.00	
Residual	0.439	0.662		Residual	0.4346	0.6592	
R^2m	0.57	R^2c	0.57	R^2m	0.65	R^2c	0.65
AIC (mixed-effects)			120.4	AIC (mixed-effects)			118.2

Tab. S5 - Parameter estimates for inter-specific interaction models (model 6 for silver fir and model 3 for European beech) fitted through the likelihood criterion (ML). (DBH^2): diameter at breast height squared (cm^2); (*Age*): tree age (years); (*Soil_depth*): depth of soils; (CI_{2011}_*intra*): intra-specific interactions; (*Slope*): slope of the terrain; (BA_{beech}): basal area occupied by competitors of European beech; (*mix-pure*): type of stands (pure and mixed-species).

Silver fir mixed-pure				**European beech mixed-pure**			
Fixed effects	**Est.**	**SE**	**p**	**Fixed effects**	**Est.**	**SE**	**p**
CI_{2011}_*inter*	-0.039	0.166	0.812	CI_{2011}_*inter*	-0.325	0.217	0.141
DBH^2	0.467	0.136	0.001	DBH^2	0.653	0.143	<0.001
Slope	0.166	0.097	0.095	*Age*	0.240	0.116	0.044
mix-pure	-0.638	0.400	0.116	*Soil_depth*	-0.614	0.170	<0.001
				BA_{beech}	-0.484	0.159	<0.001
				mix-pure	-0.824	0.548	0.139
Random effects				**Random effects**			
Name	**Variance**	**Std. Dev.**		**Name**	**Variance**	**Std. Dev.**	
Plot (intercept)	0.00	0.00		Plot (intercept)	0.00	0.00	
Residual	0.479	0.692		Residual	0.513	0.716	
R^2m	0.53	R^2c	0.53	R^2m	0.60	R^2c	0.60
AIC (mixed-effects)			125.5	AIC (mixed-effects)			123.4