Supporting Information

Climate affects neighbour-induced changes in leaf chemical defences and tree diversity-herbivory relationships

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Figure S1. Relationship between four candidate metrics of tree phylogenetic diversity and tree species richness. Linear regressions are fitted in red and polynomial regressions in blue. The phylogenetic diversity (PD) is the total branch length spanned by the species in the plot. The mean phylogenetic distance (MPD) is the mean branch length among all pairs of species within the plot. The β mean phylogenetic distance (beta_MPD) is the mean phylogenetic distance between birch and associated species. Among these four metrics, birch evolutionary distinctiveness (ED) was the least correlated with tree species richness (see Pearson's correlation coefficients below).

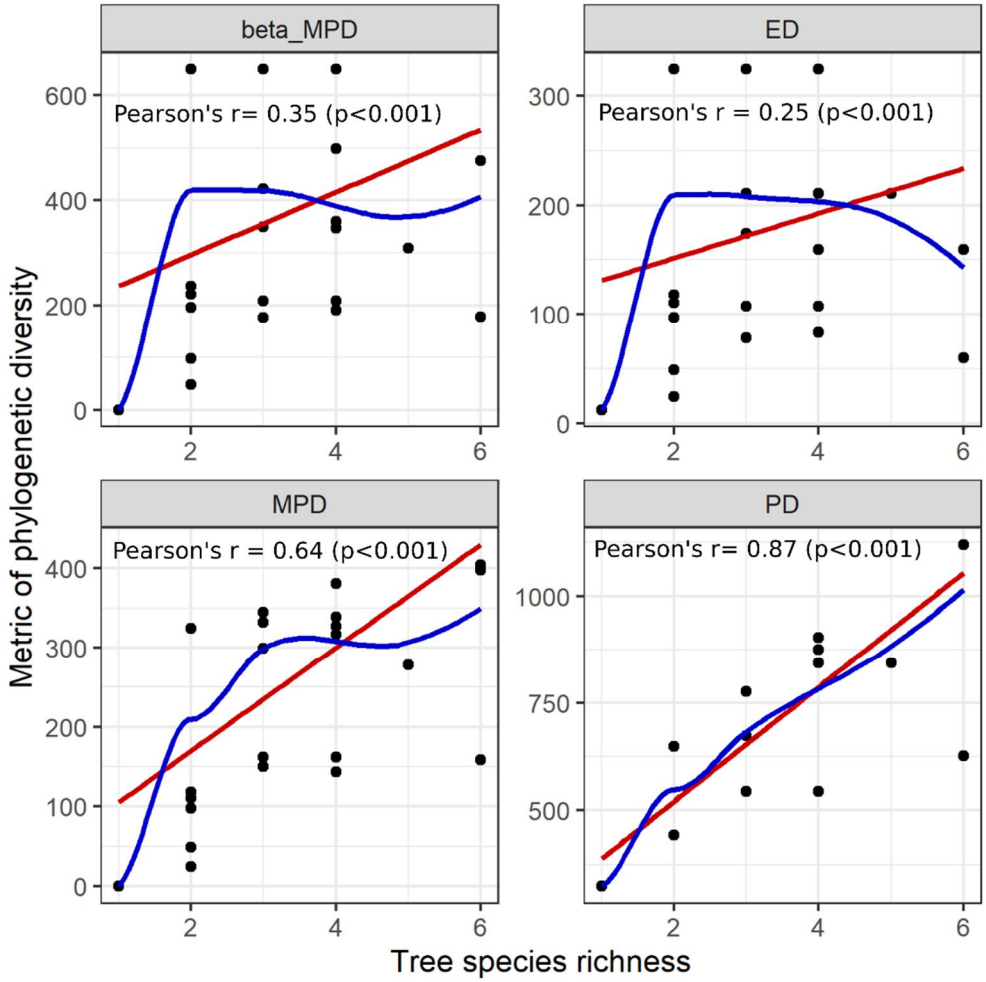

Figure S2. Phylogenetic tree of all tree species encountered in the plots selected for the study. The structure of the tree was obtained using the Phylomatic V3 platform (http://phylodiversity.net/phylomatic/) via the phylomatic function from the brranching package in R. We used the Phylomatic tree R20120829 for plants as a reference. Node ages and branch lengths (in million years) were derived from Magallon et al. 2015.

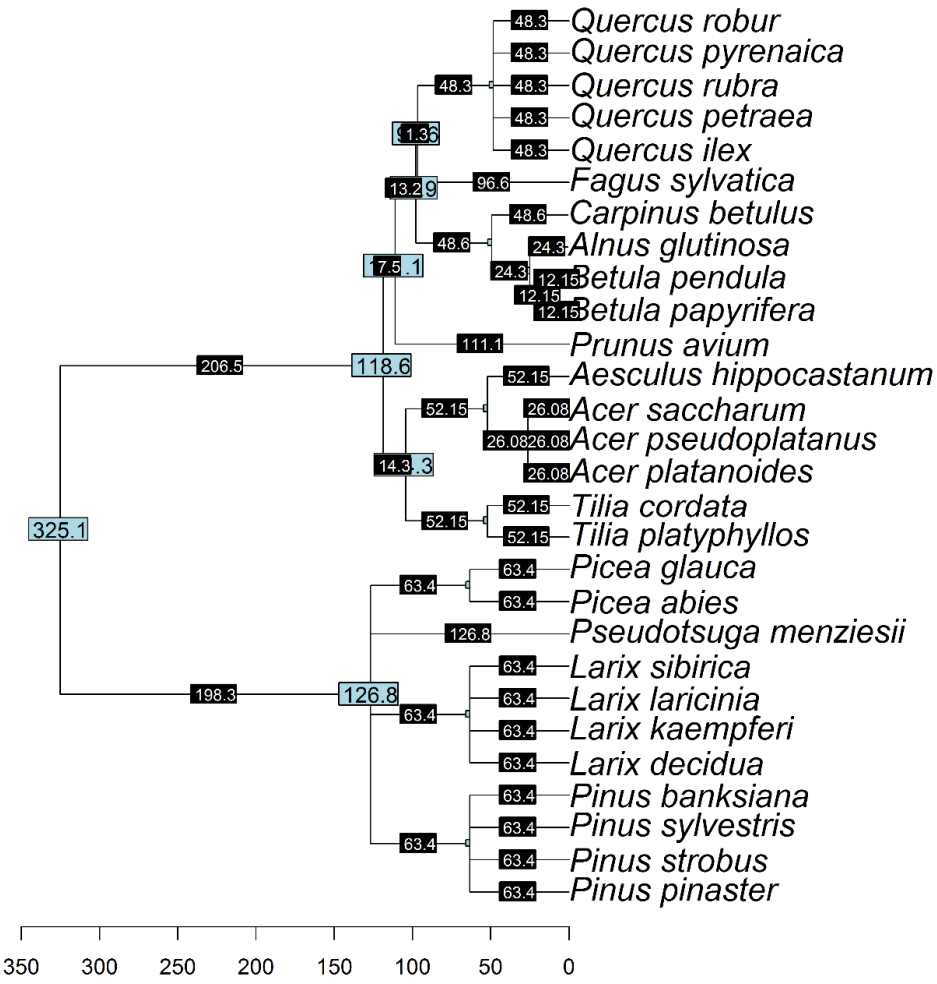

Figure S3. Evolutionary distinctiveness (ED in million years) of birch *vs* tree species richness in the plots per plot composition type (dot colour). The number associated with the dots represent the number of trees sampled. Birch ED was positively correlated with species richness (r = 0.25, p < 0.001) and ranged from 12.15 million years in birch monocultures (which corresponds to the length of the edge from *B. pendula-Betula papyrifera* bifurcation to *B. pendula* tip) to 324.40 million years in mixed plots where birch was associated with coniferous species only. Birch ED was calculated using the evol.distinct function (equal splits method; Redding & Mooers, 2006) from the picante package (Kembel et al., 2010) in R, as follows:

$$BirchED_{(T)} = 0.5^{n} \sum_{e \in s(T,R)}^{R} L_e$$

where T is the phylogenetic tree for the pool of tree species present in the plot, *R* the root of the phylogenetic tree, *e* an edge along the path from the root of the tree to the *B. pendula* tip, *L* the length of the edge *e* and *n* the number of nodes between the edge *e* and the *B. pendula* tip. Low and high ED values correspond to low and high phylogenetic isolation, respectively.

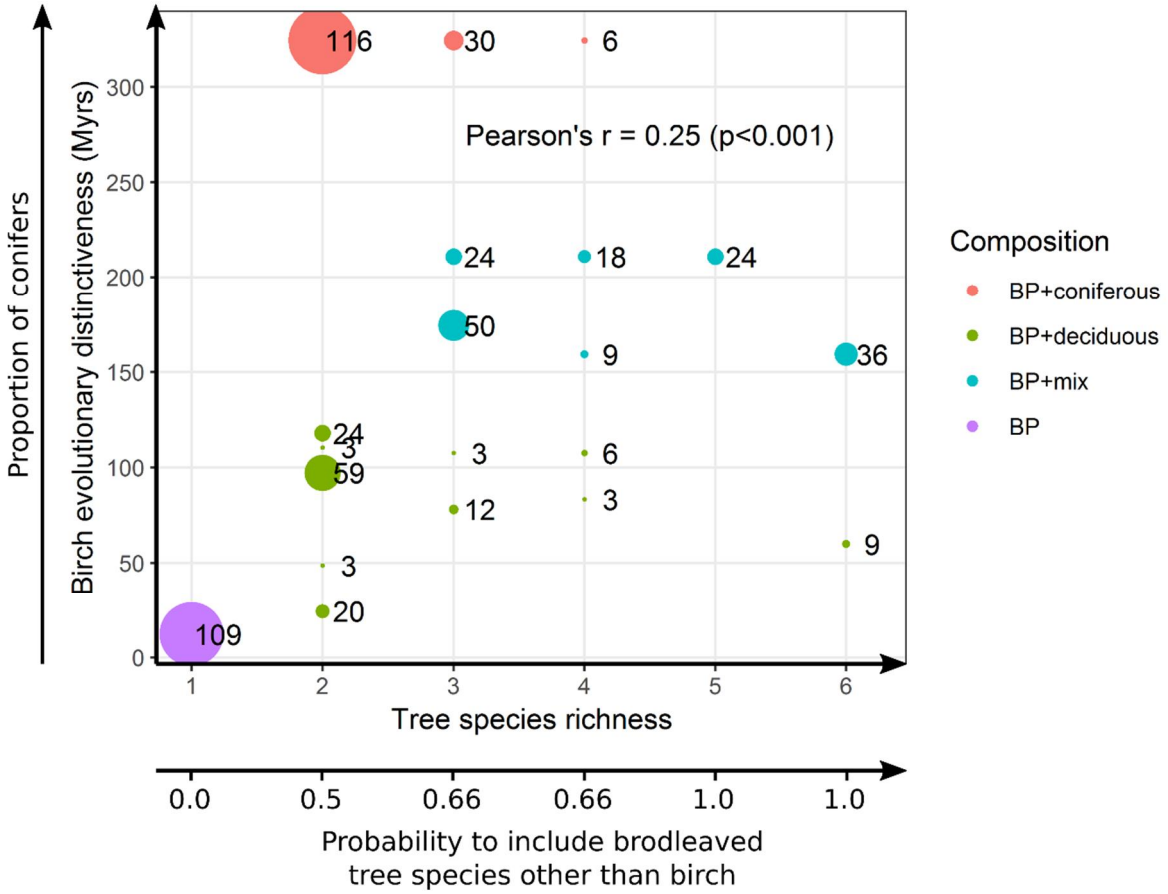

Figure S4. (a) Mean annual temperature (°C) (a) *vs* mean annual cumulated rainfall (mm) and (b) *vs* latitude (decimal degrees) at experimental sites. Climatic data is derived from the CHELSA database (http://chelsa-climate.org/) and corresponds to 1979-2013 average.

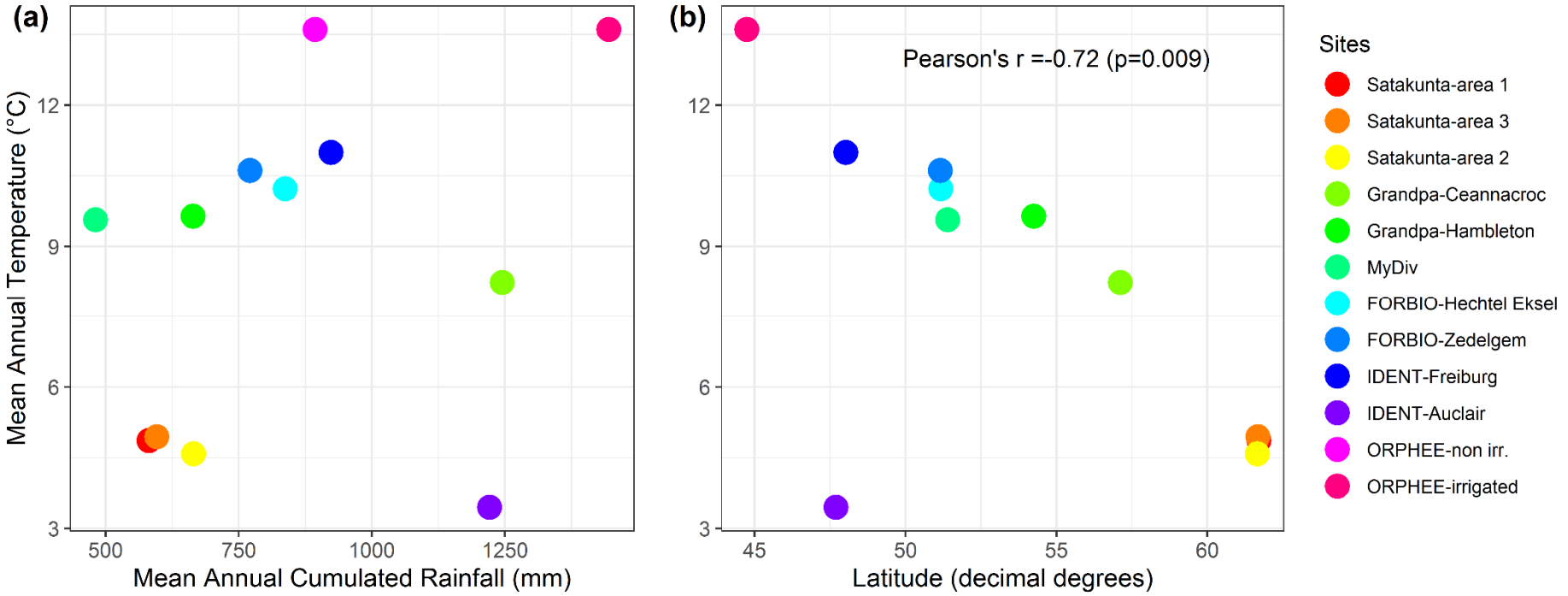

Figure S5. Herbivory and Phenols model residuals overview. Models used are the final simplified models (with the retained predictors). Model residuals are respectively plotted against predicted herbivory or phenols, as well as against latitude, temperature and rainfall to check for patterns. Area 1, 2 and 3 belongs to the Satakunta tree diversity experiment (Finland).

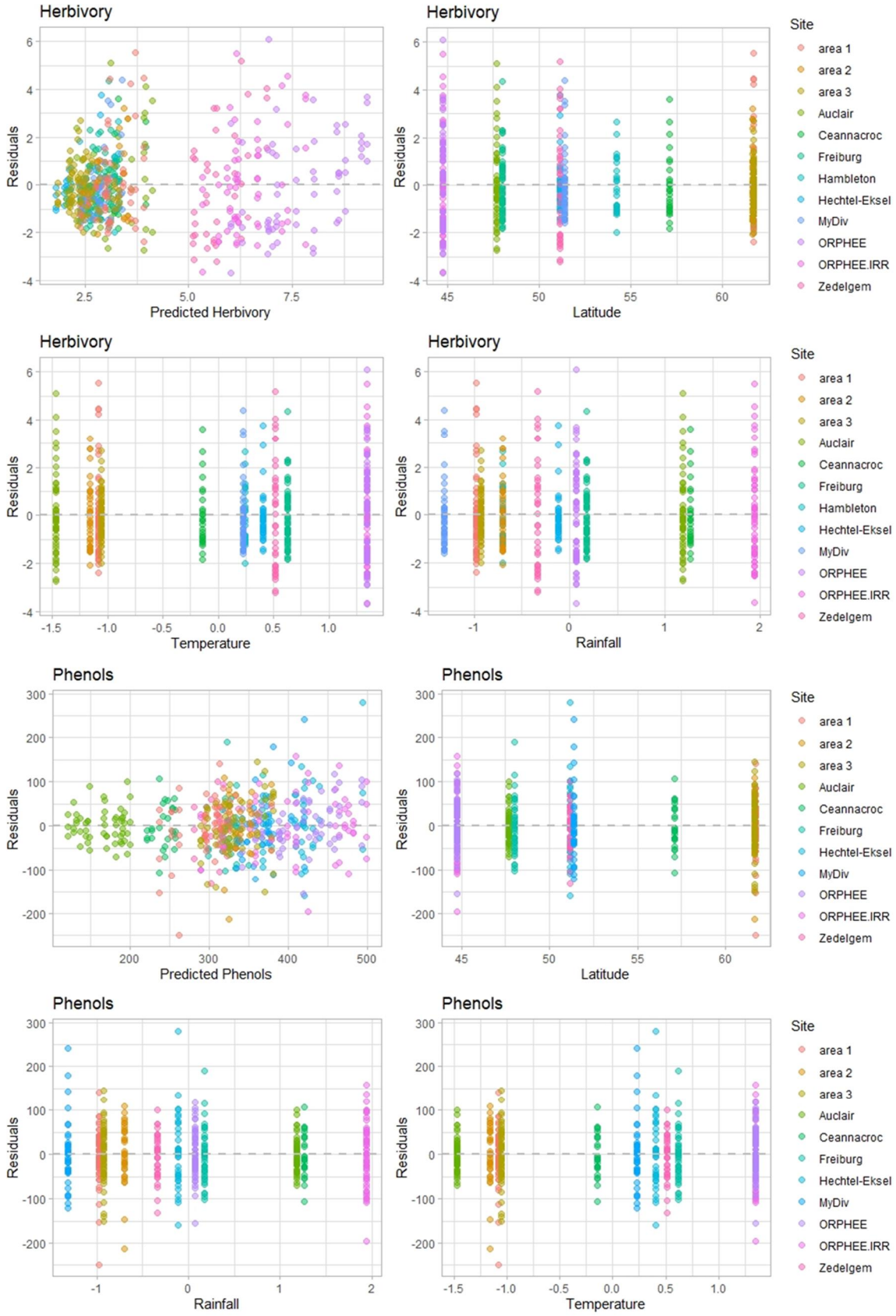

Figure S6. Correlation matrix and density plots of the concentrations of the different phenolic compounds in birch leaves (in mg per g of dry matter). Coefficient corresponds to Pearson correlation coefficients.

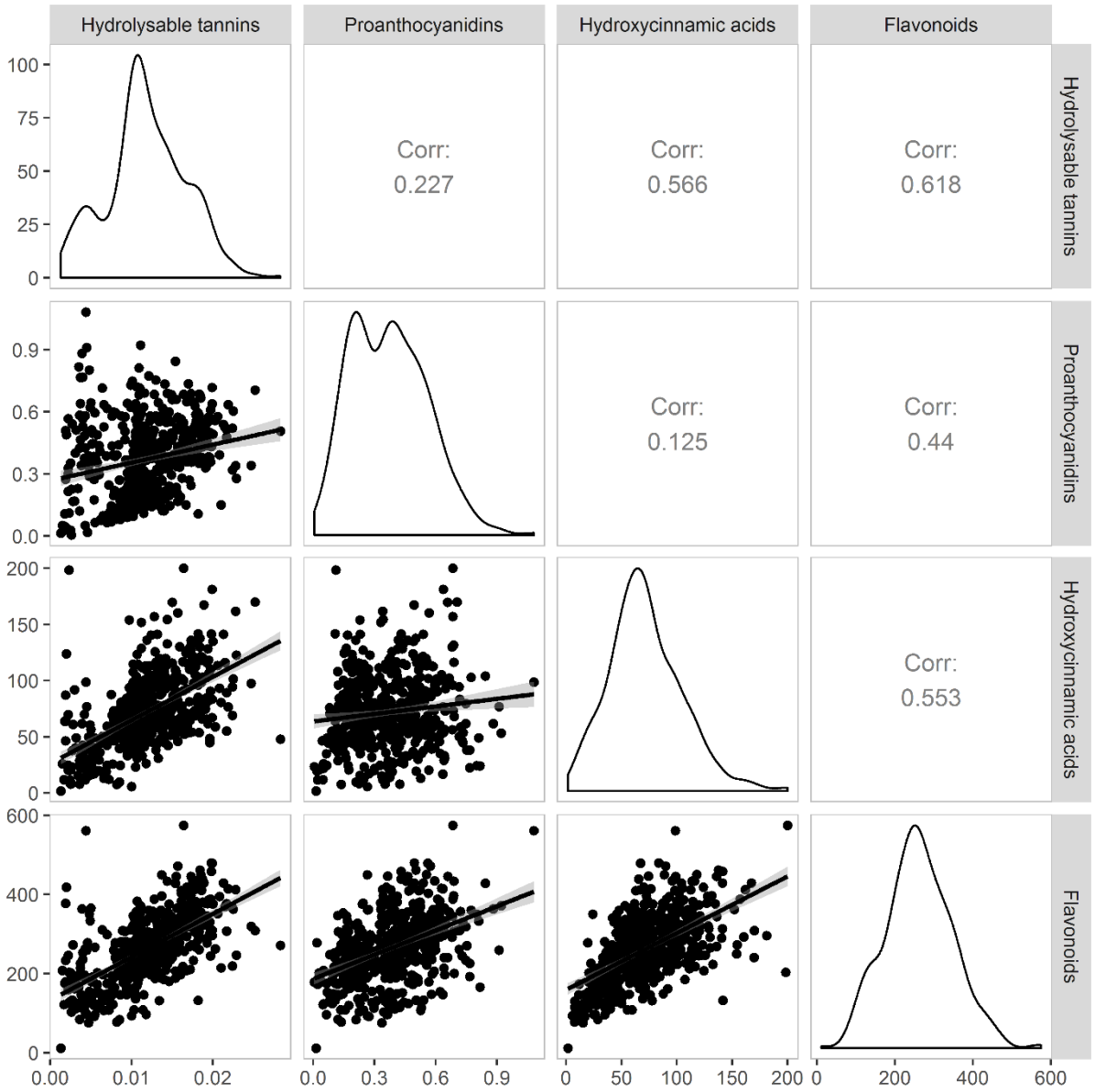

Figure S7. Principal component analysis with individual phenolic compound concentrations, with a varimax correction (maximization of axis-variables correlation). Flav: flavonoids; Lign: precursors to lignins (*i.e.* hydroxycinnamic acid); CT: condensed tannins (*i.e.* proanthocyanidins); HT: hydrolysable tannins (*i.e.* ellagitannins and gallic acid derivates). Percentages between brackets indicate the percentage of variance explained by each component.

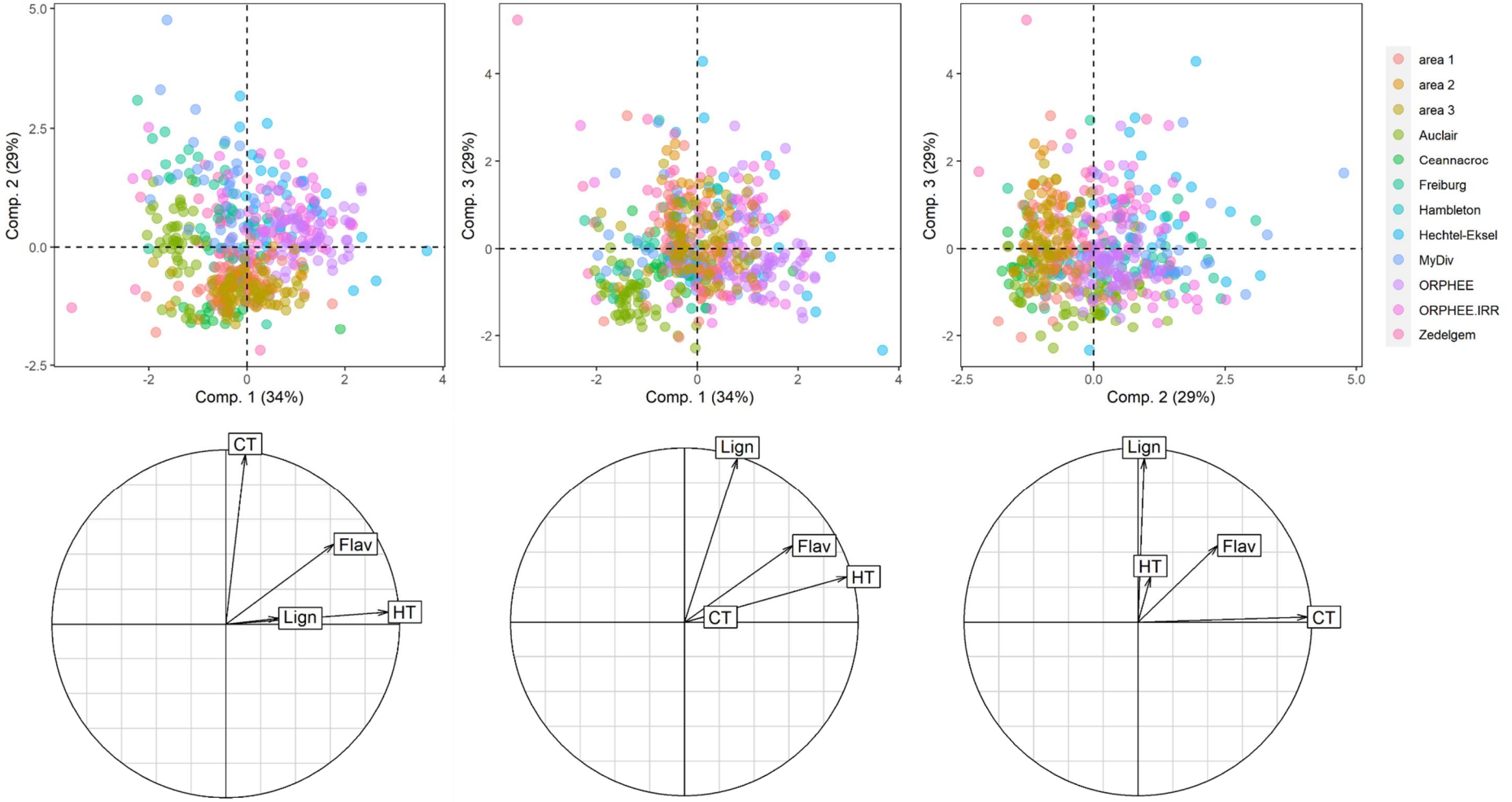

Figure S8. Correlation matrix of total phenolic concentration and coordinates of the three first principal component axes of the PCA with individual phenolic compound concentrations (Figure S7).

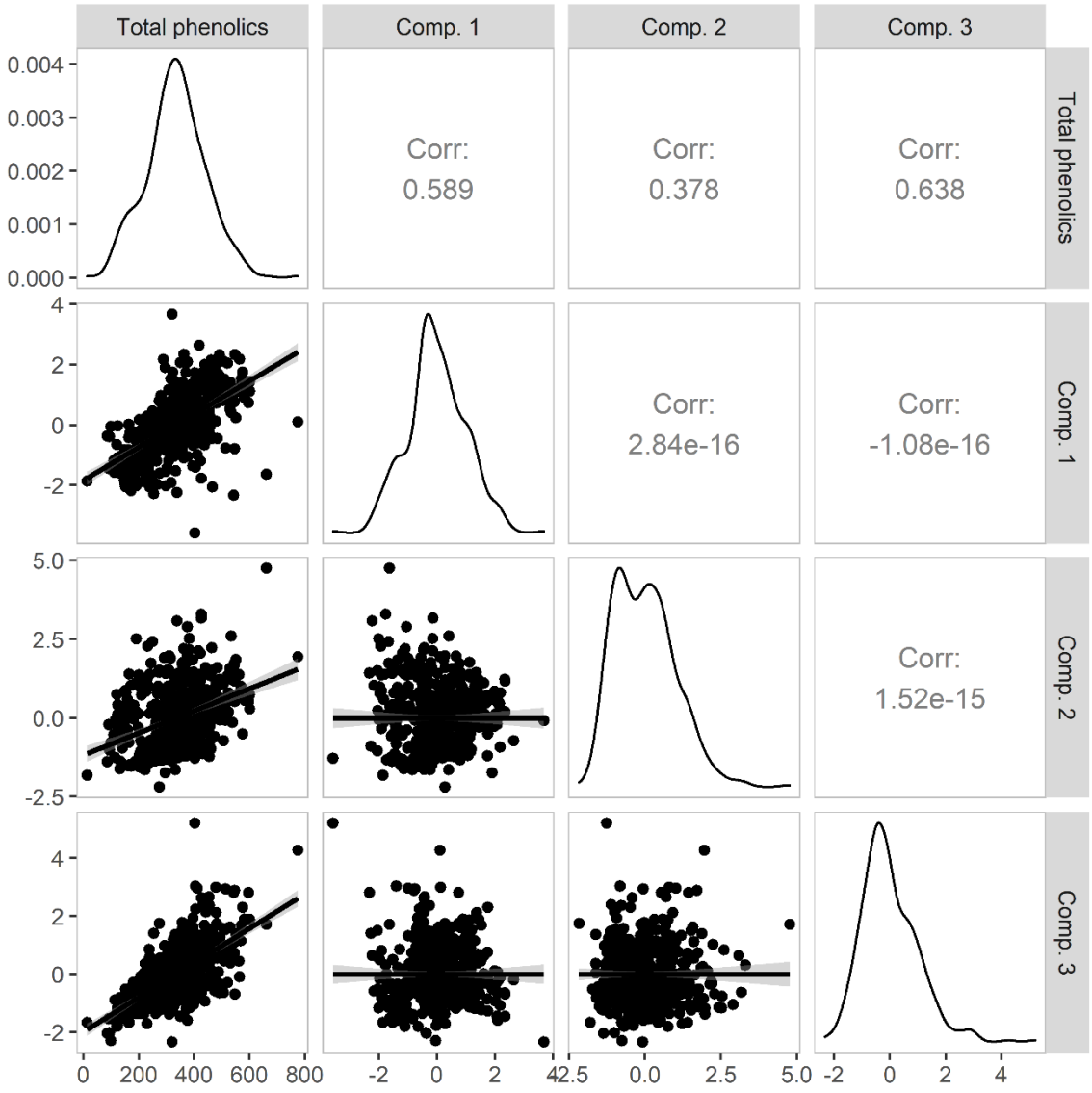

Table S1. Characteristics of the experimental sites.

Experiment	Site	Country	Latitude	Longitude	Year of installation	Plot area (m^2)	Tree density (trees per m^2)	Pool of tree species	Richness levels	Birch evolutionary distinctiveness levels
Satakunta	area 1	Finland	61.7	21.97	1999	400	0.42	*Betula pendula, Alnus glutinosa, Larix sibirica, Pinus sylvestris*	1, 2, 3	12.15, 24.30, 174.35, 324.40
Satakunta	area 3	Finland	61.67	21.7	1999	400	0.42	*Betula pendula, Alnus glutinosa, Larix sibirica, Pinus sylvestris*	1, 2, 3	12.15, 24.30, 174.35, 324.40
Satakunta	area 2	Finland	61.65	22.15	1999	400	0.42	*Betula pendula, Alnus glutinosa, Larix sibirica, Pinus sylvestris*	1, 2, 3	12.15, 174.35, 324.40
Grandpa	Ceannacroc	United Kingdom	57.12	-4.75	1960	2000	0.43	*Betula pendula, Pinus sylvestris*	1, 2	12.15, 324.40
Grandpa	Hambleton	United Kingdom	54.25	-1.5	1961	2000	0.43	*Betula pendula, Pinus sylvestris*	1, 2	12.15, 324.40
MyDiv		Germany	51.39	11.89	2015	121	1.16	*Betula pendula, Acer pseudoplatanus, Aesculus hippocastanum, Carpinus betulus, Fagus sylvatica, Prunus avium, Quercus petraea, Tilia platyphyllos*	1, 2, 3, 4	12.15, 48.60, 78.08, 83.25, 97.20, 107.55, 110.40, 117.90
FORBIO	Hechtel-Eksel	Belgium	51.17	5.32	2012	1296	0.44	*Betula pendula, Larix kaempferi, Pinus sylvestris, Pseudotsuga menziesii, Quercus petraea*	1, 2, 4	12.15, 97.20, 210.80, 324.40
FORBIO	Zedelgem	Belgium	51.15	3.12	2010	1764	0.44	*Betula pendula, Fagus sylvatica, Pinus sylvestris, Quercus robur, Tilia cordata*	1, 2, 4	12.15, 97.20, 107.55, 159.18, 210.80, 324.40
IDENT	Freiburg	Germany	48.02	7.83	2013	13	3.78	*Betula pendula, Acer Platanoides, Acer saccharum, Betula papyrifera, Larix decidua, Larix laricinia, Picea abies, Picea glauca, Pinus strobus, Pinus sylvestris, Quercus rubra*	1, 2, 6	12.15, 59.85, 97.20, 117.90, 159.18, 324.40
IDENT	Auclair	Canada	47.7	-68.66	2010	14.44	3.4	*Betula pendula, Acer platanoides, Larix decidua, Larix laricinia, Picea abies, Pinus banksiana, Pinus sylvestris, Quercus robur*	1, 2, 6	12.15, 97.20, 117.90, 159.18, 324.40
ORPHEE	non-irrigated	France	44.74	-0.8	2008	400	0.25	*Betula pendula, Pinus pinaster, Quercus ilex, Quercus pyrenaica, Quercus robur*	1, 2, 3, 5	12.15, 97.20, 210.80, 324.40
ORPHEE	irrigated	France	44.74	-0.8	2008	400	0.25	*Betula pendula, Pinus pinaster, Quercus ilex, Quercus pyrenaica, Quercus robur*	1, 2, 3, 5	12.15, 97.20, 210.80, 324.40

Table S2. Minimum, maximum, mean and standard deviation of insect herbivory (% leaf area removed) on birch leaves at the experimental sites.

Experimental site		Nb. of pure plots	Nb. of mixed plots	Nb. of birch trees sampled	Insect Herbivory (% leaf area removed)	
					min - max	mean ± sd
Satakunta	area 1	2	10	60	0.59 - 9.24	3.14 ± 1.87
Satakunta	area 3	2	10	60	0.48 - 5.10	2.30 ± 1.02
Satakunta	area 2	2	5	35	0.71 - 6.68	3.11 ± 1.52
Grandpa	Ceannacroc	3	6	27	1.47 - 6.90	3.27 ± 1.43
Grandpa	Hambleton	3	6	27	1.23 - 5.94	2.97 ± 1.25
MyDiv		2	12	42	0.78 - 7.79	2.81 ± 1.55
FORBIO	Hechtel-Eksel	2	11	40	0.75 - 6.66	2.23 ± 1.15
FORBIO	Zedelgem	2	10	36	1.98 - 11.5	5.79 ± 2.66
IDENT	Freiburg	3	18	63	0.66 - 7.41	2.71 ± 1.36
IDENT	Auclair	3	15	54	0.36 - 8.23	3.05 ± 1.89
ORPHEE	non-irrigated	3	12	60	2.34 - 13.0	7.75 ± 2.63
ORPHEE	irrigated	3	12	60	1.69 - 12.0	6.44 ± 2.31
Overall		30	127	564	0.36 – 13.03	3.91 ± 2.60

Table S3. Average proportions of the different phenolic compounds in birch leaves (% of total phenolics) and minimum, maximum, mean and standard deviation of the concentrations of the phenolic compounds (mg g-1 dry matter) at each experimental site. n: number of observations.

			Leaf Phenolic Concentration (mg g^{-1} dry matter)									
			Hydrolysable tannins		Proanthocyanidins (condensed tannins)		Hydroxycinnamic acids (lignins)		Flavonoids		Total Phenolics	
Average proportion			0.004 %		0.111 %		21.509 %		78.377 %			
Experimental site		n	min – max	mean ± sd	min – max	mean ± sd	min – max	mean ± sd	min – max	mean ± sd	min – max	mean ± sd
Satakunta	area 1	58	0.001 - 0.023	0.011 ± 0.003	0.014 - 0.422	0.227 ± 0.073	1.72 - 154.03	69.77 ± 28.85	11.78 - 313.60	222.94 ± 51.16	13.51 - 455.00	292.95 ± 71.93
Satakunta	area 3	54	0.002 - 0.018	0.012 ± 0.003	0.090 - 0.376	0.192 ± 0.051	36.22 - 127.00	74.46 ± 21.09	108.03 - 378.11	257.55 ± 63.67	163.92 - 505.37	332.21 ± 75.87
Satakunta	area 2	35	0.004 - 0.020	0.012 ± 0.003	0.075 - 0.394	0.213 ± 0.066	28.69 - 140.51	89.24 ± 27.41	84.25 - 361.82	255.79 ± 51.47	113.06 - 472.23	345.25 ± 71.61
Grandpa	Ceannacroc	27	0.006 - 0.021	0.009 ± 0.003	0.065 - 0.259	0.138 ± 0.056	30.90 - 107.40	58.42 ± 18.22	96.04 - 258.34	182.68 ± 42.09	131.11 - 342.82	241.24 ± 51.21
Grandpa	Hambleton	0	_	_	_	_	_	_	_	_	_	_
MyDiv		42	0.003 - 0.016	0.010 ± 0.003	0.251 - 1.082	0.536 ± 0.171	24.20 - 157.01	65.80 ± 24.32	187.11 - 561.33	300.92 ± 70.74	236.61 - 661.13	367.27 ± 84.96
FORBIO	Hechtel-Eksel	37	0.011 - 0.028	0.018 ± 0.004	0.319 - 0.922	0.565 ± 0.142	47.82 - 199.93	98.95 ± 37.57	187.75 - 574.46	325.42 ± 74.05	260.64 - 775.08	424.95 ± 98.01
FORBIO	Zedelgem	36	0.002 - 0.018	0.012 ± 0.004	0.106 - 0.715	0.434 ± 0.145	37.74 - 198.38	98.06 ± 34.78	131.42 - 292.38	222.08 ± 41.34	171.08 - 427.18	320.59 ± 58.29
IDENT	Freiburg	44	0.002 - 0.017	0.009 ± 0.003	0.101 - 0.911	0.461 ± 0.186	22.47 - 151.86	65.33 ± 25.84	164.98 - 382.86	266.92 ± 53.73	218.33 - 514.08	332.72 ± 68.36
IDENT	Auclair	54	0.002 - 0.012	0.005 ± 0.002	0.005 - 0.635	0.331 ± 0.161	5.68 - 69.93	25.39 ± 13.14	75.84 - 277.72	140.32 ± 37.63	91.40 - 297.46	166.05 ± 43.91
ORPHEE	non-irrigated	60	0.010 - 0.023	0.017 ± 0.003	0.215 - 0.647	0.415 ± 0.095	42.09 - 167.32	76.75 ± 25.78	180.30 - 479.39	339.32 ± 64.06	249.36 - 596.71	416.50 ± 77.72
ORPHEE	irrigated	60	0.002 - 0.023	0.016 ± 0.004	0.300 - 0.818	0.521 ± 0.109	23.97 - 141.38	81.86 ± 30.97	154.41 - 461.92	331.18 ± 74.13	190.14 - 600.06	413.57 ± 98.96

Table S4. Summary of LMMs testing for the effects of climate, diversity and their interaction on the concentration of the different types of phenolic compounds. All full models have the following structure: Phenolics concentration ~ Species richness + Birch ED + Temperature + Rainfall + Sp. richness x Temperature + Sp. Richness x Rainfall + Birch ED x Temperature + Birch ED x Rainfall + Temperature x Rainfall + Sp. Richness x Temperature x Rainfall + Birch ED x Temperature x Rainfall + (1|Site/Block/Plot). Results correspond to the simplified models. Predictors are scaled and centred. Predictor having a significant effect on the response variable are in bold.

Response	Predictors	Standardized estimate ± sd	df	t-value	P-value
Hydroxycinnamic acids (lignins)					
	Intercept	**71.57 ± 5.21**	**6.82**	**13.74**	**<0.001**
	Species richness	**3.55 ± 1.50**	**139.94**	**2.36**	**0.020**
	Birch ED	-2.29 ± 1.76	133.22	-1.30	0.195
	Temperature	8.88 ± 5.63	6.82	1.58	0.160
	Rainfall	-9.43 ± 5.22	6.74	-1.81	0.115
	Birch ED x Temperature	-0.70 ± 1.65	115.62	-0.43	0.671
	Birch ED x Rainfall	-1.96 ± 1.61	122.58	-1.22	0.226
	Temp. x Rainfall	8.31 ± 4.99	6.70	1.67	0.142
	Birch ED x Temp. x Rainfall	**-3.88 ± 1.40**	**111.68**	**-2.77**	**0.007**
Flavonoids					
	Intercept	**255.24 ± 11.91**	**6.95**	**21.43**	**<0.001**
	Species richness	**8.05 ± 3.37**	**148.27**	**2.39**	**0.018**
	Birch ED	**-11.47 ± 3.95**	**140.11**	**-2.90**	**0.004**
	Temperature	**43.89 ± 12.84**	**6.89**	**3.42**	**0.011**
	Rainfall	-21.71 ± 11.95	6.91	-1.82	0.113
	Birch ED x Temperature	**-8.40 ± 3.73**	**123.93**	**-2.25**	**0.026**
	Birch ED x Rainfall	-3.01 ± 3.63	130.71	-0.83	0.408
	Temp. x Rainfall	21.65 ± 11.41	6.82	1.90	0.101
	Birch ED x Temp. x Rainfall	**-9.22 ± 3.16**	**120.28**	**-2.92**	**0.004**
Proanthocyanidins (condensed tannins)					
	Intercept	**0.37 ± 0.03**	**8.93**	**10.69**	**<0.001**
	Temperature	**0.10 ± 0.04**	**8.86**	**2.92**	**0.017**
Hydrolysable tannins					
	Intercept	**0.01 ± 0.00**	**9.00**	**12.20**	**<0.001**
	Species richness	**0.0004 ± 0.0002**	**129.30**	**2.28**	**0.025**
	Birch ED	**-0.001 ± 0.0002**	**109.20**	**-2.81**	**0.006**
	Temperature	**0.002 ± 0.001**	**8.95**	**2.28**	**0.049**
	Sp. Richness x Temperature	**0.0003 ± 0.0002**	**118.60**	**2.15**	**0.034**
	Birch ED x Temperature	**-0.0004 ± 0.0002**	**98.08**	**-2.08**	**0.040**