Table 1. Environmental variables characterizing the 23 beech forests studied.

Sampling site	Latitude (degrees)	Longitude (degrees)	Altitude (m a.s.l.)	DBH (m)	CLIMATIC VARIABLES																		
					Temperature (°C)											Precipitation (mm)							
					Annual Mean	Mean diurnal range	Isothermality (unitless)	Seasonality (unitless)	Max warmest month	Min coldest month	Annual range	Mean wettest quarter	Mean driest quarter	Mean warmest quarter	Mean coldest quarter	Annual	Wettest month	Driest month	Seasonality (unitless)	Wettest quarter	Driest quarter	Warmest quarter	Coldest Quarter
sw_oder (23)	57.0	13.5	197.0	0.57	6.7	65.0	255	6502	20.6	-4.9	25.5	4.3	3.8	15.8	-1.8	914	95	50	22.0	281	162	266	179
sw_ramlak (22)	57.1	12.6	107.8	0.50	7.5	49.6	214	6309	20.0	-3.2	23.2	5.4	4.4	16.4	-0.8	842	90	44	23.8	267	148	251	156
sw_bisk (21)	56.8	12.9	141.6	0.65	7.0	57.0	236	6354	20.0	-4.1	24.1	4.8	4.0	15.9	-1.4	1069	117	57	23.0	335	188	328	203
sw_bjur (20)	56.6	14.7	161.0	0.40	6.9	62.0	248	6489	20.8	-4.4	25.2	15.8	3.1	16.1	-1.5	658	76	37	22.0	211	115	203	125
sk_rabia (19)	49.10	22.5	1151.4	0.68	4.0	73.0	259	7484	18.7	-9.6	28.3	13.7	-6.0	13.9	-6.2	1125	144	60	29.8	430	182	368	213
sk_mp (18)	48.76	20.1	900.2	0.34	6.2	75.2	261	7581	21.2	-7.7	29.0	13.8	-3.7	16.3	-4.1	666	87	32	30.2	250	101	201	106
sk_kv (17)	48.69	19.8	1233.4	0.59	3.9	76.0	264	7439	18.8	-9.9	28.6	11.2	-5.9	13.8	-6.3	1065	146	56	30.4	404	174	342	186
at_kalk (16)	47.82	14.5	757.6	0.66	6.8	80.0	285	7049	21.2	-6.9	28.1	15.9	-2.3	16.3	-2.8	1031	144	58	31.4	416	183	370	209
at_trogener (15)	46.45	14.5	855.8	0.66	6.8	84.0	285	7247	21.8	-7.6	29.4	16.5	-2.6	16.5	-3.2	1278	145	63	25.0	428	194	428	208
at_loib (14)	46.46	14.3	1118.4	0.93	6.2	83.6	286	7197	21.1	-8.1	29.3	10.7	-3.1	15.9	-3.7	1644	179	83	22.2	514	256	495	292
in_cansiglio (13)	46.07	12.4	1080.2	0.84	7.0	81.0	286	6928	21.5	-6.9	28.4	7.8	-1.9	16.5	-2.4	1427	151	78	20.4	438	236	393	264
is_umbra (12)	41.81	16.0	750.2	0.47	11.9	43.4	207	5793	23.1	2.3	20.8	10.4	19.7	20.6	4.6	618	71	37	20.4	204	116	118	148
is_alburni (11)	40.50	15.4	1213.0	0.88	9.0	84.4	321	6055	23.3	-2.9	26.2	3.5	17.0	17.9	1.2	942	127	27	41.0	370	89	96	276
is_calabre (10)	39.50	16.1	1077.6	1.13	11.0	49.0	230	5657	22.6	1.4	21.2	8.4	18.4	19.5	3.8	1089	152	25	46.8	441	86	96	354
fr_pavin (9)	45.50	2.8	1272.6	0.88	6.4	77.0	314	5769	20.2	-4.3	24.4	7.5	1.3	14.7	-1.0	1113	117	73	13.6	322	231	263	278
fr_chadefour (8)	45.54	2.9	1181.8	0.80	6.1	77.0	315	5749	19.9	-4.5	24.3	7.3	1.1	14.5	-1.2	1032	106	67	12.2	291	211	264	251
fr_picherande (7)	45.47	2.8	1200.2	1.14	6.8	77.0	314	5765	20.6	-3.8	24.4	0.9	4.4	15.2	-0.5	1354	137	94	13.0	396	290	317	358
ne_irati (6)	42.99	-1.1	855.8	1.28	9.9	85.6	355	5343	23.2	-0.9	24.1	4.4	17.5	17.7	3.0	1332	152	65	24.2	450	209	209	402
ne_saja (5)	43.11	-4.3	866.2	0.88	11.1	69.0	345	4557	22.2	2.2	20.1	6.7	17.9	17.9	5.4	925	109	44	25.2	308	142	142	278
ne_redes (4)	43.11	-5.2	1237.4	1.17	8.7	78.6	365	4717	20.7	-0.8	21.5	4.0	15.7	15.7	2.7	1174	146	47	30.6	404	145	145	367
ce_cantalojas (3)	41.23	-3.4	1541.6	0.64	7.1	95.0	341	6184	23.2	-4.5	27.8	0.8	16.5	16.5	-0.6	707	80	27	28.0	228	82	82	202
ce_pedrosa (2)	41.22	-3.4	1604.4	0.64	8.0	95.0	340	6231	24.2	-3.7	27.9	1.6	17.5	17.5	0.2	681	78	24	30.0	222	72	72	200
ce_montejo (1)	41.11	-3.5	1335.2	0.54	9.4	95.0	334	6378	25.9	-2.5	28.4	2.9	19.2	19.2	1.5	563	71	17	34.0	201	54	54	168

Sampling sites: 1) Sitio Natural de Interés Nacional del Hayedo de Montejo de la Sierra; 2) Hayedo La Pedrosa; 3) Parque Natural Sierra Norte de Guadalajara; 4) Parque Natural de Redes; 5) Parque Natural Saja-Besaya; 6) La Selva de Irati; 7) Picherande; 8) Chadefour Valley Nature Reserve; 9) Réserve naturelle nationale de Chastreix-Sancy; 10) Riserva Statale Serra Nicolino - Pian d'Albero; 11) Parco Nazionale del Cilento e Valle de Diano; 12) Foresta Umbra; 13) Foresta del Cansiglio; 14) Loibltal; 15) Trögener Klamm; 16) Nationalpark Kalkalpen; 17) Klenovsý Vepor (Klenovské vrchy); 18) Cigánka-Muránsky hrad (Muránska planina NP); 19) Rabia skala

(Poloniny NP); 20) Bjurkärrs Naturreservat; 21) Biskopstorps Naturreservat; 22) Ramlaklitten i Skogsbo Naturreservat; 23) Ödegärdet Naturreservat. Countries: at=Austria, ce= Central Spain, fr= France, in=Northern Italy, is=Southern Italy, ne=northern Spain, sk=Slovakia, sw=Sweden.

Table S2: Functional trait values. Functional trait values for the 203 lichen species found in the 23 studied beech forests across Europe. Mean values ± SE of specific thallus mass (STM) in mg dry mass/cm^2, water-holding capacity (WHC) in mg water/cm^2, and carbon-nitrogen ratio (C/N) are provided for the machrolichen species (n=42 species for STM and WHC; n=57 species for C/N). Abbreviations: 1) Growth form: C=crustose, SQ=squamulose, L=leprose, FBL=foliose broad lobed, FNL=foliose narrow lobed, FR=fruticose dorsiventral, FRF=fruticose filamentous; 2) Reproductive strategy: ASEX=asexual; SEX=sexual; ASEX+SEX=both reproductive strategies (asexual and sexual); 3) Photobiont type: CB=cyanobacteria, CHL=green algae, TR=*Trentepohlia.*

Lichen species	Growth form	Reproductive strategy	Photobiont type	STM	WHC	C/N
Acrocordia cavata (Ach.) R.C. Harris	C	SEX	TR			
Acrocordia gemmata (Ach.) A. Massal. var. *gemmata*	C	SEX	TR			
Agonimia allobata (Stizenb.) P. James	C	ASEX+SEX	CHL			
Agonimia octospora Coppins & P. James	SQ	SEX	CHL			
Agonimia tristicula (Nyl.) Zahlbr.	SQ	SEX	CHL			
Alyxoria varia (Pers.) Ertz & Tehler	C	SEX	TR			
Amandinea punctata (Hoffm.) Coppins & Scheid.	C	SEX	CHL			
Anaptychia ciliaris (L.) A. Massal.	FR	SEX	CHL	12.58 ± 0.86	20.53 ± 1.32	51.6 ± 3.2
Anisomeridium biforme (Schaer.) R.C. Harris	C	SEX	TR			
Anisomeridium polypori (Ellis & Everh.) M.E. Barr	C	SEX	TR			
Arthonia atra (Pers.) A. Schneid.	C	SEX	TR			
Arthonia didyma Körb.	C	SEX	TR			
Arthonia punctiformis Ach.	C	SEX	TR			
Arthonia radiata (Pers.) Ach.	C	SEX	TR			
Arthonia sp.	C	SEX	TR			
Arthonia spadicea Leight.	C	SEX	TR			
Arthonia vinosa Leight.	C	SEX	TR			
Bacidia circumspecta (Vain.) Malme	C	SEX	CHL			
Bacidia incompta (Borrer) Anzi	C	SEX	CHL			
Bacidia laurocerasi (Duby) Zahlbr.	C	SEX	CHL			
Bacidia rosella (Pers.) De Not.	C	SEX	CHL			
Bacidia rubella (Hoffm.) A. Massal.	C	SEX	CHL			
Bacidia sp.	C	SEX	CHL			
Bacidia subincompta (Nyl.) Arnold	C	ASEX+SEX	CHL			
Bacidina arnoldiana (Körb.) V. Wirth & Vězda	C	ASEX+SEX	CHL			
Bacidina delicata (Leight.) V. Wirth & Vězda	C	SEX	CHL			
Biatora chrysantha (Zahlbr.) Printzen	C	ASEX+SEX	CHL			
Biatora efflorescens (Hedl.) Räsänen	C	ASEX+SEX	CHL			
Biatora vernalis (L.) Fr.	C	SEX	CHL			
Blastenia herbidella (Hue) Servít	C	ASEX+SEX	CHL			
Bryobilimbia hypnorum (Lib.) Fryday, Printzen & S. Ekman	C	SEX	CHL			
Bryoria fuscescens (Gyeln.) Brodo & D. Hawksw.	FRF	ASEX	CHL			29.4 ± 1.4
Buellia disciformis (Fr.) Mudd	C	SEX	CHL			
Buellia griseovirens (Sm.) Almb.	C	ASEX	CHL			
Lichen species	Growth form	Reproductive strategy	Photobiont type	STM	WHC	C/N

Calicium salicinum Pers.	C	SEX	CHL			
Calicium viride Pers.	C	SEX	CHL			
Caloplaca obscurella (J. Lahm) Th. Fr.	C	ASEX	CHL			
Candelaria concolor (Dicks.) Stein	FNL	ASEX+SEX	CHL			
Candelariella vitellina (Hoffm.) Müll. Arg.	C	SEX	CHL			
Candelariella xanthostigma (Ach.) Lettau	C	ASEX+SEX	CHL			
Carbonicola myrmecina (Ach.) Bendiksby & Timdal	SQ	ASEX+SEX	CHL			
Catillaria nigroclavata (Nyl.) J. Steiner	C	SEX	CHL			
Cetrelia olivetorum (Nyl.) W.L. Culb. & C.F. Culb.	FBL	ASEX+SEX	CHL	6.51 ± 0.4	10.79 ± 0.72	42.3 ± 1.7
Chaenotheca furfuracea (L.) Tibell	C	SEX	CHL			
Chrysothrix candelaris (L.) J.R. Laundon	L	ASEX+SEX	CHL			
Cladonia chlorophaea (Sommerf.) Spreng.	FR	ASEX+SEX	CHL			41.4 ± 1.7
Cladonia coniocraea (Flörke) Spreng.	FR	ASEX+SEX	CHL			42.0 ± 1.8
Cladonia cornuta (L.) Hoffm.	FR	ASEX+SEX	CHL			
Cladonia digitata (L.) Hoffm.	FR	ASEX+SEX	CHL			35.1 ± 2.7
Cladonia fimbriata (L.) Fr.	FR	ASEX+SEX	CHL			43.5 ± 2.0
Cladonia parasitica (Hoffm.) Hoffm.	FR	ASEX+SEX	CHL			
Cladonia pyxidata (L.) Hoffm.	FR	ASEX+SEX	CHL			46.6 ± 1.7
Coenogonium luteum (Dicks.) Kalb & Lücking	C	SEX	TR			
Coenogonium pineti (Ach.) Lücking & Lumbsch	C	SEX	TR			
Collema flaccidum (Ach.) Ach.	FBL	ASEX+SEX	CB	3.3 ± 0.08	14.13 ± 0.39	10.2 ± 0.1
Collema furfuraceum Du Rietz	FBL	ASEX+SEX	CB	2.42	11.32	10.8 ± 0.2
Collema nigrescens (Huds.) DC.	FBL	ASEX+SEX	CB			
Collema subflaccidum Degel.	FBL	ASEX+SEX	CB			
Collema subnigrescens Degel.	FBL	SEX	CB	6.48 ± 0.72	89.84 ± 42.75	14.3 ± 2.2
Coniocarpon cinnabarinum DC.	C	SEX	TR			
Enterographa crassa (DC.) Fée	C	SEX	TR			
Evernia prunastri (L.) Ach.	FR	ASEX+SEX	CHL	9.15 ± 0.19	14.37 ± 0.24	45.4 ± 1.4
Flavoparmelia caperata (L.) Hale	FBL	ASEX+SEX	CHL	9.1 ± 0.47	10.76 ± 0.47	41.9 ± 2.8
Fuscidea stiriaca (A. Massal.) Hafellner	C	SEX	CHL			
Fuscopannaria leucosticta (Tuck.) P.M. Jørg.	SQ	SEX	CB			
Graphis elegans (Sm.) Ach.	C	SEX	TR			
Graphis scripta (L.) Ach.	C	SEX	TR			
Gyalecta carneola (Ach.) Hellb.	C	SEX	TR			
Heterodermia japonica (M. Satô) Swinscow & Krog	FNL	ASEX	CHL			
Heterodermia obscurata (Nyl.) Trevis.	FNL	ASEX+SEX	CHL			

Lichen species	Growth form	Reproductive strategy	Photobiont type	STM	WHC	C/N

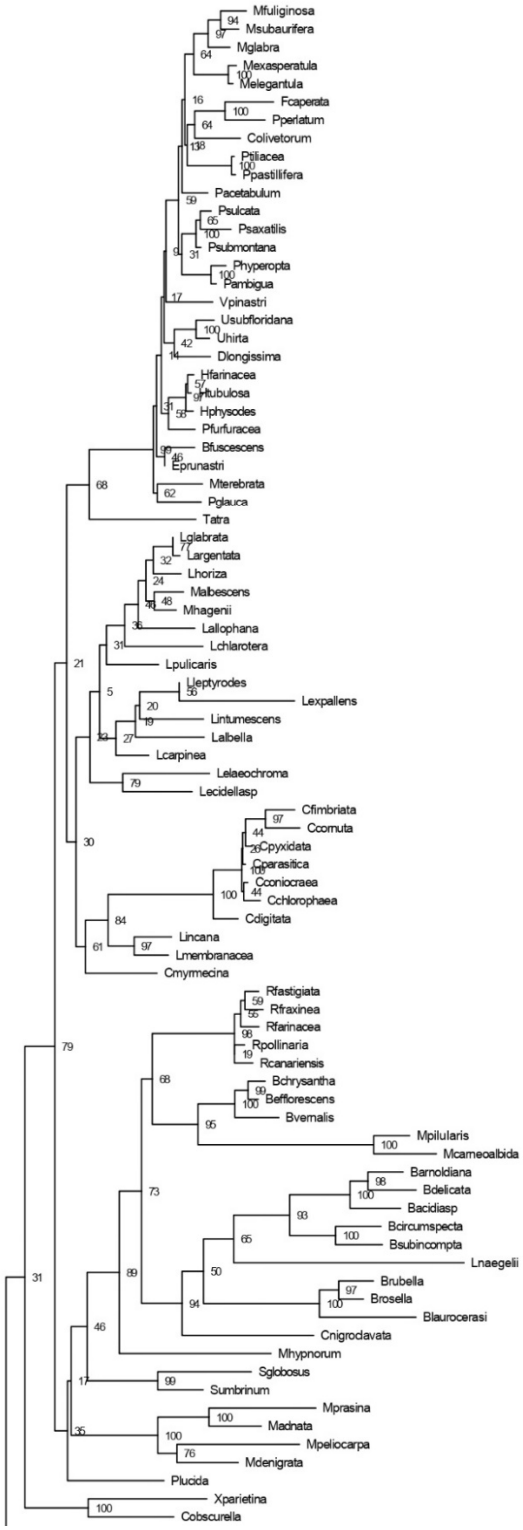
Heterodermia speciosa (Wulfen) Trevis.	FNL	ASEX+SEX	CHL	18.38 ± 3.08	23.28 ± 3.63	45.8 ± 4.2
Hyperphyscia adglutinata (Flörke) H. Mayrhofer & Poelt	FNL	ASEX+SEX	CHL			
Hypogymnia farinacea Zopf	FNL	ASEX+SEX	CHL			
Hypogymnia physodes (L.) Nyl.	FNL	ASEX+SEX	CHL	9.05 ± 0.35	16.59 ± 0.49	46.4 ± 1.9
Hypogymnia tubulosa (Schaer.) Hav.	FNL	ASEX+SEX	CHL			44.3 ± 2
Lecania naegelii (Hepp) Diederich & van den Boom	C	SEX	CHL			
Lecanora albella (Pers.) Ach.	C	SEX	CHL			
Lecanora allophana (Ach.) Nyl. f. *allophana*	C	SEX	CHL			
Lecanora argentata (Ach.) Malme	C	SEX	CHL			
Lecanora carpinea (L.) Vain.	C	SEX	CHL			
Lecanora chlarotera Nyl. subsp. *chlarotera*	C	SEX	CHL			
Lecanora expallens Ach.	C	ASEX+SEX	CHL			
Lecanora glabrata (Ach.) Nyl.	C	SEX	CHL			
Lecanora horiza (Ach.) Linds.	C	SEX	CHL			
Lecanora intumescens (Rebent.) Rabenh.	C	SEX	CHL			
Lecanora leptyrodes (Nyl.) Degel.	C	SEX	CHL			
Lecanora pulicaris (Pers.) Ach.	C	SEX	CHL			
Lecidella elaeochroma (Ach.) M. Choisy var. *elaeochroma* f. *elaeochroma*	C	SEX	CHL			
Lecidella sp.	C	SEX	CHL			
Lepra albescens (Huds.) Hafellner	C	ASEX	CHL			
Lepra amara (Ach.) Hafellner	C	ASEX	CHL			
Lepra multipuncta (Turner) Hafellner	C	ASEX+SEX	CHL			
Lepraria incana (L.) Ach.	L	ASEX	CHL			
Lepraria membranacea (Dicks.) Vain.	L	ASEX	CHL			
Leptogium saturninum (Dicks.) Nyl.	FBL	ASEX+SEX	CB	5.69 ± 0.28	27.12 ± 2.63	14.3 ± 4.5
Lobaria pulmonaria (L.) Hoffm.	FBL	ASEX+SEX	CHL	11.9 ± 0.3	20.84 ± 0.56	20.5 ± 0.4
Lobarina scrobiculata (Scop.) Nyl.	FBL	ASEX+SEX	CB	12.05 ± 0.47	24.01 ± 0.89	16.2 ± 0.2
Loxospora elatina (Ach.) A. Massal.	C	ASEX	CHL			
Melanelixia fuliginosa (Duby) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	FNL	ASEX	CHL	8.94 ± 0.33	15.42 ± 0.61	31.3 ± 1.5
Melanelixia glabra (Schaer.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	FBL	SEX	CHL	22.46	38.58	49.4 ± 3.2
Melanelixia subaurifera (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	FBL	ASEX+SEX	CHL	6.75 ± 0.57	13.36 ± 0.92	30.1 ± 2.2
Melanohalea elegantula (Zahlbr.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	FBL	ASEX+SEX	CHL			37.1 ± 1.3
Melanohalea exasperatula (Nyl.) O. Blanco, A. Crespo, Divakar, Essl., D. Hawksw. & Lumbsch	FBL	ASEX+SEX	CHL	6.55	14.17	21.8 ± 2.3
Menegazzia terebrata (Hoffm.) A. Massal.	FBL	ASEX+SEX	CHL	13.23 ± 0.64	24.65 ± 1.62	55.5 ± 3.9
Lichen species	Growth form	Reproductive strategy	Photobiont type	STM	WHC	C/N

Micarea adnata Coppins	C	SEX	CHL			
Micarea denigrata (Fr.) Hedl.	C	SEX	CHL			
Micarea peliocarpa (Anzi) Coppins & R. Sant.	C	SEX	CHL			
Micarea prasina Fr.	C	SEX	CHL			
Mycobilimbia carneoalbida (Müll. Arg.) S. Ekman & Printzen	C	SEX	CHL			
Mycobilimbia pilularis (Körb.) Hafellner & Türk	C	SEX	CHL			
Myriolecis albescens (Hoffm.) Sliwa, Zhao Xin & Lumbsch	C	SEX	CHL			
Myriolecis hagenii (Ach.) Sliwa, Zhao Xin & Lumbsch	C	SEX	CHL			
Nephroma laevigatum Ach.	FBL	SEX	CB	5.7 ± 0.21	12.96 ± 0.45	17.9 ± 2.5
Nephroma parile (Ach.) Ach.	FBL	ASEX+SEX	CB	6.39 ± 0.38	14.71 ± 0.71	11.7 ± 0.2
Nephroma resupinatum (L.) Ach.	FBL	SEX	CB	6.49 ± 0.18	18.03 ± 0.44	14.7 ± 1.8
Nevesia sampaiana (Tav.) P.M. Jørg., L. Lindblom, Wedin & S. Ekman	SQ	ASEX	CB			9.9 ± 0.1
Normandina pulchella (Borrer) Nyl.	SQ	ASEX+SEX	CHL			
Ochrolechia balcanica Verseghy	C	SEX	CHL			
Ochrolechia pallescens (L.) A. Massal.	C	SEX	CHL			
Ochrolechia subviridis (Høeg) Erichsen	C	ASEX	CHL			
Ochrolechia szatalaensis Verseghy	C	SEX	CHL			
Ochrolechia turneri (Sm.) Hasselrot	C	ASEX+SEX	CHL			
Opegrapha sp.	C	SEX	TR			
Opegrapha trochodes Coppins, F. Berger & Ertz	C	SEX	TR			
Opegrapha vermicellifera (Kunze) J.R. Laundon	C	SEX	TR			
Pannaria conoplea (Ach.) Bory	FNL	ASEX+SEX	CB			18.6 ± 5.7
Pannaria rubiginosa (Ach.) Bory	FNL	SEX	CB			
Pannaria tavaresii P.M. Jørg.	SQ	ASEX+SEX	CB			
Parmelia saxatilis (L.) Ach.	FBL	ASEX+SEX	CHL	13.54 ± 0.46	20.32 ± 0.76	41.4 ± 1.1
Parmelia submontana Hale	FBL	ASEX+SEX	CHL	8.0 ± 0.34	11.67 ± 0.43	37.4 ± 2.9
Parmelia sulcata Taylor	FBL	ASEX+SEX	CHL	10.93 ± 0.26	17.47 ± 0.47	45.8 ± 1.3
Parmeliella triptophylla (Ach.) Müll. Arg.	C	ASEX+SEX	CB			11.3 ± 0.7
Parmelina pastillifera (Harm.) Hale	FBL	ASEX+SEX	CHL	9.55 ± 0.44	14.34 ± 0.89	26.9 ± 4.5
Parmelina tiliacea (Hoffm.) Hale	FBL	ASEX+SEX	CHL	7.93 ± 0.24	12.96 ± 0.38	32 ± 1.4
Parmeliopsis ambigua (Hoffm.) Nyl.	FNL	ASEX+SEX	CHL			
Parmeliopsis hyperopta (Ach.) Arnold	FNL	ASEX+SEX	CHL			
Parmotrema perlatum (Huds.) M. Choisy	FBL	ASEX+SEX	CHL	6.17 ± 0.26	9.31 ± 0.29	41.7 ± 4.9
Lichen species	Growth form	Reproductive strategy	Photobiont type	STM	WHC	C/N

Pectenia plumbea (Lightf.) P.M. Jørg., L. Lindblom, Wedin & S. Ekman	FNL	SEX	CB	32.29 ± 4.24	116.9 ± 17.38	10 ± 0.6
Peltigera collina (Ach.) Schrad.	FBL	ASEX+SEX	CB	7.99 ± 0.3	21.58 ± 0.7	11.7 ± 0.2
Peltigera degenii Gyeln.	FBL	ASEX+SEX	CB			9.6 ± 0.3
Peltigera horizontalis (Huds.) Baumg.	FBL	SEX	CB	7.87 ± 0.26	23.33 ± 0.47	11.3 ± 0.3
Peltigera membranacea (Ach.) Nyl.	FBL	SEX	CB	10.42	27.1	10.6 ± 0.2
Peltigera praetextata (Sommerf.) Zopf	FBL	ASEX+SEX	CB	8.22 ± 0.25	22.59 ± 0.62	10.2 ± 0.1
Pertusaria coccodes (Ach.) Nyl.	C	ASEX+SEX	CHL			
Pertusaria coronata (Ach.) Th. Fr.	C	ASEX+SEX	CHL			
Pertusaria flavida (DC.) J.R. Laundon	C	ASEX	CHL			
Pertusaria hymenea (Ach.) Schaer.	C	SEX	CHL			
Pertusaria leioplaca (Ach.) DC.	C	SEX	CHL			
Pertusaria pertusa (L.) Tuck. var. *pertusa*	C	SEX	CHL			
Pertusaria pupillaris (Nyl.) Th. Fr.	C	ASEX+SEX	CHL			
Phaeographis lyellii (Sm.) Zahlbr.	C	SEX	TR			
Phaeophyscia endophoenicea (Harm.) Moberg	FNL	ASEX	CHL			
Phaeophyscia orbicularis (Neck.) Moberg	FNL	ASEX+SEX	CHL			
Phlyctis agelaea (Ach.) Flot.	C	ASEX+SEX	CHL			
Phlyctis argena (Spreng.) Flot.	C	ASEX+SEX	CHL			
Physcia adscendens H. Olivier	FNL	ASEX+SEX	CHL			
Physcia aipolia (Humb.) Fürnr.	FNL	SEX	CHL			
Physcia leptalea (Ach.) DC.	FNL	SEX	CHL			
Physcia tenella (Scop.) DC.	FNL	ASEX+SEX	CHL			
Physconia distorta (With.) J.R. Laundon	FNL	SEX	CHL	17.7 ± 0.9	27.69 ± 2.33	31.9 ± 0.9
Physconia perisidiosa (Erichsen) Moberg	FNL	ASEX+SEX	CHL	13.89 ± 2.62	29.22 ± 7.95	27.7 ± 1.6
Physconia venusta (Ach.) Poelt	FNL	SEX	CHL	16.78 ± 1.4	31.61 ± 3.96	27.9 ± 1.6
Platismatia glauca (L.) W.L. Culb. & C.F. Culb.	FBL	ASEX+SEX	CHL	7 ± 0.17	11.37 ± 0.3	47 ± 1.4
Pleurosticta acetabulum (Neck.) Elix & Lumbsch	FBL	SEX	CHL			40.1 ± 3.4
Porina aenea (Wallr.) Zahlbr.	C	SEX	TR			
Porina hibernica P. James & Swinscow	C	SEX	TR			
Protopannaria pezizoides (Weber) P.M. Jørg. & S. Ekman	C	SEX	CB			
Pseudevernia furfuracea (L.) Zopf var. *furfuracea*	FBL	ASEX+SEX	CHL	8.4 ± 0.4	14.44 ± 0.57	32.9 ± 1.4
Psilolechia lucida (Ach.) M. Choisy	L	SEX	CHL			
Psoroglaena stigonemoides (Orange) Henssen	C	ASEX+SEX	CHL			
Pyrenula macrospora (Degel.) Coppins & P. James	C	SEX	TR			
Lichen species	Growth form	Reproductive strategy	Photobiont type	STM	WHC	C/N
Pyrenula nitida (Weigel) Ach.	C	SEX	TR			

Pyrenula nitidella (Schaer.) Müll. Arg.	C	SEX	TR			
Pyrrhospora quernea (Dicks.) Körb.	C	ASEX+SEX	CHL			
Ramalina canariensis J. Steiner	FR	ASEX+SEX	CHL			
Ramalina farinacea (L.) Ach.	FR	ASEX+SEX	CHL	11.33 ± 0.37	15.43 ± 0.55	41.6 ± 1.9
Ramalina fastigiata (Pers.) Ach.	FR	SEX	CHL	12.49 ± 0.49	18.84 ± 0.74	39.9 ± 2.2
Ramalina fraxinea (L.) Ach.	FR	SEX	CHL	15.88 ± 1.66	26.35 ± 3.09	42.3 ± 2.4
Ramalina pollinaria (Westr.) Ach.	FR	ASEX+SEX	CHL			
Ricasolia amplissima (Scop.) De Not.	FBL	SEX	CHL	17.67 ± 0.59	29.63 ± 0.98	20.1 ± 0.6
Ricasolia virens (With.) H.H. Blom. & Tønsberg	FBL	SEX	CHL			17.2 ± 0.7
Rinodina colobina (Ach.) Th. Fr.	C	ASEX+SEX	CHL			
Rinodina griseosoralifera Coppins	C	ASEX+SEX	CHL			
Rinodina pyrina (Ach.) Arnold	C	SEX	CHL			
Scoliciosporum umbrinum (Ach.) Arnold	C	SEX	CHL			
Scytinium aragonii (Otálora) Otálora, P.M. Jørg. & Wedin	SQ	SEX	CB			
Scytinium lichenoides (L.) Otálora, P.M. Jørg. & Wedin	SQ	ASEX+SEX	CB			
Sorediate	C	ASEX	CHL			
Sphaerophorus globosus (Huds.) Vain.	FR	SEX	CHL			60.8 ± 4.7
Sticta limbata (Sm.) Ach.	FBL	ASEX+SEX	CB	7.77 ± 0.46	21.57 ± 1.81	10 ± 0.2
Tephromela atra (Huds.) Hafellner var. *atra*	C	SEX	CHL			
Thelenella muscorum (Th. Fr.) Vain. var. *muscorum*	C	SEX	CHL			
Thelopsis rubella Nyl.	C	SEX	TR			
Thelotrema lepadinum (Ach.) Ach.	C	SEX	TR			
Trapeliopsis flexuosa (Fr.) Coppins & P. James	C	ASEX	CHL			
Trapeliopsis gelatinosa (Flörke) Coppins & P. James	C	ASEX	CHL			
Usnea hirta (L.) F.H. Wigg.	FRF	ASEX+SEX	CHL			
Usnea longissima Ach.	FRF	ASEX+SEX	CHL			
Usnea subfloridana Stirt.	FRF	ASEX+SEX	CHL	12.06 ± 0.95	17.22 ± 1.32	34.8 ± 2
Varicellaria hemisphaerica (Flörke) I. Schmitt & Lumbsch	C	ASEX	CHL			
Vulpicida pinastri (Scop.) J.-E. Mattsson & M.J. Lai	FBL	ASEX+SEX	CHL			
Xanthoria parietina (L.) Th. Fr.	FBL	SEX	CHL			
Zwackhia viridis (Ach.) Poetsch & Schied.	C	SEX	TR			

Figure S1: Phylogenetic tree. Phylogenetic tree based on four molecular markers (nuITS, nuLSU, mtSSU and RPB1) including the lichen species found across Europe. Numbers above nodes denote the bootstrap support (ML-BS) obtained with Maximum Likelihood in RAxML. Species names can be found in Table S2.



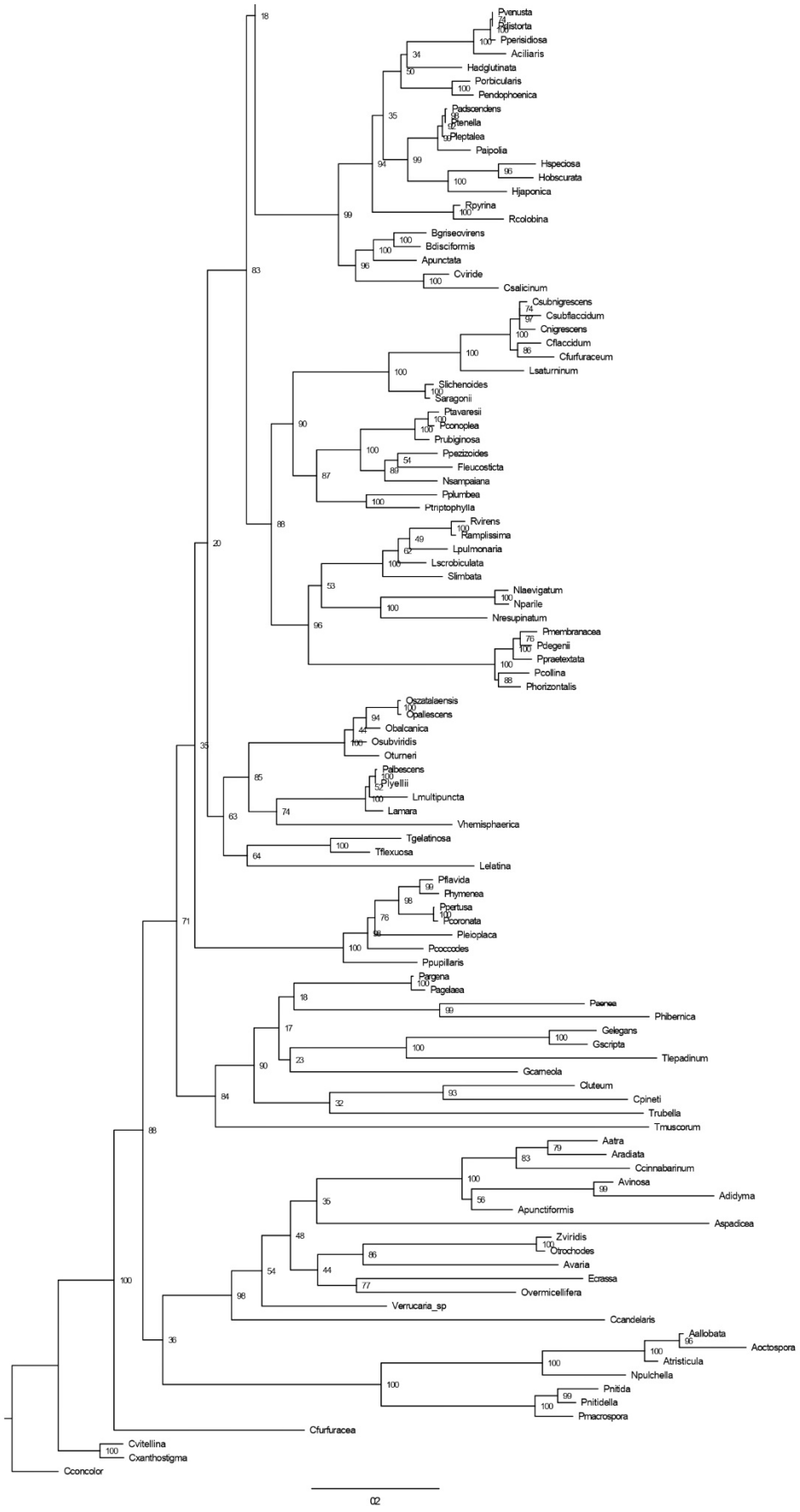

Pvenusta
Pdistorta
Pperisidiosa
Aciliaris
Hadglutinata
Porbicularis
Pendophoenica
Padscendens
Ptenella
Pleptalea
Paipolia
Hspeciosa
Hobscurata
Hjaponica
Rpyrina
Rcolobina
Bgriseovirens
Bdisciformis
Apunctata
Cviride
Csalicinum
Csubnigrescens
Csubflaccidum
Cnigrescens
Cflaccidum
Cfurfuraceum
Lsaturninum
Slichenoides
Saragonii
Ptavaresii
Pconoplea
Prubiginosa
Ppezizoides
Fleucosticta
Nsampaiana
Pplumbea
Ptriptophylla
Rvirens
Ramplissima
Lpulmonaria
Lscrobiculata
Slimbata
Nlaevigatum
Nparile
Nresupinatum
Pmembranacea
Pdegenii
Ppraetextata
Pcollina
Phorizontalis
Oszatalaensis
Opallescens
Obalcanica
Osubviridis
Oturneri
Palbescens
Plyellii
Lmultipuncta
Lamara
Vhemisphaerica
Tgelatinosa
Tflexuosa
Lelatina
Pflavida
Phymenea
Pportusa
Pcoronata
Pleioplaca
Pcoccodes
Ppupillaris
Pargena
Pagelaea
Paenea
Phibernica
Gelegans
Gscripta
Tlepadinum
Gcarneola
Cluteum
Cpineti
Trubella
Tmuscorum
Aatra
Aradiata
Ccinnabarinum
Avinosa
Adidyma
Apunctiformis
Aspadicea
Zviridis
Citrochodes
Avaria
Ecrassa
Overmicellifera
Verrucaria_sp
Ccandelaris
Aallobata
Acctospora
Atristicula
Npulchella
Pnitida
Pnitidella
Pmacrospora
Cfurfuracea
Cvitellina
Cxanthostigma
Cconcolor
02

Table S3: Phylogenetic signal. Phylogenetic signal of the three categorical (growth form, photobiont type and reproductive strategy) and three quantitative traits studied (specific thallus mass, STM; water-holding capacity, WHC; and carbon-nitrogen ratio C/N).

	Trait	Nº of levels	Observed transitions	Median null model (p-value)	Pagel's Lambda (λ)
Qualitative	Growth form	7	29	86***	-
	Photobiont type	3	10	51***	-
	Reproductive strategy	3	49	75***	-
Quantitative	STM	-	-	-	0.95
	WHC	-	-	-	0.80
	C/N				0.87

No. of levels: number of categories for a given categorical trait; Observed transitions: number of observed evolutionary transitions; Median Null Model: median of expected evolutionary transitions under a null model in which the tips of the phylogeny were randomised 1,000 times; p-value based on the comparison of observed and expected evolutionary transitions (***$p < 0.001$).

Supplementary 4: Diversity metrics

Regarding the functional characterization of the epiphytic communities, we used individual species trait data to calculate two indices at community level: community weighted mean (hereafter 'CWM') and Rao's quadratic entropy index (hereafter 'Rao'). These two indices inform about different components of functional diversity: while CWM reflects the dominant traits in a community, Rao is a multivariate form of the functional variance [1]. As an indicator of functional composition, we calculated the CWM index of every qualitative trait for each of the forests studied using the *functcomp* function implemented in the *FD* package [2]. This index was computed as the mean trait value of each species in a community, weighted by the relative abundance of this species [3]. The larger the relative abundance of one species, the more important contribution of its individual trait value to the global community average. For qualitative traits, the CWM reflects the percentage of a given category of the trait in a community. As an indicator of functional variance, we calculated a Rao index considering multiple qualitative and quantitative traits together (i.e. growth form, photobiont type, reproductive strategy, STM, WHC and C/N). First, we calculated the species dissimilarity matrix using Gower distances and giving more weight to quantitative traits (w = 1) than qualitative traits (w = 0.5) since the latter usually show higher values of dissimilarity. Dissimilarity distances (d_{ij}) closer to 0 denote that species are functionally equivalent, while d_{ij} values closer to 1 reflect higher dissimilarity between species [4]. Then, using the trait dissimilarity distances between each pair of coexisting species (d_{ij}) and the relative abundance of these species in a given forest (p_i and p_j), we computed the Rao index at forest level with the function *Rao* [1]:

$$FD_{Rao} = \sum_{i=1}^{S} \cdot \sum_{j=1}^{S} \cdot p_i p_j d_{ij}$$

We finally applied the Jost correction [5] to express the index in equivalent numbers. Higher values of Rao index denote higher community functional diversity in a given forest. Some of the advantages of this metric are the combination of functional richness and functional divergence [6], and the quantification of species dissimilarity including the relative abundance of species [1].

Since Rao allows the measurement of species dissimilarity based on functional and phylogenetic data, it is a useful metric to compare these different diversity facets (i.e. FD and PD) [1]. Hence, we calculated a Rao index combining the species relative abundance with the phylogenetic tree as metric of PD. In this case, we used the function *cophenetic* implemented in the *picante* package [7], to compute the phylogenetic distance between pairs of coexisting species (*dij*).

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Figure S2: Relationships among TD, FD, and PD. Scatterplots representing the relation between different diversity metrics for the 23 beech forests surveyed across Europe. 1) taxonomic diversity, TD (Shannon and Inverse Simpson) and functional diversity, FD (Rao); 2) phylogenetic diversity, PD (Rao) and FD (Rao); and 3) evenness (Shannon/ln(richness)) and FD (Rao).

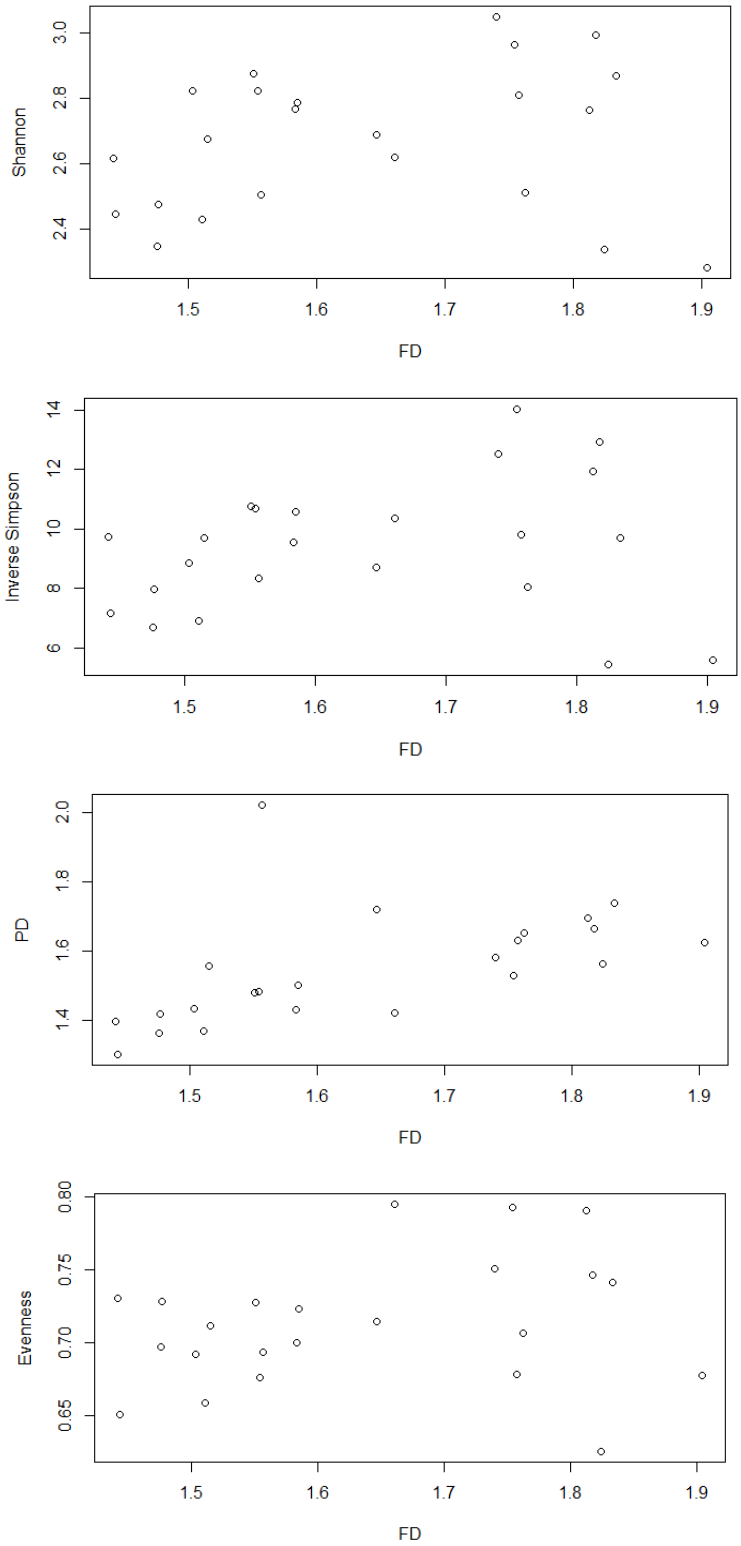

Table S4: Ranking of linear models of species richness, Shannon, Inverse Simpson, Rao FD (multitrait) and Rao PD following an AIC-based model selection procedure (ΔAICc ≤ 2). For each community diversity metric, the best model (i.e. lowest AICc value) is presented in the first row followed by the rest of models with ΔAICc ≤ 2. Columns represent environmental predictors related to forest structure (DBH) and climate (temperature and precipitation). Grey cells indicate environmental predictors included in a particular model. R^2, percentage of variance explained by a particular model; AICc, relative goodness of fit; ΔAICc, AIC differences; wi, Akaike weight; I_P, Moran index p-value. Abbreviations: TD, taxonomic diversity; FD, functional diversity; PD, phylogenetic diversity; DBH, tree diameter at breast height; BIO2, Annual Mean Diurnal Range; BIO5, Max Temperature of the Warmest Month; BIO6, Min Temperature of the Coldest Month; BIO8, Mean Temperature of the Wettest Quarter; BIO13, Precipitation of the Wettest Month; BIO14, Precipitation of the Driest Month.

		ENVIRONMENTAL PREDICTORS										
		DBH	Temperature				Precipitation		R^2	AIC_c	ΔAIC_c	w_i	I_p
			BIO2	BIO5	BIO6	BIO8	BIO13	BIO14					
TD	Richness				■	■	■		0.59	168.2	0	0.67	0.82
					■	■	■	■	0.63	169.6	1.45	0.33	0.68
	Shannon						■		0.22	-3.7	0	0.38	0.61
				■			■		0.29	-2.8	0.9	0.24	0.96
					■		■		0.28	-2.6	1.08	0.22	0.73
							■	■	0.26	-1.9	1.79	0.15	0.78
	Inverse Simpson						■		0.13	105.6	0	0.46	0.57
				■			■		0.17	107.4	1.80	0.19	0.37
FD	Rao functional		■						0.27	-24.1	0	1	0.07
PD	Rao phylogenetic		■		■				0.25	-16.2	0	0.15	0.30
		■	■						0.24	-16.2	0.02	0.15	0.41
			■						0.14	-16.1	0.09	0.15	0.06
		■							0.13	-15.9	0.32	0.13	0.14
		■	■		■				0.33	-15.8	0.34	0.13	0.78
		■		■					0.21	-15.1	1.10	0.09	0.21
				■					0.09	-14.8	1.34	0.08	0.02*

Figure S3: Variation partitioning Venn diagram for Inverse Simpson. Variation partitioning Venn diagram representing the percentages of unique and shared contribution of climate (precipitation of the wettest month) and functional diversity (FD) to $TD_{Inverse\ Simpson}$ variation. The intersection represents the amount (%) of explained variation shared by different explanatory variables. Residuals represent the % of unexplained variation.