

**Supplementary material for the manuscript:** Valerio, M.; Ibáñez, R.; Gazol, A. The Role of Canopy Cover Dynamics over a Decade of Changes in the Understory of an Atlantic Beech-Oak forest. *Forests* **2021**.

**Table S1.** Results of the Pearson's correlation testing for relationships between the abundance of one of the most frequent species in the understory in 2006 and the abundance of the same species in 2016.

Species	Correlation	p value
<i>Deschampsia flexuosa</i>	0.8478048	$<2.20 \times 10^{-16}***$
<i>Pteridium aquilinum</i>	0.8786237	$<2.20 \times 10^{-16}***$
<i>Hypericum androsaemum</i>	0.7124534	$<2.20 \times 10^{-16}***$
<i>Erica vagans</i>	0.8391238	$<2.20 \times 10^{-16}***$
<i>Calluna vulgaris</i>	0.6411106	$3.92 \times 10^{-13}***$
<i>Hedera helix</i>	0.4841942	$2.52 \times 10^{-7}***$
<i>Fagus sylvatica</i>	0.6175451	$4.74 \times 10^{-12}***$
<i>Ilex aquifolium</i>	0.6230402	$2.70 \times 10^{-12}***$
<i>Quercus robur</i>	0.4098876	$1.88 \times 10^{-5}***$

Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1.

**Table S2.** List of species present in the understory of the Bertiz Forest over the two years studied, together with their values for the five functional traits measured (LDMC: leaf dry matter content; SLA: specific leaf area; LS: leaf size; plant height; SM: seed mass).

Species	Family	LDMC (mg/g)	SLA (mm <sup>2</sup> /mg)	LS (mm <sup>2</sup> )	Plant height (cm)	SM (mg) (TRY)
<i>Agrostis capillaris</i> L.	Gramineae	179.391	26.323	70.960	19.200	0.154
<i>Agrostis curtisii</i>	Gramineae	247.582	17.257	42.560	21.313	0.078
Kerguélen						
<i>Ajuga reptans</i> L.	Labiatae	-	-	-	-	1.322
<i>Anemone nemorosa</i> L.	Ranunculaceae	-	-	-	-	2.576
<i>Arum</i> sp.	Araceae	-	-	-	-	-
<i>Asphodelus albus</i> Miller subsp. <i>albus</i>	Liliaceae	130.554	13.216	4556.975	46.000	8.314
<i>Asplenium trichomanes</i> L.	Aspleniaceae	-	-	-	-	-
<i>Athyrium filix-femina</i> (L.) Roth	Athyriaceae	173.905	44.606	27454.086	30.280	-
<i>Betula pubescens</i> Ehrh.	Betulaceae	-	-	-	-	0.235
<i>Blechnum spicant</i> (L.) Roth subsp. <i>spicant</i>	Blechnaceae	291.370	11.756	7838.095	20.840	-
<i>Brachypodium sylvaticum</i> Beauv. subsp. <i>sylvaticum</i>	Gramineae	278.409	18.844	367.505	30.920	2.588
<i>Calluna vulgaris</i> (L.) Hull	Ericaceae	406.071	24.268	4.002	44.760	0.168
<i>Campanula patula</i> L. subsp. <i>patula</i>	Campanulaceae	-	-	-	-	0.025
<i>Cardamine flexuosa</i> With.	Cruciferae	158.012	30.207	85.855	10.480	0.124
<i>Cardamine pratensis</i> L. subsp. <i>pratensis</i>	Cruciferae	157.052	23.969	233.335	12.640	0.852
<i>Carex pilulifera</i> L. subsp. <i>pilulifera</i>	Cyperaceae	282.734	26.200	260.305	18.720	1.425

<i>Carex remota</i> L.	<i>Cyperaceae</i>	218.120	24.771	374.790	29.520	0.406
<i>Carex sylvatica</i> Hudson subsp. <i>sylvatica</i>	<i>Cyperaceae</i>	290.222	20.747	680.125	25.468	1.522
<i>Chrysosplenium</i> <i>oppositifolium</i> L.	<i>Saxifragaceae</i>	124.983	29.839	103.560	6.520	0.050
<i>Circaea lutetiana</i> L.	<i>Onagraceae</i>	121.479	73.999	803.590	7.312	2.132
<i>Clematis vitalba</i> L.	<i>Ranunculaceae</i>	-	-	-	-	2.634
<i>Crataegus monogyna</i> Jacq.	<i>Rosaceae</i>	-	-	-	-	117.214
<i>Crepis capillaris</i> (L.) Wallr.	<i>Compositae</i>	-	-	-	-	0.204
<i>Cytisus scoparius</i> (L.) Link subsp. <i>scoparius</i>	<i>Leguminosae</i>	191.873	33.109	155.935	43.320	8.166
<i>Daboezia cantabrica</i> (Huds.) K. Koch	<i>Ericaceae</i>	377.122	17.648	55.790	28.160	0.13
<i>Danthonia decumbens</i> (L.) DC. in Lam. & DC.	<i>Gramineae</i>	-	-	-	-	1.897
<i>Daphne laureola</i> L.	<i>Thymelaeaceae</i>	340.701	8.309	869.695	64.600	35.6
<i>Deschampsia flexuosa</i> (L.) Trin.	<i>Gramineae</i>	246.190	18.881	80.185	14.680	0.472
<i>Digitalis purpurea</i> L. subsp. <i>purpurea</i>	<i>Scrophulariaceae</i>	100.711	34.084	9435.900	42.960	0.089
<i>Dryopteris affinis</i> (Lowe) Fraser-Jenk. subsp. <i>affinis</i>	<i>Aspidiaceae</i>	184.815	27.170	58271.860	61.320	-
<i>Dryopteris dilatata</i> (Hoffm.) A. Gray	<i>Aspidiaceae</i>	-	-	-	-	-
<i>Epilobium parviflorum</i> Schreb.	<i>Onagraceae</i>	-	-	-	-	0.082
<i>Epilobium tetragonum</i> L. subsp. <i>tetragonum</i>	<i>Onagraceae</i>	-	-	-	-	0.098
<i>Epipactis</i> sp.	<i>Orchidaceae</i>					
<i>Erica cinerea</i> L.	<i>Ericaceae</i>	376.223	16.205	4.988	42.680	0.079
<i>Erica vagans</i> L.	<i>Ericaceae</i>	236.645	18.165	4.955	33.280	0.047
<i>Eupatorium cannabinum</i> L.	<i>Compositae</i>					0.571
<i>Euphorbia amygdaloides</i> L. subsp. <i>amygdaloides</i>	<i>Euphorbiaceae</i>	222.270	29.785	393.655	19.360	3.543
<i>Euphorbia dulcis</i> L.	<i>Euphorbiaceae</i>	194.955	50.135	179.690	9.760	2.120
<i>Fagus sylvatica</i> L.	<i>Fagaceae</i>	404.368	33.217	2164.625	135.772	185.73
<i>Festuca rubra</i> L. subsp. <i>rubra</i>	<i>Gramineae</i>	233.848	21.253	70.290	8.400	0.992
<i>Fraxinus excelsior</i> L.	<i>Oleaceae</i>	-	-	-	-	58.746
<i>Galium</i> sp.	<i>Rubiaceae</i>	-	-	-	-	-
<i>Geranium robertianum</i> L.	<i>Geraniaceae</i>	-	-	-	-	1.296
<i>Hedera helix</i> L. subsp. <i>helix</i>	<i>Araliaceae</i>	303.731	13.269	987.635	6.064	35.117
<i>Helleborus viridis</i> L. subsp. <i>occidentalis</i> (Reut.) Schiffn.	<i>Ranunculaceae</i>	188.005	16.168	15534.275	16.640	-
<i>Hepatica nobilis</i> Schreb.	<i>Ranunculaceae</i>	-	-	-	-	2.721
<i>Holcus lanatus</i> L.	<i>Gramineae</i>	-	-	-	-	0.367

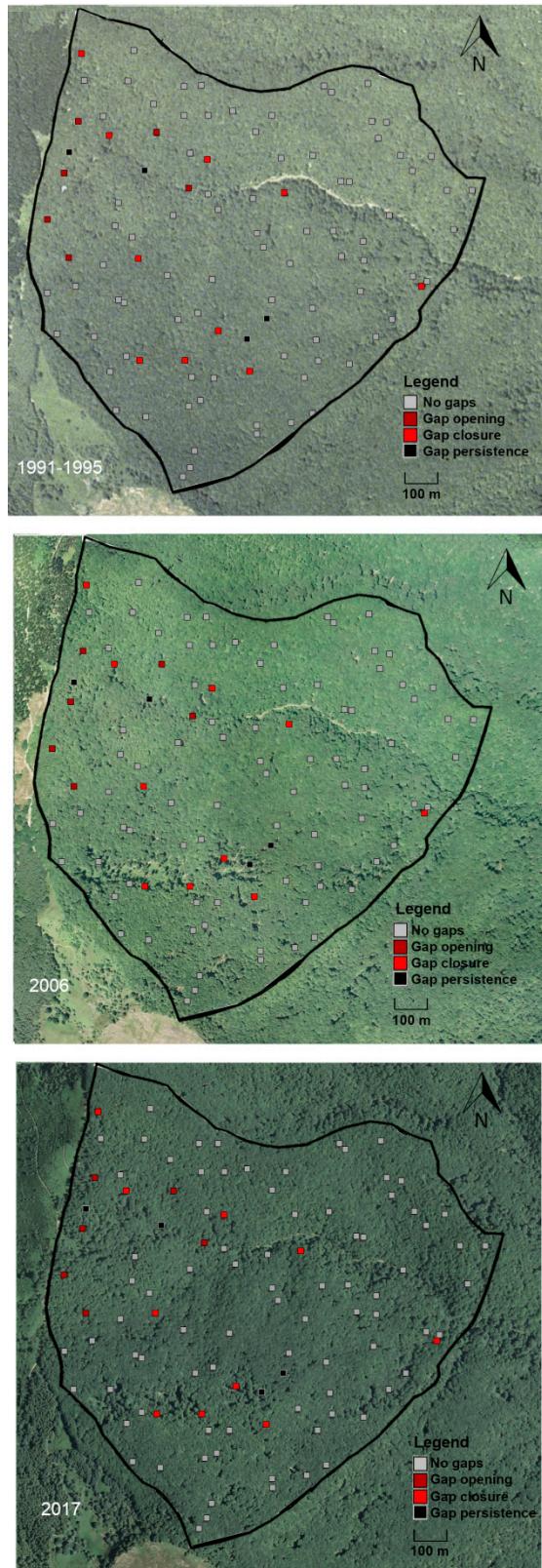
<i>Hypericum androsaemum</i> L.	<i>Guttiferae</i>	229.178	33.471	2628.750	42.640	0.071
<i>Hypericum pulchrum</i> L.	<i>Guttiferae</i>	237.582	31.383	98.865	25.000	0.087
<i>Ilex aquifolium</i> L.	<i>Aquifoliaceae</i>	440.952	5.796	1535.455	704.318	41.250
<i>Juncus gr. effusus</i> ( <i>Juncus</i> <i>conglomeratus</i> L.; <i>Juncus</i> <i>effusus</i> L.)	<i>Juncaceae</i>	227.293	7.164	0.000	60.92	-
<i>Lathraea clandestina</i> L.	<i>Scrophulariaceae</i>	-	-	-	-	-
<i>Lathyrus linifolius</i> (Reichard) Bässler	<i>Leguminosae</i>	257.255	26.445	535.935	13.280	13.022
<i>Lotus</i> sp.	<i>Leguminosae</i>	171.958	42.432	163.260	7.264	-
<i>Luzula multiflora</i> (Retz.)	<i>Juncaceae</i>	188.374	25.004	334.790	12.040	0.797
<i>Lej.</i> subsp. <i>multiflora</i>						
<i>Luzula sylvatica</i> (Hudson) Gaudin subsp. <i>henriquesii</i> (Degen) P.	<i>Juncaceae</i>	222.159	24.865	2297.305	28.32	-
<i>Silva</i>						
<i>Lysimachia nemorum</i> L.	<i>Primulaceae</i>	160.379	46.547	219.580	6.368	0.403
<i>Moehringia trinervia</i> (L.)	<i>Caryophyllaceae</i>	229.177	32.982	70.430	9.411	0.204
<i>Clairv.</i>						
<i>Monotropa hypopitys</i> L.	<i>Monotropaceae</i>	-	-	-	-	0.002
<i>Oxalis acetosella</i> L.	<i>Oxalidaceae</i>	94.143	69.980	528.920	8.960	1.167
<i>Phyllitis scolopendrium</i> (L.) Newman subsp. <i>scolopendrium</i>	<i>Aspleniaceae</i>	-	-	-	-	-
<i>Picris hieracioides</i> L.	<i>Compositae</i>	-	-	-	-	0.833
<i>Pilosella</i> sp.	<i>Compositae</i>	-	-	-	-	-
<i>Polypodium</i> sp.	<i>Polypodiaceae</i>	-	-	-	-	-
<i>Polystichum setiferum</i> (Forssk.) Woyn.	<i>Aspidiaceae</i>	220.200	20.602	42181.605	47.160	-
<i>Potentilla sterilis</i> (L.)	<i>Rosaceae</i>	227.928	20.448	477.505	6.936	0.528
<i>Garcke</i>						
<i>Primula acaulis</i> (L.) L.	<i>Primulaceae</i>	115.127	38.070	3288.700	6.996	0.822
<i>subsp. acaulis</i>						
<i>Pseudarrhenatherum</i> <i>longifolium</i> (Thore) Rouy	<i>Gramineae</i>					
<i>Pteridium aquilinum</i> (L.)	<i>Hypolepidaceae</i>	256.218	15.802	178280.247	38.320	-
<i>Kuhn</i> subsp. <i>aquilinum</i>						
<i>Quercus robur</i> L.	<i>Fagaceae</i>	354.131	29.465	1357.850	17.360	2969.234
<i>Ranunculus tuberosus</i>	<i>Ranunculaceae</i>	149.947	21.339	838.840	16.560	-
<i>Lapeyr.</i>						
<i>Rubia peregrina</i> L.	<i>Rubiaceae</i>	-	-	-	-	26.478
<i>Rubus</i> sp. pl.	<i>Rosaceae</i>	412.496	13.944	3957.950	36.080	
<i>Ruscus aculeatus</i> L.	<i>Liliaceae</i>	442.071	6.604	0.000	36.960	196.655
<i>Salix atrocinerea</i> Brot.	<i>Salicaceae</i>					
<i>Saxifraga hirsuta</i> L.	<i>Saxifragaceae</i>	115.268	27.526	616.530	6.640	-
<i>subsp. hirsuta</i>						
<i>Scilla lilio-hyacinthus</i> L.	<i>Liliaceae</i>	65.225	35.198	2390.360	12.480	-
<i>Scrophularia alpestris</i> Gay ex Bentham	<i>Scrophulariaceae</i>	130.971	31.761	3003.775	24.844	-
<i>Solanum dulcamara</i> L.	<i>Solanaceae</i>	146.356	46.044	721.495	36.000	31.518

<i>Solidago virgaurea</i> L.	<i>Compositae</i>	180.077	29.177	1783.475	13.468	0.787
<i>Sonchus asper</i> (L.) Hill	<i>Compositae</i>	-	-	-	-	0.277
<i>Sonchus oleraceus</i> L.	<i>Compositae</i>	-	-	-	-	0.303
<i>Sorbus aria</i> (L.) Crantz	<i>Rosaceae</i>	-	-	-	-	84.384
<i>Sorbus torminalis</i> (L.) Crantz	<i>Rosaceae</i>	-	-	-	-	98.828
<i>Stellaria media</i> (L.) Vill.	<i>Caryophyllaceae</i>	-	-	-	-	0.393
<i>Taraxacum</i> gr. <i>officinale</i> Weber	<i>Compositae</i>	307.939	45.294	1519.825	8.788	-
<i>Teucrium scorodonia</i> L.	<i>Labiatae</i>	161.820	57.268	828.790	22.500	1.040
<i>Ulex gallii</i> Planch. subsp. <i>gallii</i>	<i>Leguminosae</i>	491.385	2.818	0.000	127.800	6.287
<i>Urtica dioica</i> L.	<i>Urticaceae</i>	-	-	-	-	0.188
<i>Vaccinium myrtillus</i> L.	<i>Ericaceae</i>	300.668	32.283	150.690	12.080	0.403
<i>Verbascum</i> sp.	<i>Scrophulariaceae</i>					
<i>Veronica chamaedrys</i> L. subsp. <i>chamaedrys</i>	<i>Scrophulariaceae</i>	162.791	45.620	124.665	6.120	0.220
<i>Veronica montana</i> L.	<i>Scrophulariaceae</i>	161.806	47.509	262.065	9.480	0.420
<i>Veronica officinalis</i> L.	<i>Scrophulariaceae</i>	245.452	22.641	69.000	4.740	0.240
<i>Veronica serpyllifolia</i> L.	<i>Scrophulariaceae</i>	-	-	-	-	0.053
<i>Vicia sepium</i> L.	<i>Leguminosae</i>	-	-	-	-	20.577
<i>Viola riviniana</i> Rchb.	<i>Violaceae</i>	175.743	29.742	430.820	6.680	1.640
<i>Wahlenbergia hederacea</i> (L.) Rchb.	<i>Campanulaceae</i>	-	-	-	-	0.026

**Figure S1.** Picture of a plot with closed canopy (A) and a plot with a large canopy gap in which there are remains of dead trees (B).



**Figure S2.** Aerial photographs of the study site showing the distribution of the plots studied (squares) and the condition of the canopy layer at three different periods of time: 1991-1995, when the whole basin was covered by a closed canopy; 2006, the first year of study, in which the largest gaps can be detected; and 2017, after revisiting the plots in 2016. Plots are classified in four categories: no gaps (plots closed both in 2006 and 2016), gap opening (plots closed in 2006 but opened in 2016), gap closure (plots opened in 2006 but closed in 2016) and gap persistence (plots opened both in 2006 and 2016).

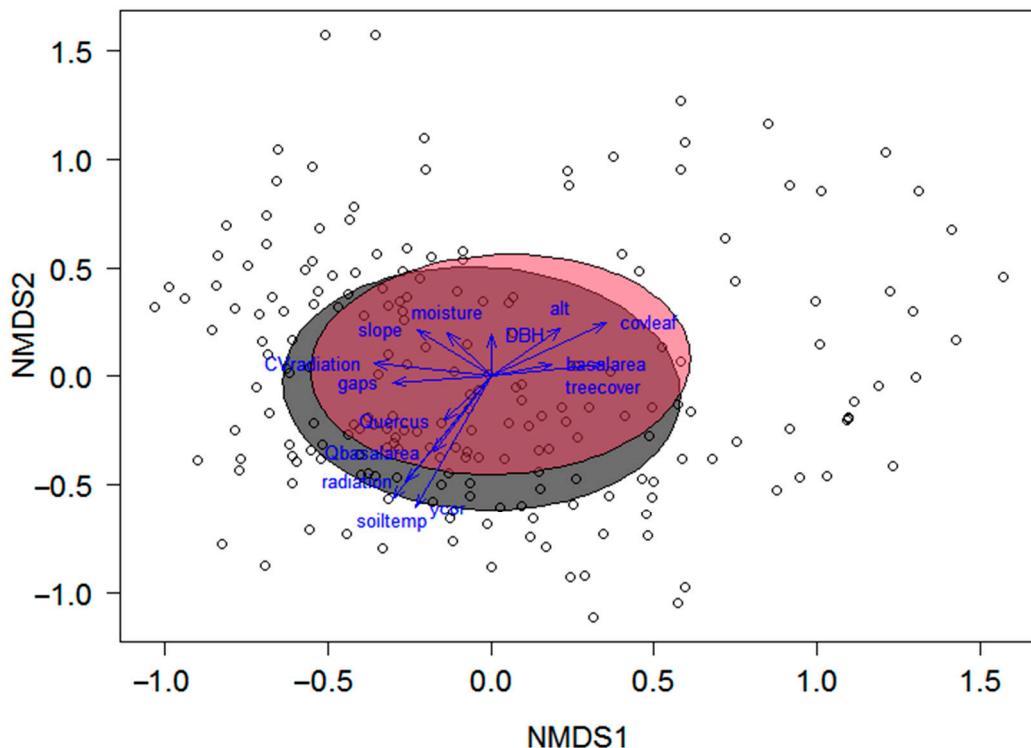


**Table S3.** Environmental variables studied, with the mean and range of values measured in the 102 plots in the Bertiz forest.

Variable	Mean	Range
x-coor (UTM)	-	610740-612080
y-coor (UTM)	-	4778907-4780267
Altitude (m.a.s.l.)	396	262-635
Slope (sexagesimal degrees)	22	2-42
Soil temperature (°C)	12.23	10.30-13.43
Soil moisture (%vol)	35.23	25.60-43.91
CV soil moisture	0.22	0.09-0.37
Leaf litter cover (%)	73.84	10-99
Radiation (Indirect Solar Factor)	0.15	0.03-0.61
CV radiation	0.24	0.01-0.99
Diameter at Breast Height (cm)	40.79	7.53-80.06
Basal area ( $m^2 ha^{-1}$ )	49.33	5.99-118.83
<i>Quercus</i> basal area (%)	15.02	0-96.95

**Table S4.** Datasets used via the TRY database.

Dataset ID	Dataset	Reference
4	BiolFlor Database	Kühn <i>et al.</i> 2004
21	KEW Seed Information Database (SID)	Royal Botanical Gardens KEW 2008
25	The LEDA Traitbase	Kleyer <i>et al.</i> 2008
27	BROT Plant Trait Database	Paula <i>et al.</i> 2009
28	Global Seed Mass, Plant Height Database	Moles <i>et al.</i> 2004
37	Sheffield Database	Cornelissen <i>et al.</i> 1996
50	Leaf and Whole Plant Traits Database	Unpublished
68	The Functional Ecology of Trees (FET) Database - Jena	Wirth & Lichstein 2009
80	French Massif Central Grassland Trait Database	Louault <i>et al.</i> 2005
86	Sheffield-Iran-Spain Database	Díaz <i>et al.</i> 2004
92	PLANTSdata USDA	Green 2009
98	New South Wales Plant Traits Database	Unpublished
119	Seed Information Database (SID) Seed Mass 2010	Royal Botanical Gardens KEW 2014
171	Seed Characteristics of <i>Ericaceae</i>	Fagundez & Izco 2008
174	Ecological Flora of the British Isles	Fitter & Peat 1994
202	Traits from the Wildfire Project	Moretti & Legg 2009
245	Ecotron Species Composition and Global Change Experiment	Manning <i>et al.</i> 2009
270	Plant Traits of Acidic Grasslands in Central Spain	Peco <i>et al.</i> 2005
272	Plant Coastal Dune Traits (France, Aquitaine)	Unpublished
285	Functional traits explaining variation in plant life history strategies	Adler <i>et al.</i> 2014
301	Specific leaf area responses to environmental gradients through space and time	Dwyer <i>et al.</i> 2014
347	Traits of 59 grassland species	Schroeder-Georgi <i>et al.</i> 2016
419	Sherbrooke	Li & Shipley 2018
435	Functional Resilience of Temperate Forests Dataset	Liebergesell <i>et al.</i> 2016
439	Functional Traits of Trees	Paine <i>et al.</i> 2015



**Figure S3.** NMDS plot showing significant correlations between the first two axes of the ordination and environmental variables (altitude, leaf litter cover, basal area, tree layer cover, y coordinates, soil temperature, radiation and its CV, *Quercus* basal area, abundance of *Quercus* saplings, presence of gaps, slope, soil moisture and Diameter at Breast Height). Arrow length and direction indicate the strength and sign of the correlation, respectively. The two ellipses represent the hull of plots in 2006 (grey ellipse) and 2016 (red ellipse). Circles represent relevé plots in the Bertiz forest.

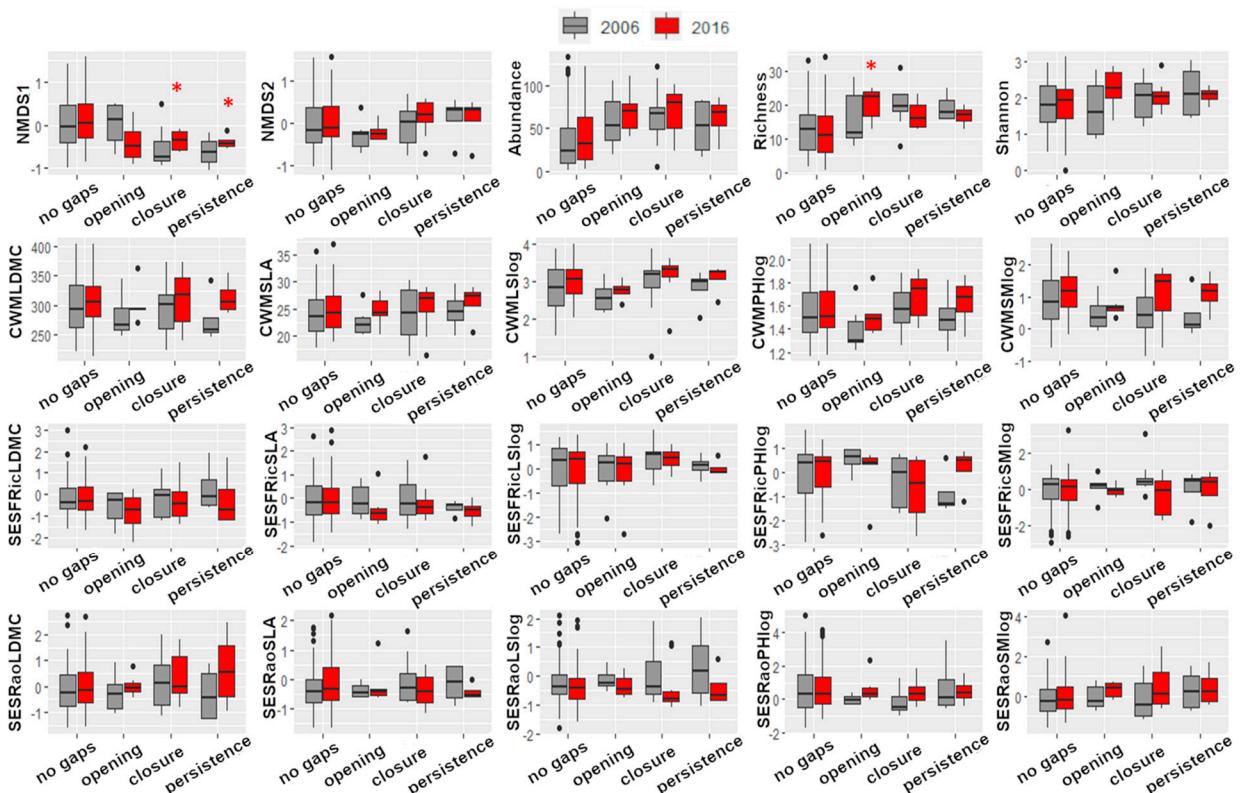
**Table S5.** Pearson's correlation values between the two ordination axes and the environmental variables studied, and their p values. Significant correlations ( $p < 0.05$ ) are marked in bold.

Variable	NMDS1		NMDS2	
	Correlation	p value	Correlation	p value
xcor	-0.0932	0.185	0.0738	0.294
ycor	<b>-0.2313</b>	<b>0.001</b>	<b>-0.6073</b>	<b><math>5.965 \times 10^{-22}</math></b>
Altitude	<b>0.2139</b>	<b>0.002</b>	<b>0.2211</b>	<b>0.001</b>
Slope	<b>-0.2281</b>	<b>0.001</b>	<b>0.2152</b>	<b>0.002</b>
Soil temperature	<b>-0.3016</b>	<b><math>1.168 \times 10^{-5}</math></b>	<b>-0.5675</b>	<b><math>8.734 \times 10^{-19}</math></b>
Soil moisture	-0.1343	0.056	<b>0.2010</b>	<b>0.004</b>
CV soil moisture	-0.0967	0.169	0.0021	0.977
Leaf litter cover	<b>0.3543</b>	<b><math>2.010 \times 10^{-7}</math></b>	<b>0.2493</b>	<b>0.0003</b>
Radiation	<b>-0.2604</b>	<b>0.0002</b>	<b>-0.4860</b>	<b><math>1.731 \times 10^{-13}</math></b>
CV radiation	<b>-0.3570</b>	<b><math>1.588 \times 10^{-7}</math></b>	0.0604	0.391
Diameter at Breast Height	0.0015	0.983	<b>0.1936</b>	<b>0.006</b>
Basal area	<b>0.1883</b>	<b>0.007</b>	0.0555	0.430
<i>Quercus</i> basal area	<b>-0.1762</b>	<b>0.012</b>	<b>-0.3490</b>	<b><math>3.117 \times 10^{-7}</math></b>
<i>Quercus</i> saplings abundance	<b>-0.1440</b>	<b>0.040</b>	<b>-0.2030</b>	<b>0.004</b>
<i>Fagus</i> saplings abundance	-0.1257	0.073	0.0816	0.246
Presence/absence of gaps	<b>-0.3014</b>	<b><math>1.183 \times 10^{-5}</math></b>	-0.0282	0.689
Tree layer cover	<b>0.3422</b>	<b><math>5.454 \times 10^{-7}</math></b>	0.0551	0.434

**Table S6.** Results of the *t*-test showing differences in environmental variables between plots without and with gaps. Significant differences ( $p < 0.05$ ) are marked in bold.

Variable	Mean difference	p value
Soil temperature	0.49	0.142
Soil moisture	22.57	0.197
CV soil moisture	0.03	0.378
Leaf litter cover	<b>-0.32</b>	<b>0.021*</b>
Radiation	<b>0.10</b>	<b>0.007**</b>
CV radiation	0.15	0.358
<i>Quercus</i> saplings abundance	-	0.054
<i>Fagus</i> saplings abundance	-	0.318

Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1.



**Figure S4.** Boxplots showing understory taxonomical and functional composition and diversity in each plot category (no gaps, gap opening, gap closure and gap persistence) and in each year studied (2006 and 2016) in the Bertiz forest. Red asterisks signal significant differences found at the end of the decade between plots with gap opening, closure or gap persistence and plots without gaps.