The following supplement accompanies the article

Assessing the vulnerability of blanket peat to climate change using an ensemble of statistical bioclimatic envelope models

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CONTENTS

1. EVAPOTRANSPIRATION EQUATIONS

1.1. Modified Thornthwaite Equation (Thornthwaite 1948, Mather 1978)

$$\mathrm{PET} = 16\left(\frac{N}{12}\right)\left(\frac{10\mathrm{T_a}}{\mathrm{HI}}\right)^m \qquad \text{(S1)}$$

where PET is the potential evapotranspiration (mm mo^{-1}), T_a is the mean monthly temperature (°C), defined here as the mean of daily maximum and minimum temperature (Allen et al. 1998). PET was taken to be zero when T_a <0°C). HI is the annual heat index, m is a parameter based on HI, and Nd is the mean number of daylight hours (Allen et al. 1998):

$$\mathrm{HI} = \sum_{i=1}^{12}\left(\frac{\mathrm{T}_{ai}}{5}\right)^{1.514} \qquad \text{(S2)}$$

$$m = 6.7\times10^{-7}[\mathrm{HI}]^3 - 7.7\times10^{-5}[\mathrm{HI}]^2 + 1.8\times10^{-2}[\mathrm{HI}] + 0.49 \qquad \text{(S3)}$$

$$Nd = \frac{24}{\pi}\left(\arccos\left[-\tan(L)\tan\left(0.409\sin\left[\frac{2\pi}{365}J - 1.39\right]\right)\right]\right) \quad \text{(S4)}$$

where J is the day of the year and L is the latitude (radians).

1.2. Priestly-Taylor Equation (Priestly & Taylor 1972)

$$\mathrm{PE}_0 = \alpha\left(\frac{1}{2}\right)\left(\frac{\Delta[R_\mathrm{n} - G]}{\Delta + \gamma}\right) \quad \text{(S5)}$$

where, PE_0 is the potential evapotranspiration (mm d^{-1}), α is the Priestley-Taylor coefficient (taken as 1.26 here), λ is the latent heat of vaporisation (2.45 MJ kg^{-1}), Δ is the slope of the vapour pressure curve, γ is the psychrometric constant (kPa °C^{-1}), G is the soil heat flux (assumed to be 0 MJ m^{-2} d^{-1}), R_n is the net surface radiation (MJ m^{-2} d^{-1}). R_n, Δ and γ can be calculated as (Allen et al. 1998):

$$R_\mathrm{n} = R_{ns} - R_{nl} \quad \text{(S6)}$$

$$R_{ns} = (1 - A)R_s \quad \text{(S7)}$$

$$R_s = \left(\mathrm{a}_s + \mathrm{b}_s\frac{n}{N}\right)R_a \quad \text{(S8)}$$

$$R_a = \frac{24(60)}{\pi}0.0820\left(1 + 0.033\cos\left(\frac{2\pi}{365}J\right)\right)[\omega_s\sin(L)\sin(\delta) + \cos(\varphi)\cos(\delta)\sin(\omega_s)] \quad \text{(S9)}$$

$$\omega_s = \arccos(-\tan(L)\tan(\partial)) \quad \text{(S10)}$$

$$\partial = 0.409\sin\left(\frac{2\pi}{365}J - 1.39\right) \quad \text{(S11)}$$

$$R_{nl} = 4.903E-9\left[\frac{(\mathrm{T}_{\max} + 273.3)^4 + (\mathrm{T}_{\min} + 273.3)^4}{2}\right]\left(0.34 - 0.14\sqrt{e_\mathrm{a}}\right)\left(1.35\frac{R_s}{R_{so}} - 0.35\right) \quad \text{(S12)}$$

$$e_\mathrm{a} = 0.6108\exp\left[\frac{17.2\mathrm{T}_{\min}}{\mathrm{T}_{\min} + 237.3}\right] \quad \text{(S13)}$$

$$R_{so} = (\mathrm{a}_s + \mathrm{b}_s)R_a \quad \text{(S14)}$$

$$\Delta = \frac{4098\left[0.6108\exp\left(\frac{17.2T}{T + 237.3}\right)\right]}{(T + 237.3)^2} \quad \text{(S15)}$$

$$\gamma = \frac{c_p P}{\epsilon\lambda} \quad \text{(S16)}$$

$$P = 101.3\left(\frac{293 - 0.0065a}{293}\right)^{5.26} \quad \text{(S17)}$$

where A is the albedo (assumed to be 0.23), a_s and b_s are Ångström values (0.25 and 0.5, respectively), n is the actual duration of sunshine hours (hr), e_a is the actual vapour pressure (kPa) estimated from $\mathrm{T}_{\min}$, T is the mean daily temperature (calculated from the mean of the maximum ($\mathrm{T}_{\max}$) and minimum daily temperature ($\mathrm{T}_{\min}$) °C), a is altitude (m).

1.3. Hargreaves Equation (Hargreaves et al. 1985, Allen et al. 1998)

$$\mathrm{PE}_0 = 0.0023(T + 17.8)(\mathrm{T}_{\max} - \mathrm{T}_{\min})^{0.5}(0.408R_a) \quad \text{(S18)}$$

2. BIOCLIMATIC ENVELOPE MODELS

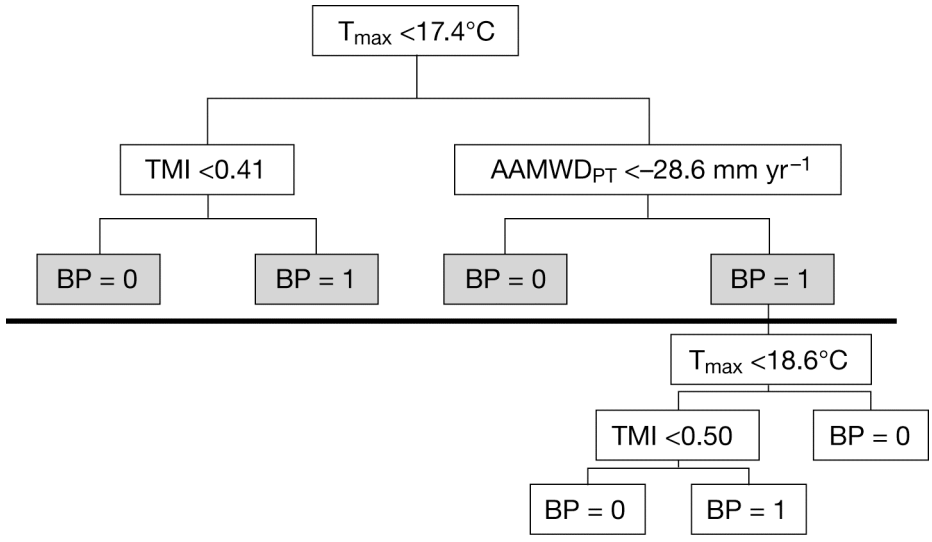

Fig. S1. Classification tree of blanket peat presence (BBOG-TREE). Climate variables defined in Table 2 in the main paper. Tmax: mean maximum monthly temperature; TMI: Thornthwaite-Mather moisture index; AAMWDPT: annual accumulated monthly water deficit calculated using the Priestley-Taylor PET mode; BP: blanket peat presence (1) or absence (0). Black line: point at which the tree was stopped for the BBOG-TREE model used in the main paper

3. 'LD50' FOR BLANKET PEAT BIOCLIMATIC SPACE

Table S1. 'LD50' for climate change required to reduce the area cover by the envelope model to 50% of the mapped area of blanket peat presence (5 km). NB: not all BCEM have 100% cover using the 1961–1990 baseline climate data

BCEM	1961–1990 blanket peat cover by BCEM				'LD50'							
					Precipitation change (%)				Temperature change (°C)			
	GB	W	E	S	GB	W	E	S	GB	W	E	S
P50	67	82	52	69	-13	-26	-2	-15	-	-	-	-
P65-PT	82	81	61	85	-22	-25	-7	-26	8.2	9.3	2.1	9.7
LM	89	88	81	90	-30	-40	-20	-32	2.2	1.6	1.5	2.5
H-GLM	95	87	97	99	-	-	-	-	1.8	1.3	1.8	2.0
BBOG	95	91	95	97	-30	-33	-24	-32	11.0	12.5	8.3	12
BBOG-TREE	90	82	82	92	-32	-36	-21	-35	8.3	9.7	5.9	9.1
BBOG-GLM	95	85	86	97	-46	-45	-31	-50	2.0	1.7	1.1	2.3
BBOG-GAM	95	81	86	97	-43	-43	-31	-45	1.9	1.4	1.2	2.2

4. BLANKET PEAT CLIMATIC VULNERABILITY

4.1. Model threshold values

Table S2. Bioclimatic model threshold values covering certain quantiles of blanket peat distribution in Great Britain. Models are described in Table 1 in the main paper. NB: whole data set used. q = 0.001-0.05 shows blanket peat at the lower limit of the bioclimatic envelope. The table allows independent assessment of specific grid cells using the 1961–1990 baseline climate data available from http://www.metoffice.gov.uk/climatechange/science/monitoring/ukcp09/index.html

Blanket peat cover	**Bioclimatic envelope model**				
	BBOG	**BBOG-GLM**	**BBOG-GAM**	**LM-GLM**	**L-GLM**
(quantile)	(mm yr^{-1})	P(BP)			
<0.001	-73.4	0.02	0.02	0.02	0.03
<0.05	-44.9	0.27	0.27	0.25	0.23
<0.10	-33.2	0.42	0.43	0.40	0.39
<0.25	-15.4	0.65	0.69	0.62	0.67
<0.50	0.00	0.87	0.88	0.87	0.91
<0.75	0.00	0.97	0.97	0.99	0.98
1.00	0.00	1.00	1.00	1.00	1.00

Blanket peat climatic vulnerability by region

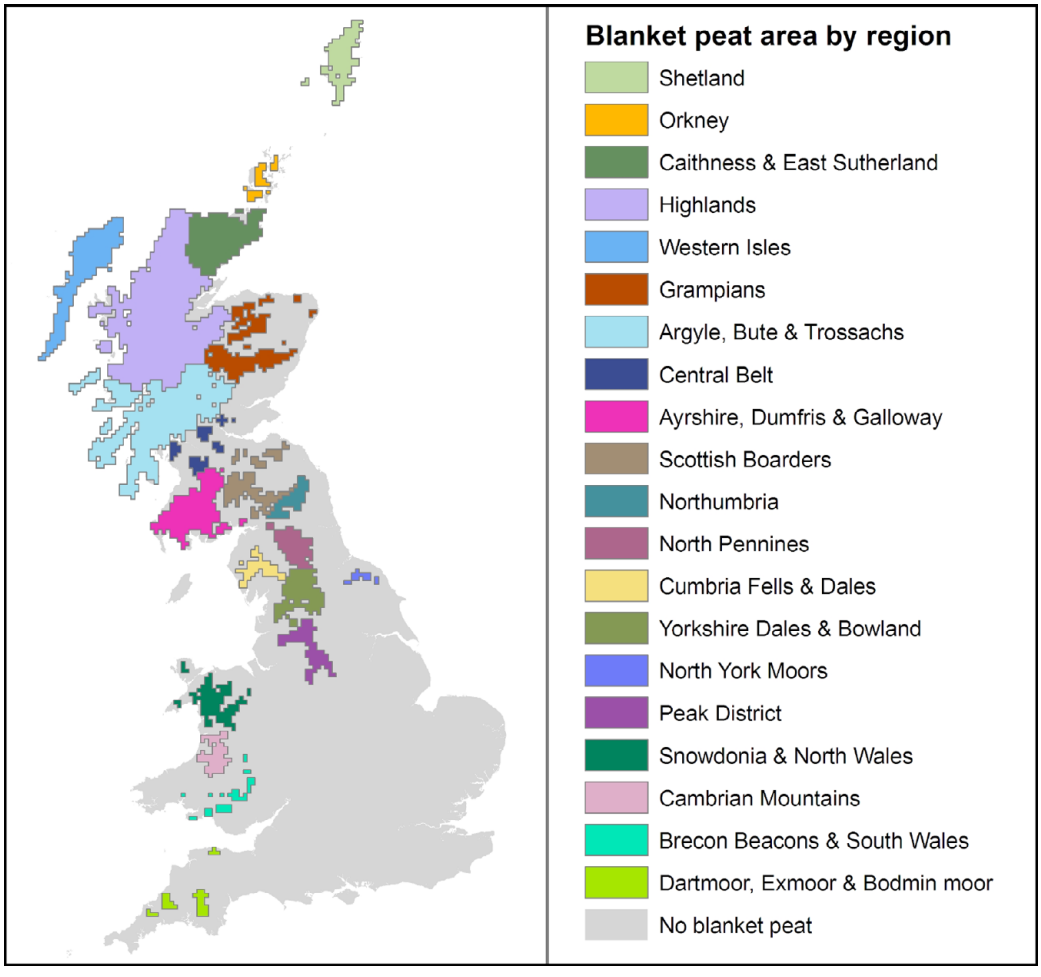

Fig. S2. Blanket peat area by region based on 5 km gridded data of blanket peat presence. NB: area covering Caitheness & East Surtherland includes all RAMSAR sites (www.jncc.gov.uk)

5. BLANKET PEAT REGIONS AND SUMMARY STATISTICS

Table S3. Summary of blanket peat area and baseline climate (1961–1990) for each region shown in Fig. S2. T: mean annual temperature; Tm: maximum mean monthly temperature; T_{max}: mean maximum monthly temperature. BBOG-TREE is described in main article and shown in Fig. S1. AW (annual wetness): areas classified by TMI; SW (seasonal wetness): areas classified by AAMWD; n/c: areas not classified with blanket peat present using BBOG-TREE

	Area				Example classification (% of mapped area)			Climate (mean value, 1961–1990)				
Country and Region	**Total 5km grid**		**Mapped blanket peat**		**BBOG-TREE**			**Rain**	**Raindays**	**T**	**T_m**	**T_{max}**
	(No. cells)	**(km^2)**	**(km^2)**	**(% of total)**	**(AW)**	**(SW)**	**(n/c)**	**(mm yr^{-1})**	**(d yr^{-1})**		**(°C)**	
Scotland												
Shetland	100	2500	648	4.1	80.0	0	20	1165	197	7.1	12.0	14.8
Orkney	29	725	115	0.7	65.5	0	34.5	1028	187	7.6	12.5	15.3
Caithness & East Sutherland	216	5400	1903	12.0	71.8	3.2	25	1119	189	6.8	12.4	16.2
Highlands	774	19350	3995	25.2	87.0	5.6	7.5	1886	214	6.6	12.0	15.3
Western Isles	197	4925	1366	8.6	82.2	0	17.8	1504	219	8.0	12.6	15.3
Grampians	165	4125	718	4.5	74.5	3.6	21.8	1102	175	5.4	11.4	15.3
Argyle, Bute & Trossachs	506	12650	2142	13.5	79.2	15.2	5.5	1840	200	7.3	12.6	16.1
Central Belt	44	1100	238	1.5	68.2	29.5	2.3	1494	182	7.2	13.0	16.8
Ayrshire, Dumfris & Galloway	181	4525	1118	7.1	60.2	34.8	5.0	1476	179	7.4	13.1	17.1
Scottish Borders	98	2450	238	2.0	65.3	18.4	16.3	1280	173	6.4	12.4	16.5
England												
Northumbia	49	1225	325	2.1	63.3	12.2	24.5	924	148	7.3	13.5	17.6
North Pennines	72	1800	691	4.5	72.2	9.7	18.1	1122	173	6.3	12.4	16.3
Cumbria Fells & Dales	44	1100	182	1.2	79.5	20.5	0	2070	189	6.8	12.7	16.5
Yorkshire Dales & Bowland	105	2625	765	4.8	65.7	23.8	10.5	1390	175	6.9	13.0	16.8
North York Moors	13	325	40	0.3	23.1	7.7	69.2	1064	165	6.4	12.5	16.7
Peak District	73	1825	476	3.0	46.6	45.2	8.2	1287	173	7.5	13.7	17.4
Dartmoor, Exmoor & Bodmin moor	37	925	146	0.9	21.6	73.0	5.4	1714	175	8.6	14.4	18.1
Wales												
Snowdonia & North Wales	86	2150	393	2.5	58.1	30.2	11.6	1881	188	7.6	13.3	17.0
Cambrian Mountains	49	1225	209	1.3	61.2	34.7	4.1	1614	187	7.4	13.3	17.2
Brecon Beacons & South Wales	30	750	52	0.3	36.7	43.3	20.0	1618	172	8.1	14.2	18.1
Total	2868	71700	15830	100	74.6	13.6	11.8	1584	195	7.0	12.5	16.0

6. CHANGE IN EACH OF THE 8 BCEM IN THE ENSEMBLE UNDER UKCIP02 HIGH EMISSIONS

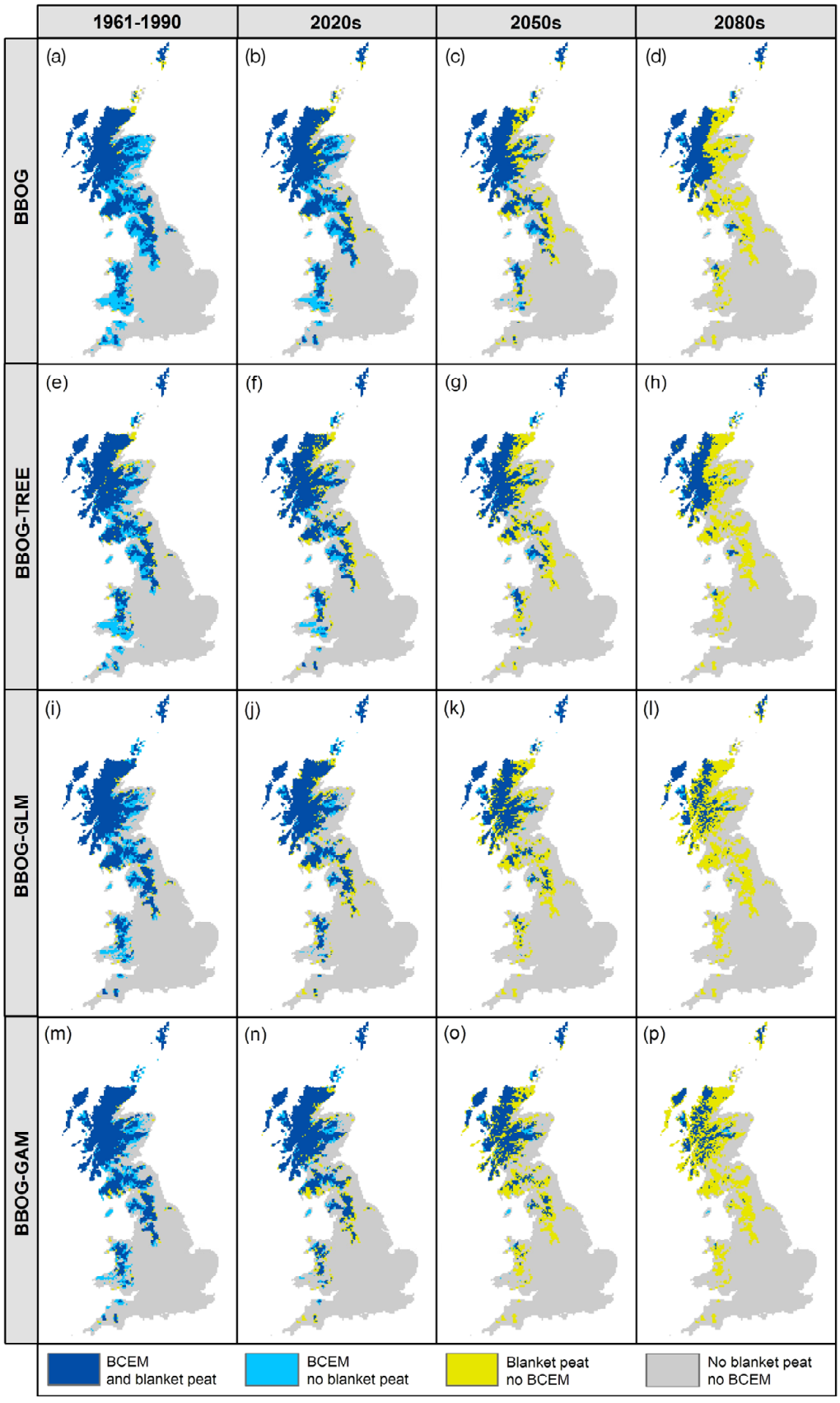

Fig. S3. Change in bioclimatic space for (a–d) BBOG, (e–h) BBOG-TREE, (i–l) BBOG-GLM, (m–p) BBOG-GAM, under the UKCIP02 high emission scenario, for the 2020s, 2050s and 2080s

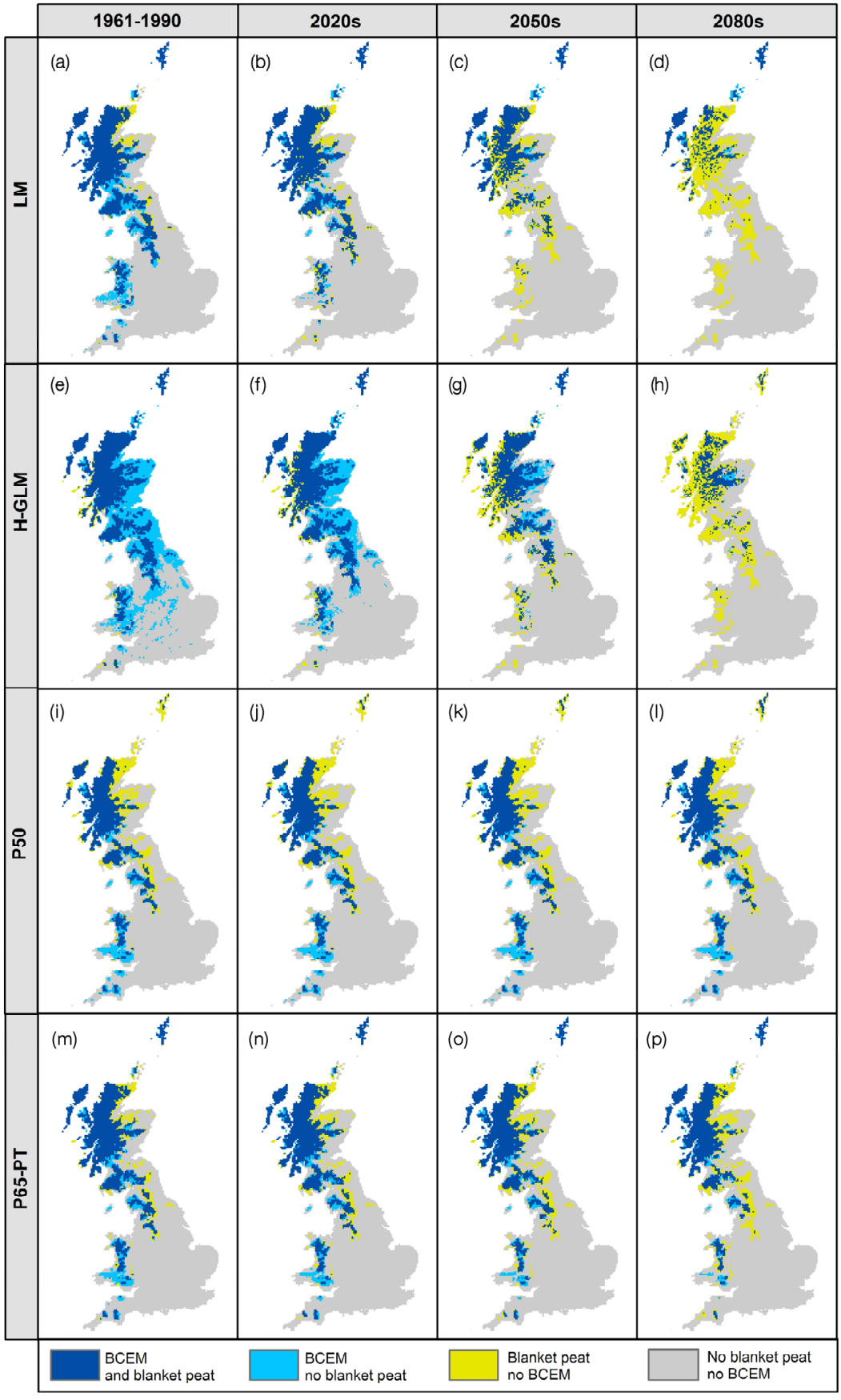

Fig. S4. Change in bioclimatic space for (a–d) LM, (e–h) H-GLM, (i–l) P50, (m–p) P65-PT, under UKCIP02 high emission scenario, for the 2020s, 2050s and 2080s