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Broadleaf afforestation impacts on terrestrial hydrology insignificant compared to climate change in Great Britain

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This supplementary material includes six figures, four tables and an equation.

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Supplementary Figures

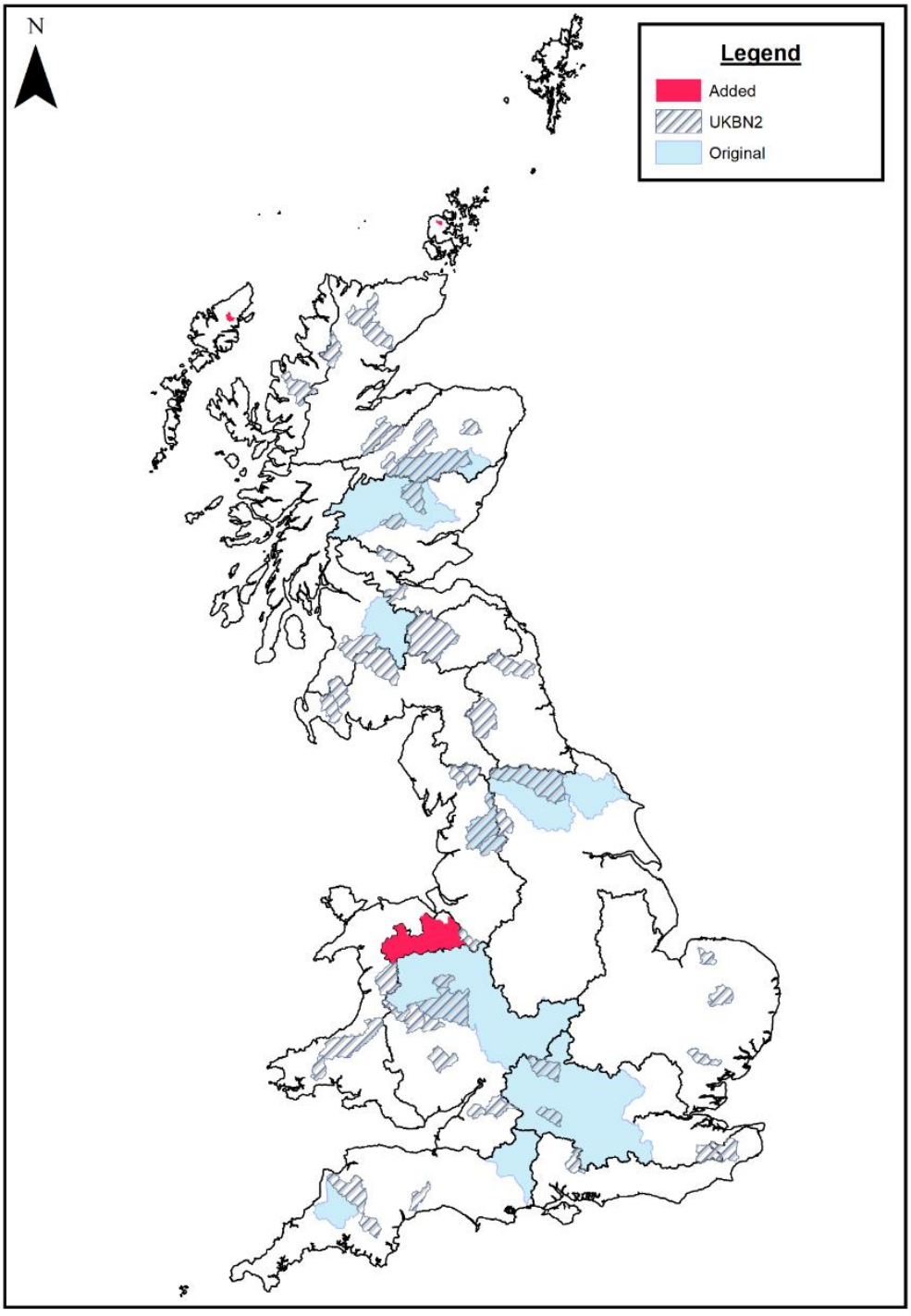

Figure S1: Map of the 51 catchments used to study streamflow changes to afforestation and climate. They include the original catchments studied in Buechel et al. (2022), near-natural catchments over 150 km2 from the UKBN2 network and the catchment for the Dee and regions in Scottish hydro-regions where there were no catchments from the initial selection.

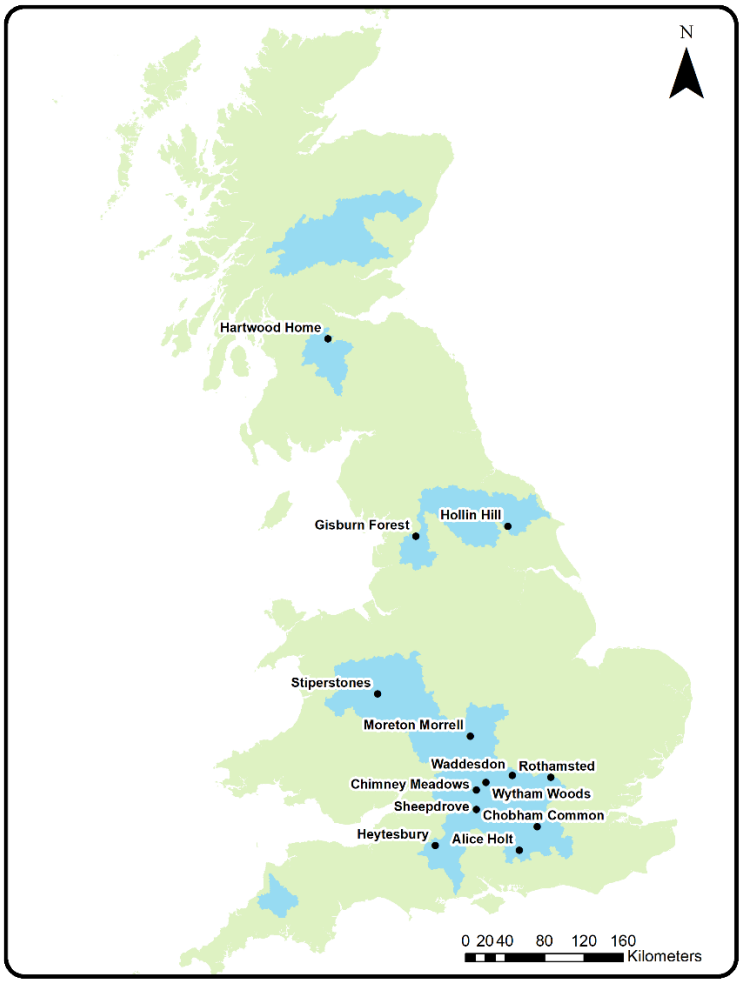

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Figure S2. Location of the COSMOS-UK sites used to validate model outputs.

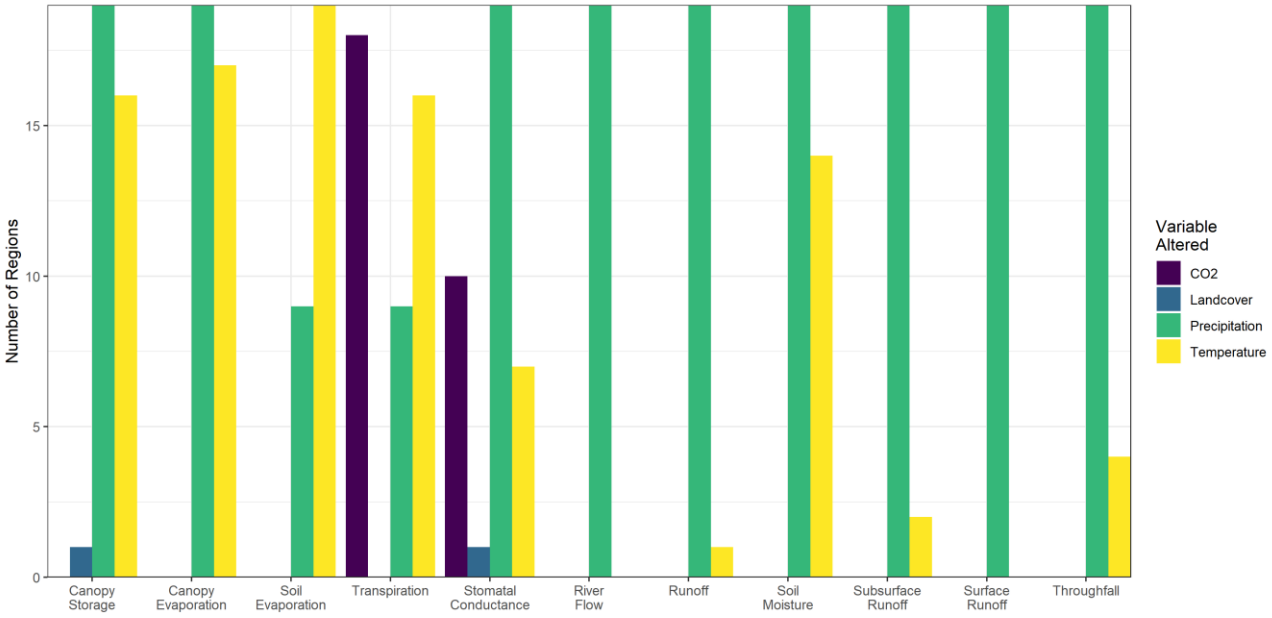

Figure S3: Number of UKCP18 regions that show significant changes ($p < 0.01$ with ANOVA) in the system states (on the x axis), for the entire period for the four variables altered: CO_2, afforestation (landcover), precipitation and temperature. Only in the Orkney and Shetland region are significant changes seen due to afforestation. Figure S4 shows how this varies per season. Northeast Scotland not included due to computational issues.

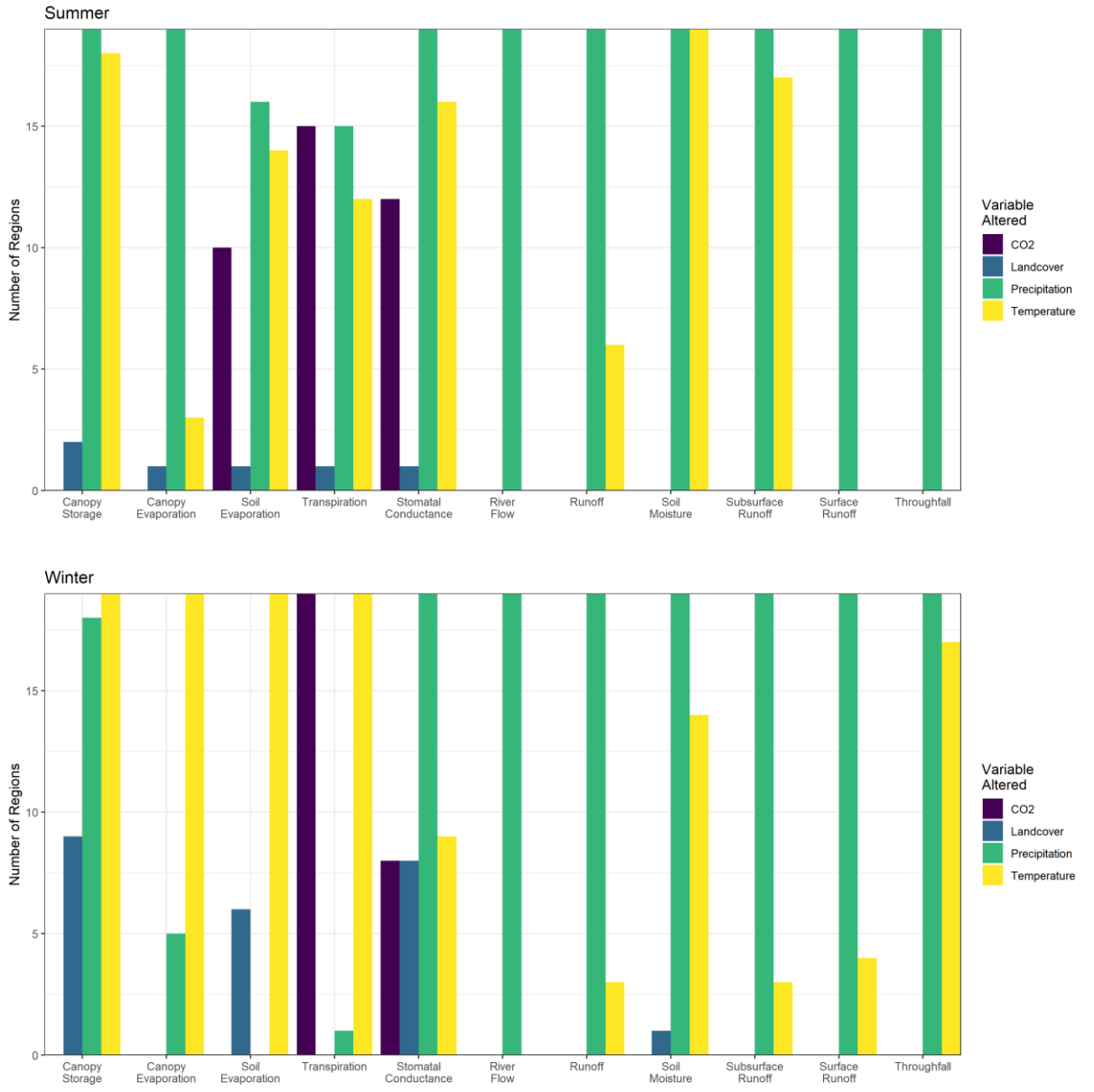

Figure S4: Number of UKCP18 regions that show significant changes ($p < 0.01$ with ANOVA) in the system states (on the x axis), for the entire period for the four variables altered: CO_2, afforestation (landcover), precipitation and temperature. The graphs are for winter and summer. Northeast Scotland not included due to computational issues.

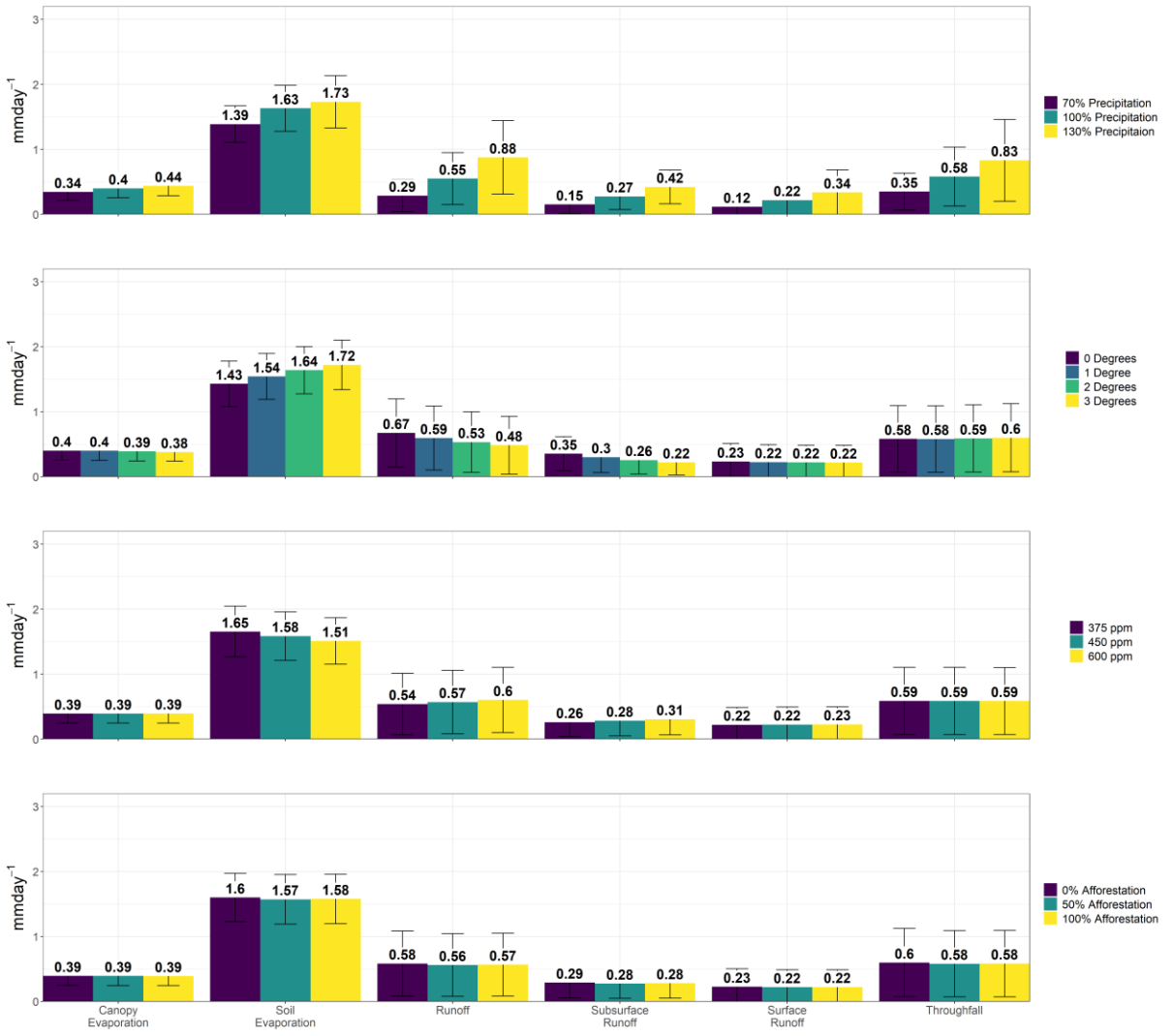

Figure S5: Mean hydrological fluxes across all UKCP18 regions in <u>summer</u> for each of the four variables altered: precipitation, temperature, CO2 and landcover. Error bars indicate one standard deviation.

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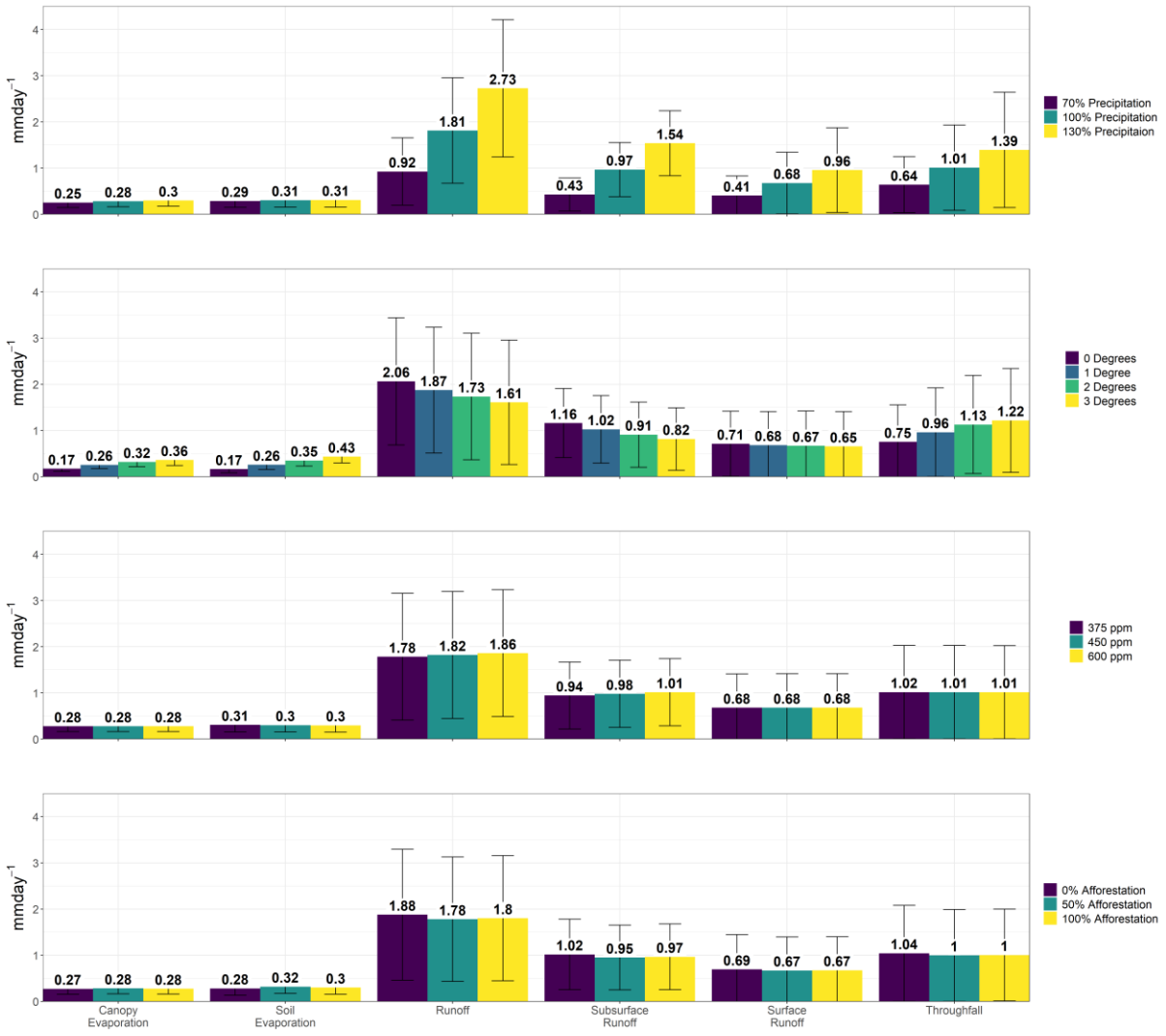

Figure S6: Mean hydrological fluxes across all UKCP18 regions in <u>winter</u> for each of the four variables altered: precipitation, temperature, CO_2 and landcover. Error bars indicate one standard deviation.

Supplementary Tables

Table S1: Error metrics for the 51 catchments in this study for the period 2000-2015.

Station	NSE	KGE	R^2
2002	0.36	0.43	0.39
7001	0.14	0.21	0.20
8004	0.06	0.28	0.19
8009	0.18	0.37	0.26
8013	0.10	0.40	0.26
11004	-0.11	0.47	0.39
12002	0.23	0.38	0.27
15006	0.48	0.68	0.53
17005	0.20	0.15	0.34
18001	0.41	0.48	0.48
21006	0.44	0.60	0.45
22001	0.16	0.39	0.23
23004	0.12	0.35	0.19
27009	0.45	0.61	0.48
27035	0.50	0.59	0.53
27041	0.46	0.70	0.59
33019	-0.18	0.15	0.42
34011	-0.03	0.30	0.64
37005	0.62	0.70	0.64
39001	0.66	0.63	0.78
40005	0.60	0.48	0.67
40011	0.47	0.64	0.70
43021	-0.27	0.40	0.44
45005	0.04	0.48	0.27
46003	0.49	0.53	0.53
47001	0.46	0.61	0.49
50002	0.42	0.49	0.43
53006	0.60	0.51	0.66
53008	0.55	0.53	0.61
54057	0.63	0.68	0.63
55014	0.05	0.55	0.41
55026	0.43	0.65	0.48
55029	0.23	0.58	0.35
60003	0.35	0.57	0.46
62001	0.67	0.66	0.70
64001	0.45	0.58	0.49
67033	0.58	0.76	0.64
68005	0.16	0.08	0.60
71001	0.19	0.42	0.24
72005	0.16	0.39	0.25
73005	0.25	0.50	0.34
79002	0.37	0.53	0.39
81002	0.25	0.48	0.30
81004	0.36	0.26	0.54
83006	0.22	0.30	0.23
84013	0.48	0.50	0.50
94001	0.39	0.67	0.61
96002	0.44	0.54	0.46
106001	0.38	0.35	0.64
107001	0.20	0.11	0.67

Table S2. Topsoil moisture error metrics for the twelve COSMOS-UK sites [Figure S2], ordered by Nash-Sutcliffe Efficiency (NSE) score.

COSMOS-UK Site	NSE	KGE	R^2
Gisburn Forest	-33.58	0.26	0.36
Chobham Common	-7.93	0.23	0.62
Stiperstones	-6.32	0.20	0.70
Wytham Woods	-5.13	0.29	0.15
Hollin Hill	-4.93	0.34	0.61
Heytesbury	-4.63	0.52	0.73
Sheepdrove	-1.15	0.57	0.67
Alice Holt	-0.86	0.43	0.21
Chimney Meadows	0.29	0.68	0.79
Hartwood Home	0.47	0.45	0.51
Waddesdon	0.49	0.58	0.61
Rothamsted	0.81	0.82	0.84

Table S3. Potential evapotranspiration error metrics for the twelve COSMOS-UK sites [Figure S2], ordered by Nash-Sutcliffe Efficiency (NSE) score.

COSMOS-UK Site	NSE	KGE	R^2
Hartwood Home	-0.46	0.22	0.55
Chimney Meadows	-0.23	0.27	0.62
Rothamsted	-0.13	0.32	0.62
Sheepdrove	0.11	0.46	0.62
Alice Holt	0.11	0.54	0.53
Heytesbury	0.13	0.51	0.57
Hollin Hill	0.20	0.55	0.59
Gisburn Forest	0.28	0.60	0.59
Stiperstones	0.43	0.70	0.61
Wytham Woods	0.44	0.47	0.67
Chobham Common	0.45	0.72	0.60
Waddesdon	0.46	0.69	0.57

Table S4. Catchment attributes for those in this study as derived from the CAMELS-GB (Coxon et al. 2020) dataset (which is produced using the data used to drive JULES in this study). Also included is the percentage increase in woodland for the catchments.

Station	Mean Precipitation (mm day^{-1})	Mean Potential Evapotranspiration (mm day^{-1})	Runoff Ratio	Area (km^2)	Mean Elevation (m)	Percentage Increase in Woodland	Percentage Point Increase in Woodland
2002	3.41	1.11	0.72	423.48	259.00	2400.56	6.31
7001	3.42	1.07	0.87	415.59	560.00	279.83	5.06
8004	3.08	1.07	0.75	540.75	525.00	191.08	6.99
8009	2.83	1.09	0.69	272.20	461.00	513.50	6.66
8013	3.68	1.03	0.78	229.63	618.00	243.06	1.10
11004	2.44	1.20	0.59	195.44	206.00	649.39	18.38
12002	3.11	1.11	0.71	1833.21	447.00	197.31	5.86
15006	4.16	1.12	0.81	4586.79	411.00	137.37	7.11
17005	2.87	1.25	0.65	194.81	161.00	165.89	13.64
18001	4.10	1.20	0.72	160.29	245.00	446.06	13.37
21006	3.35	1.21	0.64	1505.54	358.00	282.73	11.75
22001	2.39	1.32	0.53	578.25	225.00	33.76	2.28
23004	3.18	1.26	0.66	749.89	350.00	16.95	0.69
27009	2.52	1.35	0.53	3300.80	185.00	13.87	0.76
27035	3.18	1.33	0.63	283.39	230.00	132.47	6.42
27041	2.15	1.37	0.42	1594.24	128.00	2.82	0.23
33019	1.76	1.48	0.30	311.37	39.00	13.93	1.28
34011	1.94	1.47	0.23	162.93	62.00	2.95	0.17
37005	1.61	1.47	0.25	235.88	66.00	2.02	0.13
39001	1.99	1.42	0.27	9930.80	109.00	9.23	1.25
40005	1.94	1.40	0.33	278.05	45.00	1.75	0.23
40011	2.10	1.40	0.38	341.26	84.00	0.68	0.10
42016	2.41	1.41	0.67	234.17	123.00	0.04	0.00
43021	2.33	1.43	0.44	1712.31	120.00	0.43	0.04
45005	2.75	1.45	0.50	202.83	144.00	2.28	0.25
46003	5.16	1.42	0.75	249.99	327.00	0.03	0.00
47001	3.43	1.44	0.62	920.22	155.00	69.29	6.09
50002	3.37	1.43	0.61	664.25	160.00	44.87	5.23
53006	2.29	1.43	0.44	151.63	73.00	11.16	0.55
53008	2.27	1.44	0.42	305.17	119.00	10.48	0.76
54057	2.22	1.40	0.42	9885.46	145.00	24.56	2.20
55014	2.84	1.36	0.59	202.54	299.00	181.38	7.88
55026	4.61	1.33	0.76	172.12	387.00	337.28	6.18
55029	2.73	1.38	0.54	355.01	228.00	11.03	1.27
60003	4.02	1.43	0.76	216.44	125.00	381.18	18.33
62001	3.85	1.37	0.74	897.59	209.00	193.36	12.63
64001	5.18	1.32	0.85	464.61	281.00	70.36	6.30
67033	3.11	1.35	0.51	1800.75	242.00	50.66	3.28
68005	1.96	1.41	0.34	201.38	89.00	13.30	0.54
71001	3.73	1.32	0.67	1144.70	220.00	55.52	4.12
72005	4.72	1.27	0.85	219.24	317.00	40.66	1.37
73005	4.88	1.29	0.78	212.24	234.00	69.51	3.89
79002	4.22	1.22	0.74	797.71	294.00	432.43	14.44
81002	5.20	1.25	0.73	366.21	238.00	63.01	2.21
81004	3.87	1.33	0.67	329.07	105.00	140.46	4.29
83006	3.51	1.23	0.66	579.03	219.00	552.96	12.03
84013	3.28	1.22	0.68	1901.23	265.00	334.33	13.56
94001	6.49	1.07	0.90	441.21	311.00	6.01	0.08
96002	3.81	1.08	0.75	474.01	224.00	358.55	5.03
106001	4.16	1.13	0.78	44.93	100.00	0.00	0.00
107001	3.16	1.07	0.73	19.60	99.00	1.75E+20	5.58

Coxon, G. et al. (2020) ‘CAMELS-GB: hydrometeorological time series and landscape attributes for 671 catchments in Great Britain’, Earth System Science Data, 12(4), pp. 2459–2483. doi:10.5194/essd-12-2459-2020.

Supplementary Equation

$$KGE = 1 - \sqrt{(r-1)^2 + \left(\frac{\sigma_{sim}}{\sigma_{obs}} - 1\right)^2 + \left(\frac{\mu_{sim}}{\mu_{obs}} - 1\right)^2}$$

KGE = Kling-Gupta Efficiency Score

σ_{sim} = simulated discharge

σ_{obs} = observed discharge

r = linear corelation between simulated and observed discharge

μ_{sim} = mean simulated discharge

μ_{obs} = mean observed discharge