

## **SUPPLEMENTARY MATERIAL**

### **Simulated climate change reduced the capacity of lichen-dominated biocrusts to act as carbon sinks in two semi-arid Mediterranean ecosystems**

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**Table S1** Results of the MIXED model analysis evaluating the treatments effects on the  $F_v/F_m$  of biocrusts in Sorbas. Date = date on which measurement took place; Crust = biocrust cover (<25% vs. >75%); WA = warming; RE = rainfall exclusion. P values below 0.05 are in bold; those between 0.05 and 0.10 are in italics

$F_v/F_m$ Bimonthly Survey	DF	F-value	p-value
Date	6, 117	442.70	<b>&lt;0.001</b>
Crust	1, 42	6.86	<b>0.008</b>
WA	1, 42	0.32	0.568
RE	1, 42	1.09	0.300
Date x Crust	6, 117	6.71	<b>&lt;0.001</b>
Date x WA	6, 117	1.12	0.347
Date x RE	6, 117	0.20	0.974
Crust x WA	1, 42	2.83	<i>0.070</i>
Crust x RE	1, 42	0.79	0.469
WA x RE	1, 42	0.01	0.920
Date x Crust x WA	6, 117	2.76	<b>0.011</b>
Date x Crust x RE	6, 117	0.98	0.546
Date x WA x RE	6, 117	0.59	0.736
Crust x WA x RE	1, 42	0.05	0.948
Date x Crust x WA x RE	6, 117	0.39	0.716

**Table S2** Results of the MIXED model analysis evaluating the treatments effects on gas exchange of biocrusts at Sorbas and Aranjuez study sites. Rest of legend as in Table S1

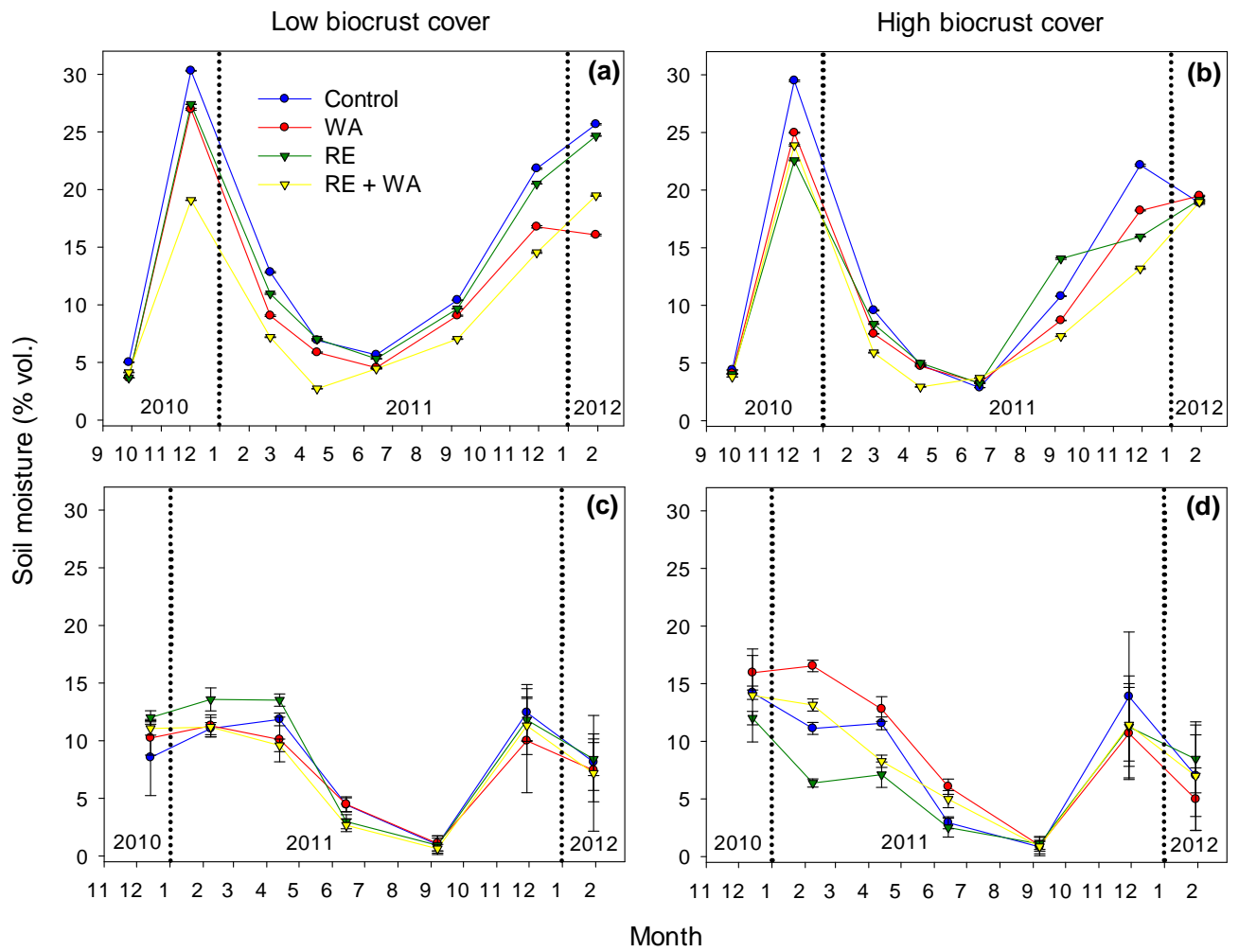
Bimonthly Survey	SORBAS								
	Net photosynthesis			Gross photosynthesis			Dark respiration		
	DF	F-value	p-value	DF	F-value	p-value	DF	F-value	p-value
Date	7, 269	68.46	<b>&lt;0.001</b>	4, 150	61.13	<b>&lt;0.001</b>	4, 150	6.74	<b>&lt;0.001</b>
Crust	1, 49	1.57	0.216	1, 49	0.20	0.660	1, 49	1.25	0.277
WA	1, 49	3.93	0.053	1, 49	0.33	0.578	1, 49	2.48	0.127
RE	1, 49	0.14	0.708	1, 49	1.26	0.272	1, 49	0.21	0.652
Date x Crust	7, 269	6.98	<b>&lt;0.001</b>	4, 150	17.68	<b>&lt;0.001</b>	4, 150	5.04	<b>&lt;0.001</b>
Date x WA	7, 269	0.81	0.581	4, 150	0.30	0.889	4, 150	1.21	0.314
Date x RE	7, 269	0.73	0.651	4, 150	1.15	0.348	4, 150	1.03	0.402
Crust x WA	1, 49	5.88	<b>0.019</b>	1, 49	1.57	0.221	1, 49	0.00	0.974
Crust x RE	1, 49	0.06	0.804	1, 49	1.22	0.271	1, 49	1.12	0.306
WA x RE	1, 49	0.07	0.792	1, 49	0.00	0.965	1, 49	0.12	0.739
Date x Crust x WA	7, 269	2.90	<b>0.006</b>	4, 150	3.37	<b>0.012</b>	4, 150	2.19	0.071
Date x Crust x RE	7, 269	1.31	0.247	4, 150	0.96	0.438	4, 150	0.30	0.871
Date x WA x RE	7, 269	1.11	0.360	4, 150	1.90	0.110	4, 150	1.32	0.279
Crust x WA x RE	1, 49	0.08	0.784	1, 49	2.87	0.104	1, 49	1.55	0.229
Date x Crust x WA x RE	7, 269	0.12	0.997	4, 150	1.18	0.322	4, 150	1.25	0.292
<b>ARANJUEZ</b>									
Date	6, 216	32.93	<b>&lt;0.001</b>	4, 135	45.20	<b>&lt;0.001</b>	4, 135	15.30	<b>&lt;0.001</b>
Crust	1, 216	1.96	0.163	1, 135	0.83	0.363	1, 135	0.15	0.700
WA	1, 216	6.78	<b>0.009</b>	1, 135	1.82	0.180	1, 135	0.03	0.872
RE	1, 216	0.15	0.706	1, 135	1.61	0.2106	1, 135	1.64	0.202
Date x Crust	6, 216	10.10	<b>&lt;0.001</b>	4, 135	3.18	<b>0.016</b>	4, 135	1.67	0.159
Date x WA	6, 216	7.58	<b>&lt;0.001</b>	4, 135	1.26	0.299	4, 135	0.37	0.827
Date x RE	6, 216	0.53	0.788	4, 135	1.23	0.299	4, 135	1.05	0.386
Crust x WA	1, 216	0.64	0.424	1, 135	0.16	0.686	1, 135	0.24	0.622
Crust x RE	1, 216	2.00	0.168	1, 135	1.11	0.292	1, 135	0.59	0.443
WA x RE	1, 216	0.14	0.708	1, 135	1.41	0.237	1, 135	0.28	0.595
Date x Crust x WA	6, 216	2.42	<b>0.027</b>	4, 135	1.20	0.313	4, 135	0.64	0.632
Date x Crust x RE	6, 216	0.48	0.826	4, 135	1.18	0.323	4, 135	1.32	0.266
Date x WA x RE	6, 216	1.76	0.109	4, 135	1.55	0.191	4, 135	0.92	0.454
Crust x WA x RE	1, 216	1.09	0.298	1, 135	0.72	0.398	1, 135	0.16	0.685
Date x Crust x WA x RE	6, 216	3.50	<b>0.003</b>	4, 135	0.80	0.527	4, 135	1.94	0.108

**Table S3** Results of the MIXED model analysis of the climate change factors effects on biocrusts gas exchange in January daily cycle surveys in Sorbas and Aranjuez. Time = hour of the day at which measurement took place; PAR = covariate Photosynthetic Active Radiation ( $\mu\text{mol photon m}^{-2} \text{s}^{-1}$ ). Rest of legend as in Table S1

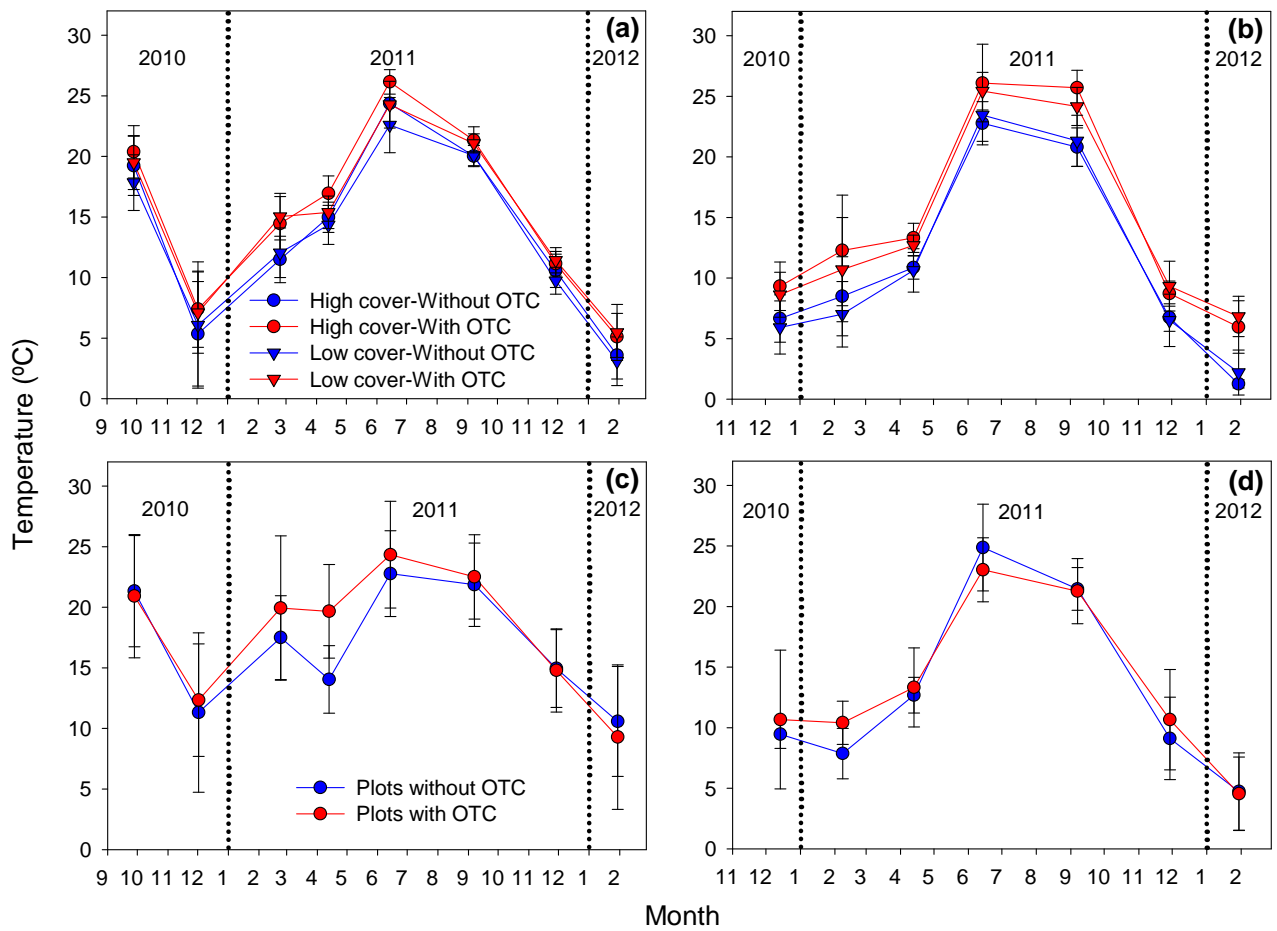
Daily cycle survey in January	SORBAS								
	Net photosynthesis			Gross photosynthesis			Dark respiration		
	DF	F-value	p-value	DF	F-value	p-value	DF	F-value	p-value
Time	11, 87	4.85	<b>&lt;0.001</b>	11, 78	2.00	<b>0.046</b>	11, 79	4.73	<b>&lt;0.001</b>
WA	1, 6	0.07	0.803	1, 6	1.93	0.213	1, 6	3.19	0.124
RE	1, 6	5.63	0.062	1, 6	3.23	0.126	1, 6	0.05	0.835
PAR	1, 87	95.92	<b>&lt;0.001</b>	1, 78	16.94	<b>&lt;0.001</b>			
Time x WA	11, 87	0.82	0.622	11, 78	1.22	0.298	11, 79	1.07	0.406
Time x RE	11, 87	2.28	<b>0.029</b>	11, 78	1.12	0.365	11, 79	0.60	0.827
WA x RE	1, 6	0.35	0.588	1, 6	0.38	0.568	1, 6	0.00	0.953
Time x WA x RE	11, 87	0.66	0.770	11, 78	0.94	0.500	11, 79	1.36	0.217
ARANJUEZ									
Time	8, 65	23.83	<b>&lt;0.001</b>	7, 49	0.79	0.600	7, 49	3.12	<b>0.008</b>
WA	1, 9	0.05	0.829	1, 9	0.06	0.819	1, 9	0.07	0.804
RE	1, 9	1.16	0.309	1, 9	0.06	0.812	1, 9	0.17	0.693
Time x WA	8, 65	4.22	<b>&lt;0.001</b>	7, 49	0.01	0.934	7, 49	0.84	0.562
Time x RE	8, 65	1.43	0.200	7, 49	0.69	0.683	7, 49	0.26	0.966
WA x RE	1, 9	2.33	0.161	1, 9	0.53	0.812	1, 9	0.94	0.358
Time x WA x RE	8, 65	0.71	0.680	7, 49	0.77	0.612	7, 49	0.46	0.859

**Table S4** Results of the MIXED model analysis of the climate change factors effects on biocrusts net photosynthesis in May daily cycle survey in Aranjuez. Rest of legend as in Table S3

Daily cycle survey in May	ARANJUEZ		
	Net photosynthesis		
	DF	F-value	p-value
WA	1, 9	1.72	0.223
RE	1, 9	0.32	0.587
Time	6, 41	11.01	<b>&lt;0.001</b>
WA x RE	1, 9	1.06	0.331
WA x Time	6, 41	2.60	<b>0.032</b>
RE x Time	6, 41	0.41	0.870
WA x RE x Time	6, 41	1.13	0.362



**Fig. S1** Treatment effects on soil moisture on the gas exchange measurement days at Sorbas (**a, b**) and at Aranjuez (**c, d**). Data are means  $\pm$  SE ( $n = 3$ ). WA = Warming, and RE = Rainfall exclusion



**Fig. S2** Warming treatment (WA) effects on soil and air temperature at Sorbas (**a, c**) respectively; and at Aranjuez (**b, d**) respectively. Data are means  $\pm$  SE ( $n = 4$ )