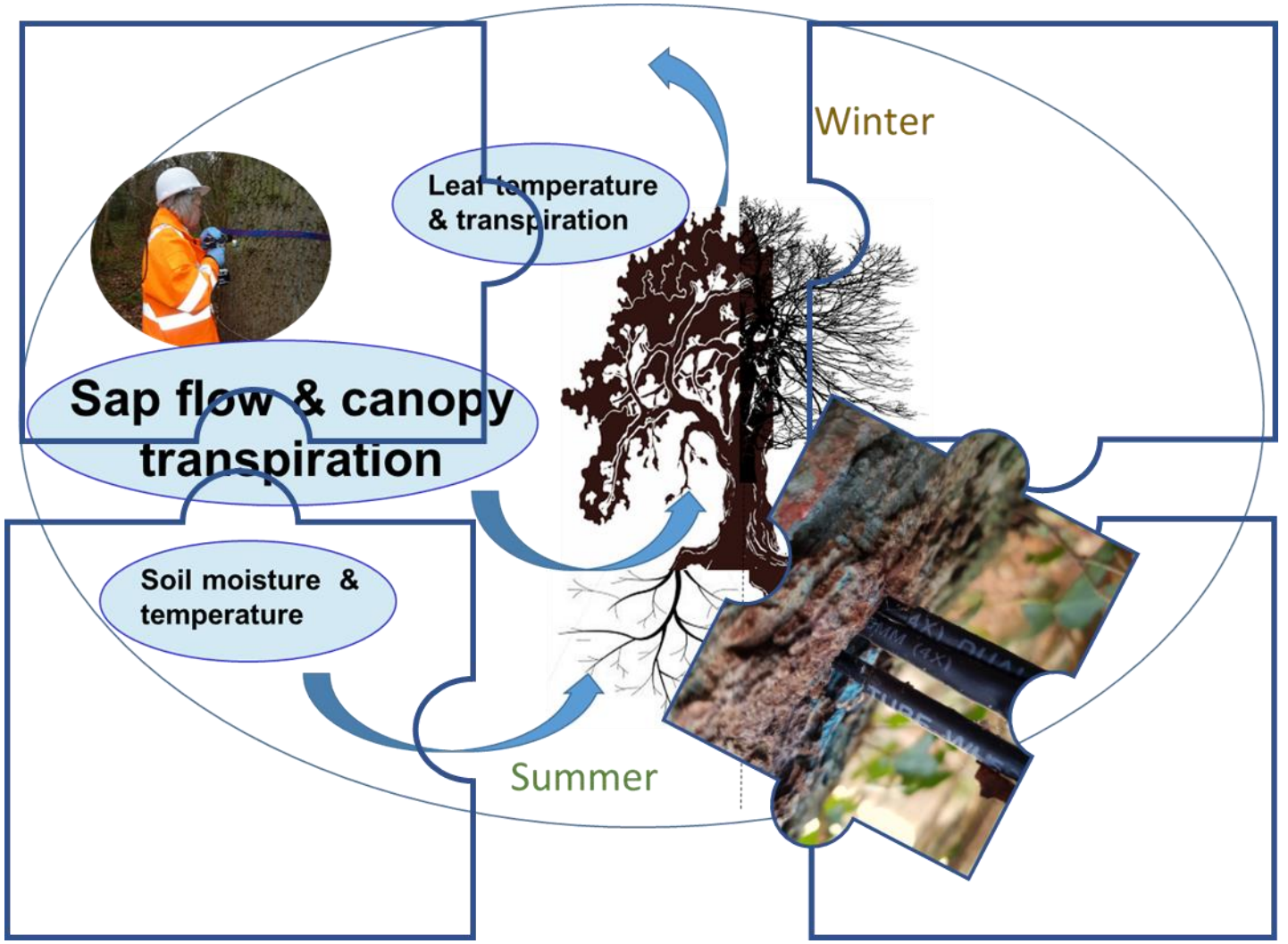
Graphical Abstract



Supplementary information for:

Water usage of old growth oak at elevated CO_2 in the FACE of climate change.

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Section 2.2

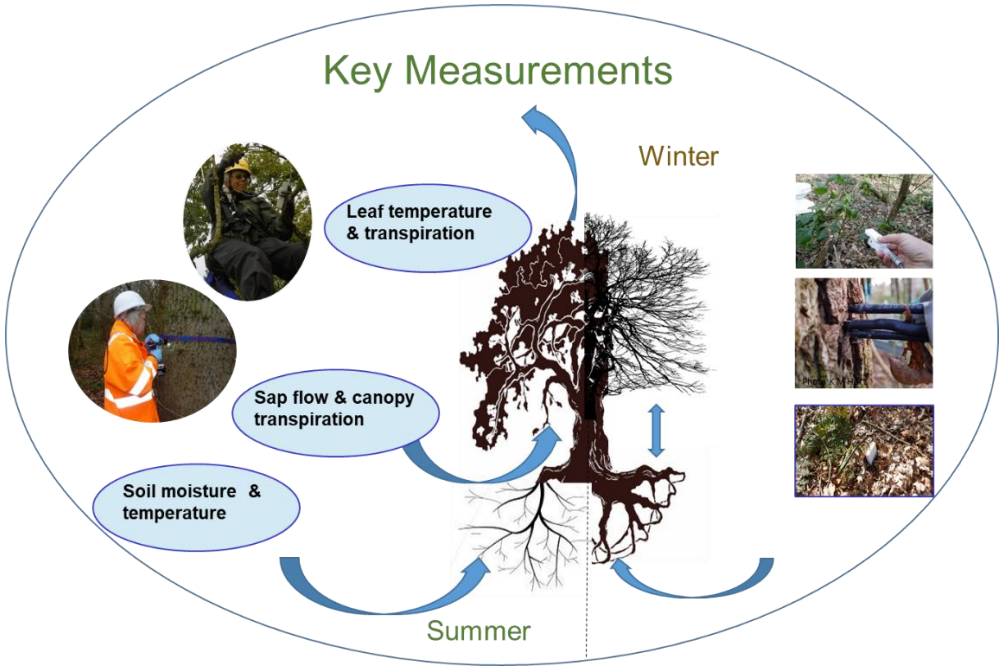

Figure S1: Key plant hydraulic related measurements

Tree ID	Array No.	Treatment	Install & Measure date	Initial Circum-ference (m)	Initial Average R_b at probeset (m)	2022 Circum-ference (m)	2022 Average R_b at probeset (m)	Average probeset height (m)
8467	1	eCO2	13/07/2017	1.640	<u>0.261</u>	1.656	<u>0.264</u>	1.13
8468	1	eCO2	13/07/2017	1.720	0.274	1.734	0.276	1.2
8673	2	aCO_2	28/08/2018	2.360	0.376	2.372	0.378	1.26
8749	2	aCO_2	28/08/2018	2.600	0.414	2.636	0.420	1.2
8351	3	aCO_2	20/07/2017	1.710	0.272	1.726	0.275	1.19
9301	3	aCO_2	20/07/2017	2.560	0.407	2.621	0.417	1.13
6621	4	eCO2	28/08/2018	2.350	0.374	2.372	0.378	1.3
6632	4	eCO2	05/09/2018	2.270	0.361	2.288	0.364	1.28
6382	5	aCO_2	18/07/2018	2.210	0.352	2.220	0.353	1.3
6406	5	aCO_2	18/07/2018	2.890	0.460	2.864	0.456	1.28
3755	6	eCO2	17/07/2018	2.260	0.360	2.278	0.363	1.23
5846	6	eCO2	17/07/2018	2.920	0.465*	2.968	0.472*	1.3
6027	7	none/ ghost	21/07/2017	2.050	0.326	2.104	0.335	1.29
6021	7	none/ ghost	21/07/2017	2.620	0.417	2.644	0.421	1.23
3642	8	none/ ghost	24/07/2017	1.720	0.274	1.790	0.285	1.24
3634	8	none/ ghost	24/07/2017	2.690	0.428	2.718	0.433	1.28
7476	9	none/ ghost	05/01/2017	2.160	0.344	2.202	0.350	1.3
7331	9	none/ ghost	05/07/2017	2.500	0.398	2.556	0.407	1.25

Table S1: Tree identification, array number, treatment type, species and installation/ measurement dates along with circumference and diameter at probeset insertion point height for target oak trees at start and in 2022. Underlined R_b values are smallest (initial & 2022). Largest R_b is marked with an asterix.

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Figure S2: Photo of soil moisture and throughfall set-up array

Section 2.7

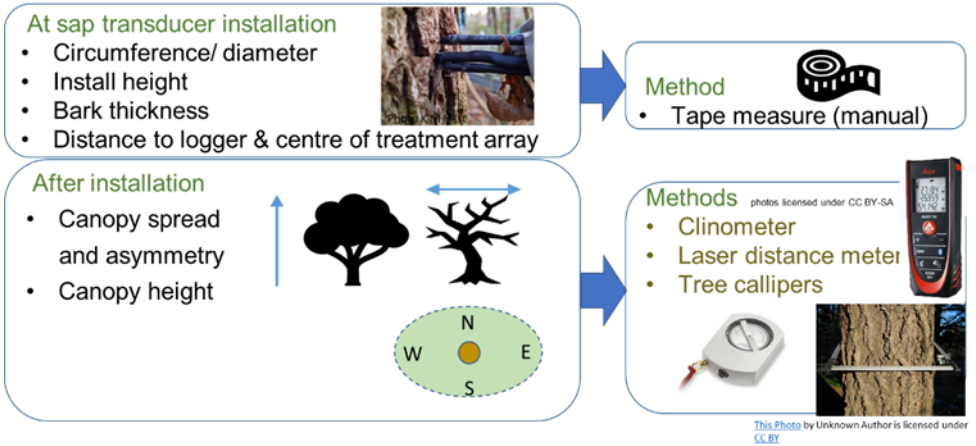

Figure S3: Methods of measuring tree size including tape measure for circumference, callipers for stem diameter E-W and N-S and use of clinometer and laser distance device to identify canopy extent at the four cardinal compass points. Canopy diameter and stem diameter are combined to calculate average canopy spread diameter and approximate canopy area.

Section 2.5

Description	Make	Model	Position	Parameter	Parameter symbol	Where	Units	Sampling rate	Logger rate
hemispherical solar radiation	Hukseflux pyranometer	LP02-03	Top canopy (c25 m)	Solar Radiation (Av)	*TG*	A 1-6	Watt m^{-2}	10 secs	Every hour
temperature sensor (thermistor)	Campbell Sci	T107	Top canopy (c20 m)	Air Temp (Av)	T_a	A 1-6	^{o}C	10 secs	Every hour
Met tower precipitation	Texas Electronics (Dallas; Texas)	TR-525M	2 m above ground	Precipitation - accumulative	*P*	Met Towers	mm		15 minutes

Table S2: FACE and Met tower instrumentation.

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2022	Tree	GH	Tree	aCO2	Tree	eCO2
	6027	**2.104**	8673	**2.372**	8467	**1.656**
	6021	**2.644**	8749	**2.636**	8468	**1.734**
	3642	**1.79**	8351	**1.726**	6621	**2.372**
	3634	**2.718**	9301	**2.621**	6632	**2.288**
	7476	**2.202**	6382	**2.22**	3755	**2.278**
	7331	**2.556**	6406	**2.864**	5846	**2.968**
mean circumference		2.34		2.41		2.22

sm	3642	**1.79**	sm	8351	**1.726**	sm	8467	**1.656**
med	7476	**2.202**	med	8673	**2.372**	med	6632	**2.288**
lg	3634	**2.718**	lg	6406	**2.864**	lg	5846	**2.968**

Table S3: To show circumference measures in 2022 for all trees. Also mean circumference (metres) and sizes of smallest (sm), largest (lg) and medium (med) sized trees in each treatment category.

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Parameter	Author	Reported value	Conversion factor	Metric equivalent	Tree size
Sap flux (density) maximum	Tatarinov (2005)	0.1 kg cm−2 h−1	10^4 / 3600	2.7778 x 10^{-1} Kg m-2 s-1 [litres m-2 s-1]	Dbh>30cm, Height=29m
Sapflux max hourly (mean of 2x trees)	Sanchex-Perez (2008) HP	The hourly Maximum (total) fluxes were [30 litres h-1].		The hourly maximum fluxes were [30 litres h-1]. [July circa 380 (litres tree-1 day-1)] see below	Dbh=83cm Height=22
Total daily sapflux (summer max)	Čermák et al (1992) ref in Tatarinov (2005)*	200 kg tree−1 h−1		200 kg tree−1 h−1 [circa 1600 (kg tree-1 day-1)]	Dbh=30cm Height=29m
Total daily sapflux mean	Sanchex-Perez (2008) HP		N/A	[385 +/-41 l tree-1 day-1 July 1996]	Dbh=83cm Height=22
Total daily sapflux max *Q.suber	David (2013)	250 (kg tree −1 day -1)		250 (kg tree −1 day -1)	
Breast height Sap flux area (typical)	(Čermák et al (1992) & as quoted/Implied Tatarinov (2005)	2000 cm +2	10^{-4}	2.0 x 10^{-1} (m +2)	

Table S4: Comparison of sap parameters with other studies of oak.

Section 3.1

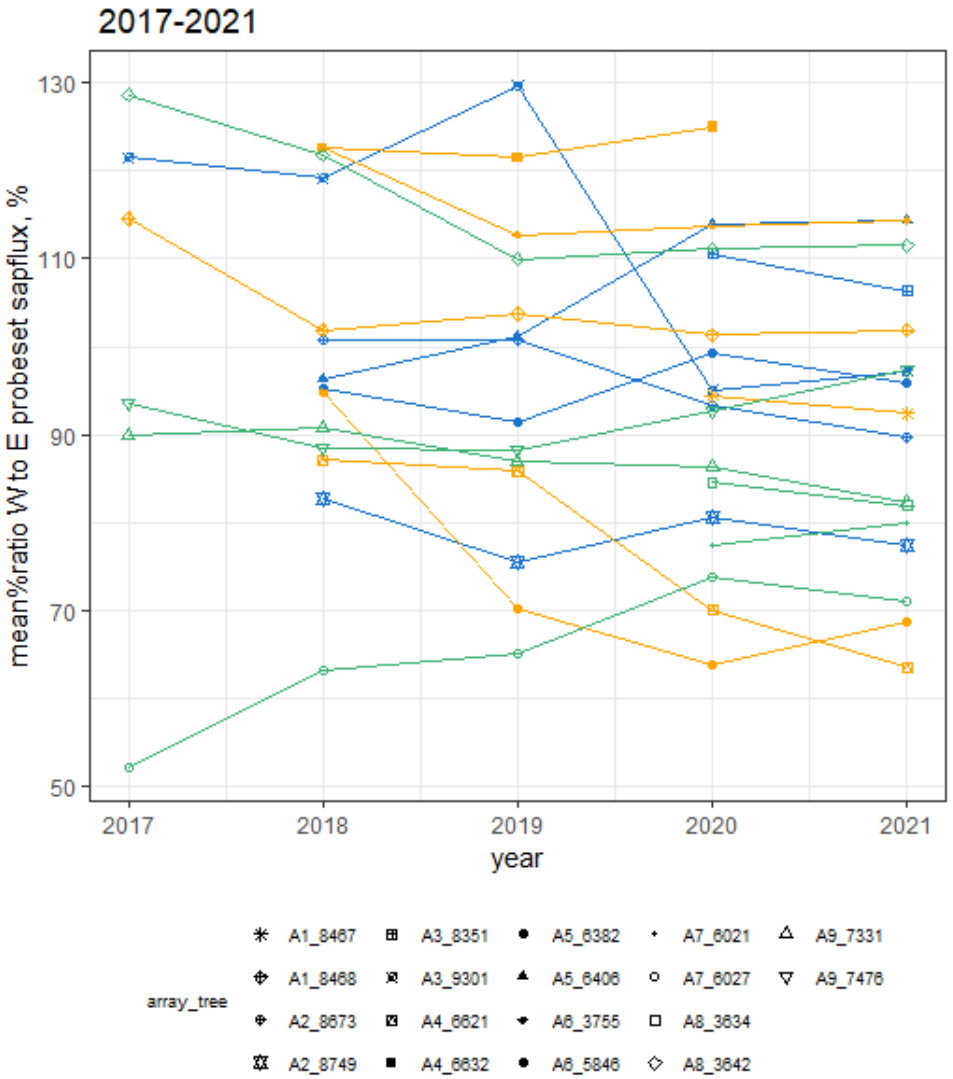

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Figure S4: Imbalance of median sap flux values for each probeset by tree. Tree sapflux data for W- facing probeset as a percentage of E-facing sapflux data, averaged for each year of two probeset operation. Points are derived from means of monthly median probeset sapflux values for each tree. Note 2017 is only a partial year.

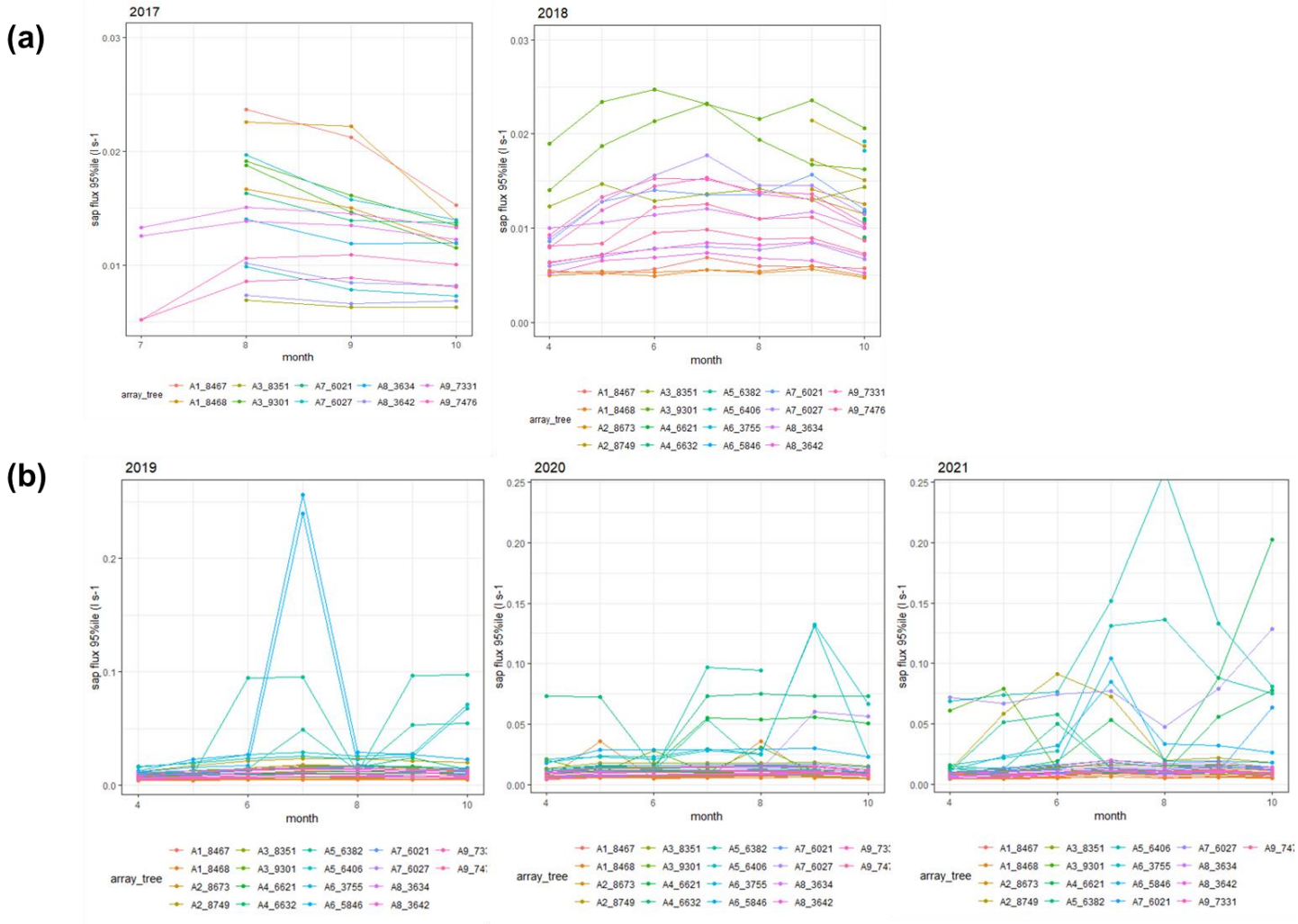

Figure S5: In years 2017 to 2021, summary monthly treatment season 95%ile sap flux (l s^{-1}) for each functional probeset all trees are shown. Colours represent individual trees and are also labelled with Array number. A1,A4, A6 are *eCO₂* trees, A3,A2, A5 are *aCO₂* trees, . A7,A8, A9 are *ghost* trees. (a) years 2017 and 2018, scaled to show a maximum of 0.03 l s^{-1}. (b) years 2019, 2020 and 2021, scaled to show a maximum of 0.25 l s^{-1}.

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	slope	SE	intercept	t	df	p
	(litres per day per millimetre)		(litres)			
aCO2	3.86	**1.25**	**-775**	**3.09**	16	P<0.01
eCO2	3.55	**0.31**	**-691**	**11.53**	15	p<0.001
ghost	1.20	**0.47**	**75.4**	**2.54**	21	P<0.05

Table S5: Linear regression model parameters for oak mean TWU across a month (here July) versus bark radius (m) at insertion point. In this table slope, litres per day per millimetre bark radius, is calculated. Data from 2, 6, 12, 18 or 17 trees for years 2017, 2018, 2019, 2020 & 2021 which each have two probesets (E and W facing) fully operational across the month of interest are modelled by treatment for all years combined. July typically exhibits maximum mean TWU across summer months in control arrays.

Tree_ID	Array	year	SprdAvdia	TotSpread_dia	CanopyArea	treatment	barkradius	FirstLast
8467	1	2017	9.695	10.217	81.986	eCO2	0.26	First
8467	1	2022	8.377	8.904	62.264	eCO2	0.26	Last
8468	1	2017	9.545	10.092	79.999	eCO2	0.27	First
8468	1	2022	8.92	9.472	70.464	eCO2	0.28	Last
8673	2	2017	15.175	15.926	199.212	aCO2	0.38	First
8673	2	2022	11.448	12.203	116.963	aCO2	0.38	Last
8749	2	2017	12.48	13.308	139.088	aCO2	0.41	First
8749	2	2022	12.947	13.786	149.262	aCO2	0.42	Last
8351	3	2017	13.925	14.469	164.432	aCO2	0.27	First
8351	3	2022	12.398	12.948	131.667	aCO2	0.28	Last
9301	3	2017	16.375	17.19	232.079	aCO2	0.41	First
9301	3	2022	16.083	16.918	224.786	aCO2	0.42	Last
6621	4	2017	11.155	11.903	111.277	eCO2	0.37	First
6621	4	2022	14.598	15.353	185.139	eCO2	0.38	Last
6632	4	2018	11.49	12.213	117.14	eCO2	0.36	First
6632	4	2022	11.248	11.977	112.657	eCO2	0.36	Last
6382	5	2017	15.03	15.733	194.419	aCO2	0.35	First
6382	5	2022	12.573	13.28	138.511	aCO2	0.35	Last
6406	5	2017	15.795	16.715	219.431	aCO2	0.46	First
6406	5	2022	16.747	17.658	244.9	aCO2	0.46	Last
3755	6	2017	11.74	12.459	121.922	eCO2	0.36	First
3755	6	2022	11.232	11.957	112.284	eCO2	0.36	Last

Tree_ID	Array	year	SprdAvdia	TotSpread_dia	CanopyArea	treatment	barkradius	FirstLast
5846	6	2017	15.315	16.244	207.253	eCO2	0.46	First
5846	6	2022	16.083	17.028	227.73	eCO2	0.47	Last
6021	7	2017	13.3	14.134	156.898	ghost	0.42	First
6021	7	2022	14.635	15.477	188.123	ghost	0.42	Last
6027	7	2017	14.42	15.073	178.428	ghost	0.33	First
6027	7	2022	11.568	12.238	117.629	ghost	0.33	Last
3634	8	2017	13.195	14.051	155.067	ghost	0.43	First
3634	8	2022	11.39	12.255	117.949	ghost	0.43	Last
3642	8	2017	10.675	11.222	98.916	ghost	0.27	First
3642	8	2022	9.802	10.371	84.483	ghost	0.28	Last
7331	9	2017	16.875	17.671	245.246	ghost	0.40	First
7331	9	2022	16.785	17.599	243.246	ghost	0.41	Last
7476	9	2017	9.685	10.373	84.501	ghost	0.34	First
7476	9	2022	10.967	11.668	106.918	ghost	0.35	Last

Table S6: Table of canopy spread v. bark radius and canopy spread diameter data for oak. Two separate repeat measures (First at installation year, Last early 2022) are listed. Bark radius is for the year of measurement.

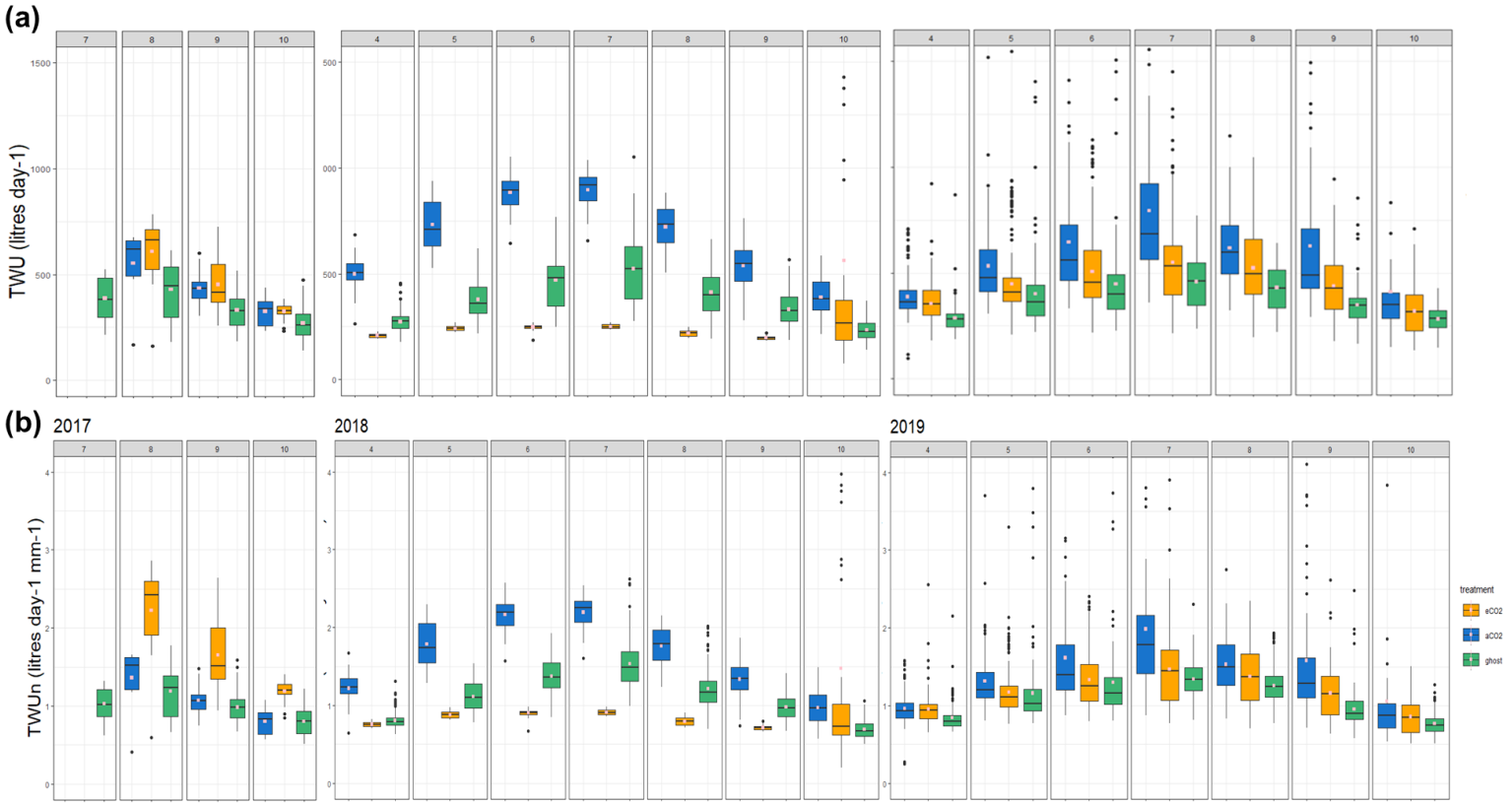

Figure S6: (a) Ghost and Infrastructure TWU(litres d-1) boxplots years 2017-2019. Boxplots 2018, 2019, show mean daylight daily tree water usage (TWU in litres day-1) combined by treatment for each treatment month April to October. (b) TWU_n (litres d-1 mm^{-1}), i.e. TWU normalised by tree radius (mm) at stem probe insertion height. Numbers of trees with both sap probeset installations functioning differs by month and year from July 2017 (2 trees) until Oct 2019 (18 trees).) . Mean values, calculated from the entire range of data, are shown as spots (pink).

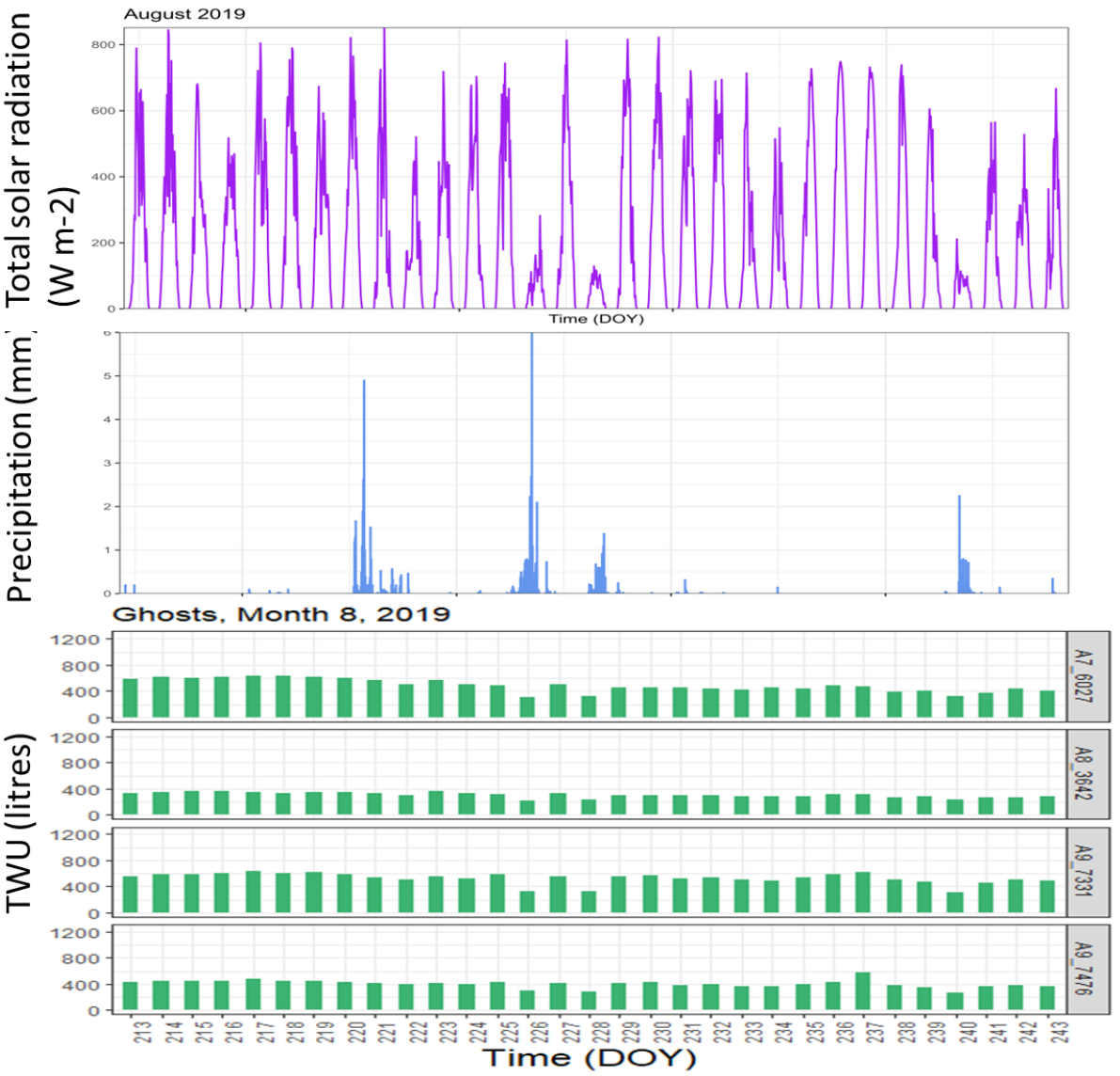

Figure S7: Example TWU (litres) per DOY v. solar radiation and precipitation for August 2019. Note if precipitation is nocturnal, then it does not influence TWU directly.

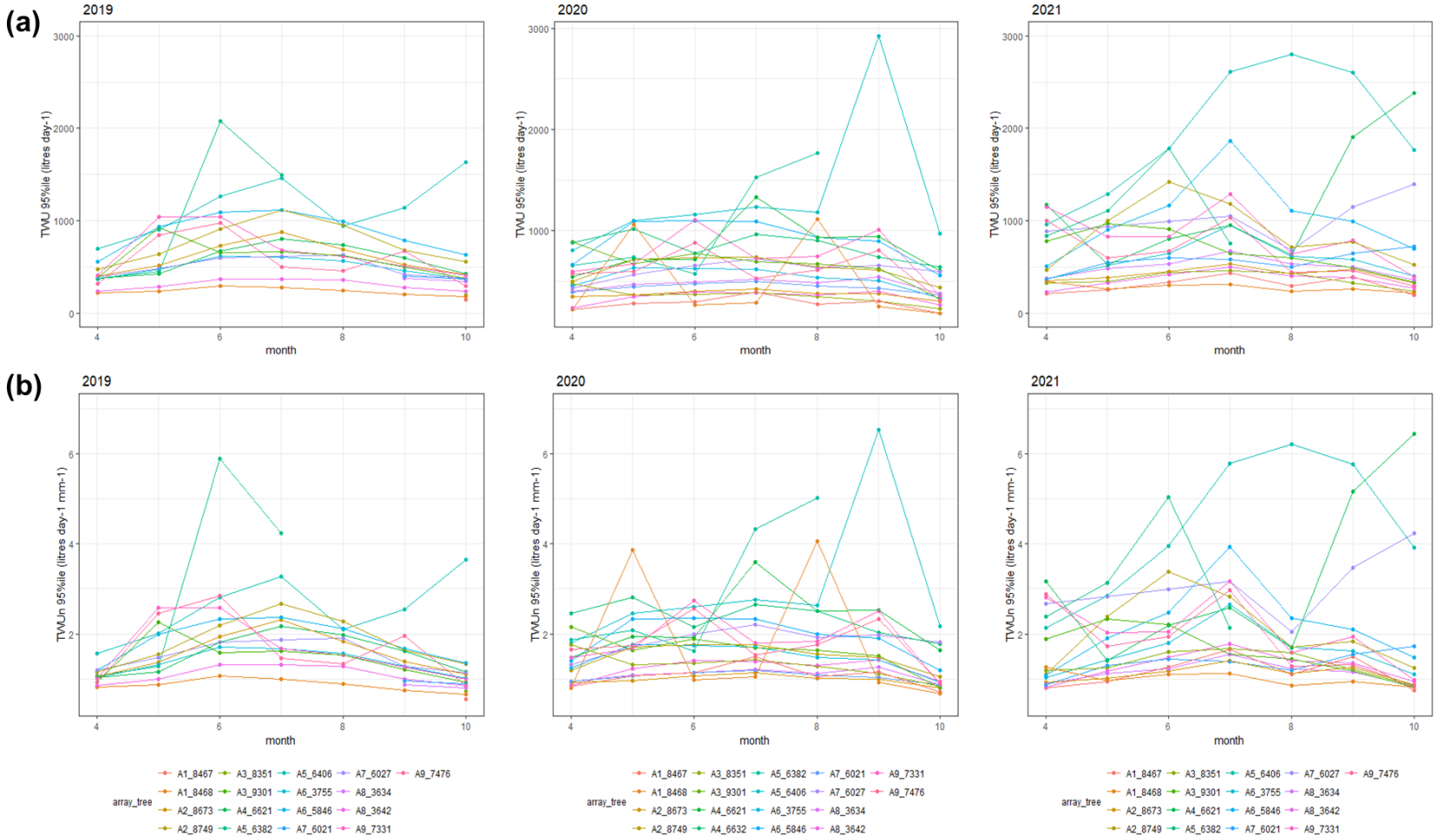

Figure S8: Comparison of monthly water usage data for all trees, (a) TWU and (b) TWU_n 95%iles, across seasons 3 to 5 of treatment (2019–2022). Colours correspond to individual trees.

Section 3.3

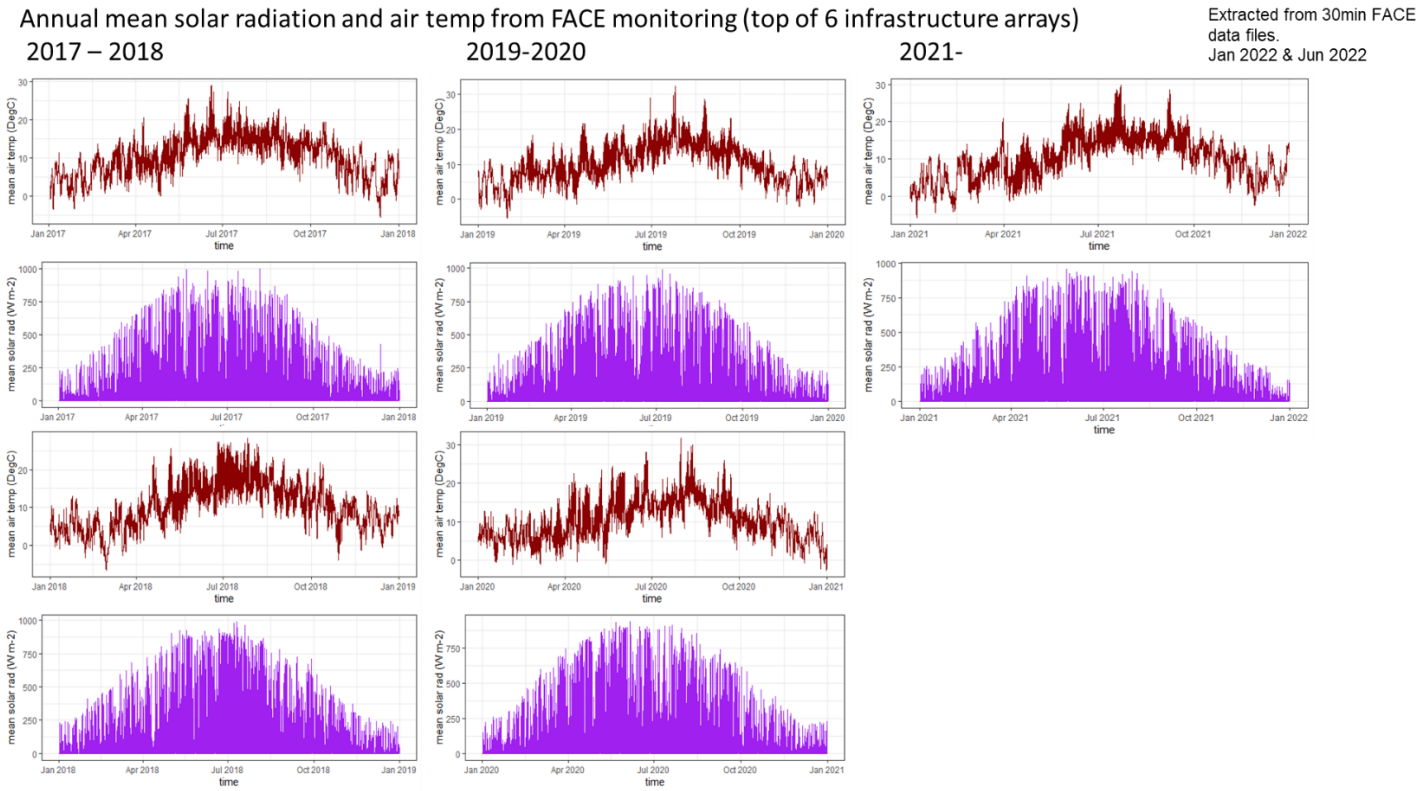

Figure S9: Annual mean solar radiation (W m-2) and air temp (degrees C) for 2017 to 2021 from FACE monitoring (top of six infrastructure arrays).