

Supplemental tables and figures for ‘Stem water storage dynamics of three boreal tree species under short-term drought’

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Table S1: Yearly average air temperature and total precipitation (1981-2023) computed at the sites from ERA5 reanalysis data

Site	Average annual air temperature (°C)	Average total annual precipitation (mm)
AMS	2.65	967
AUC	2.51	917
AUS	2.51	917
BEC	2.58	943

Table S2: Diameter at breast height (DBH) of the trees surveyed by point dendrometers

Site	Tree ID	Species	Soil surficial deposit	DBH (cm)
AMS	AMS_SEVolt_Avg.1.	Black spruce	sand	16.5
AMS	AMS_SEVolt_Avg.2.	Black spruce	sand	22.9
AMS	AMS_SEVolt_Avg.3.	Black spruce	sand	18.0
AMS	AMS_SEVolt_Avg.4.	Black spruce	sand	15.9
AMS	AMS_SEVolt_Avg.5.	Black spruce	sand	19.6
AMS	AMS_SEVolt_Avg.9.	Jack pine	sand	21.6
AMS	AMS_SEVolt_Avg.10.	Jack pine	sand	20.6
AMS	AMS_SEVolt_Avg.11.	Jack pine	sand	29.6
AMS	AMS_SEVolt_Avg.12.	Jack pine	sand	25.4
AMS	AMS_SEVolt_Avg.13.	Jack pine	sand	21.1
AUC	AUC_SEVolt_Avg.1.	Black spruce	clay	20.0
AUC	AUC_SEVolt_Avg.2.	Black spruce	clay	21.1
AUC	AUC_SEVolt_Avg.3.	Black spruce	clay	22.8
AUC	AUC_SEVolt_Avg.4.	Black spruce	clay	22.5
AUC	AUC_SEVolt_Avg.5.	Black spruce	clay	21.3
AUC	AUC_SEVolt_Avg.11.	Trembling aspen	clay	22.5
AUC	AUC_SEVolt_Avg.12.	Trembling aspen	clay	25.0
AUC	AUC_SEVolt_Avg.13.	Trembling aspen	clay	38.9
AUC	AUC_SEVolt_Avg.14.	Trembling aspen	clay	32.6
AUC	AUC_SEVolt_Avg.15.	Trembling aspen	clay	31.9
AUC	AUC_SEVolt_Avg.6.	Jack pine	clay	24.4
AUC	AUC_SEVolt_Avg.7.	Jack pine	clay	28.7
AUC	AUC_SEVolt_Avg.8.	Jack pine	clay	27.8
AUC	AUC_SEVolt_Avg.9.	Jack pine	clay	26.6
AUC	AUC_SEVolt_Avg.10.	Jack pine	clay	25.7
AUS	AUS_SEVolt_Avg.1.	Black spruce	sand	17.9
AUS	AUS_SEVolt_Avg.2.	Black spruce	sand	15.9
AUS	AUS_SEVolt_Avg.3.	Black spruce	sand	15.3
AUS	AUS_SEVolt_Avg.4.	Black spruce	sand	15.7
AUS	AUS_SEVolt_Avg.5.	Black spruce	sand	19.8
AUS	AUS_SEVolt_Avg.9.	Jack pine	sand	19.7
AUS	AUS_SEVolt_Avg.10.	Jack pine	sand	16.3
AUS	AUS_SEVolt_Avg.11.	Jack pine	sand	18.0
AUS	AUS_SEVolt_Avg.12.	Jack pine	sand	18.7
AUS	AUS_SEVolt_Avg.13.	Jack pine	sand	17.0
BEC	BEC_SEVolt_Avg.6.	Black spruce	clay	22.7
BEC	BEC_SEVolt_Avg.7.	Black spruce	clay	22.7
BEC	BEC_SEVolt_Avg.8.	Black spruce	clay	22.5
BEC	BEC_SEVolt_Avg.9.	Black spruce	clay	19.8
BEC	BEC_SEVolt_Avg.10.	Black spruce	clay	19.7
BEC	BEC_SEVolt_Avg.1.	Trembling aspen	clay	26.5
BEC	BEC_SEVolt_Avg.2.	Trembling aspen	clay	25.3
BEC	BEC_SEVolt_Avg.3.	Trembling aspen	clay	29.0
BEC	BEC_SEVolt_Avg.4.	Trembling aspen	clay	25.8
BEC	BEC_SEVolt_Avg.5.	Trembling aspen	clay	27.1
BEC	BEC_SEVolt_Avg.11.	Jack pine	clay	32.9
BEC	BEC_SEVolt_Avg.12.	Jack pine	clay	21.2
BEC	BEC_SEVolt_Avg.13.	Jack pine	clay	23.2
BEC	BEC_SEVolt_Avg.14.	Jack pine	clay	25.0
BEC	BEC_SEVolt_Avg.15.	Jack pine	clay	22.8

Table S3: Parameters of the generalized additive mixed model of relative maximum tree water deficit in black spruce

	Parameter	Estimate	SE^a	t-value	p-value
Parametric terms	intercept	0.0068	0.00511	1.33	0.184
	AR1 ^b	0.523	0.0184	28.5	< 2e-16
	sand	-0.0252	0.00727	-3.46	0.000557
	Parameter	edf^c	Ref. df^d	F	p-value
Smooth terms	s(VPD)	2.33	2.69	396	< 2e-16
	s(REW):clay	3.74	4.62	32.9	< 2e-16
	s(REW):sand	3.77	4.64	39.9	< 2e-16
Random effects	s(site)	1.06	2	9.27	0.212
	s(site,tree)	14	18	4.4	0.00294

Adjusted model R^2 : 0.857

^a Standard error

^b Autoregressive term of order 1 (value on the previous day)

^c Estimated degrees of freedom

^d Reference degrees of freedom for test statistic computation

Table S4: Parameters of the generalized additive mixed model of relative minimum tree water deficit in black spruce

	Parameter	Estimate	SE^a	t-value	p-value
Parametric terms	intercept	0.00304	0.00488	0.624	0.533
	AR1 ^b	0.692	0.0203	34.1	< 2e-16
	sand	-0.0134	0.00692	-1.93	0.054
	Parameter	edf^c	Ref. df^d	F	p-value
Smooth terms	s(VPD)	2.33	2.69	114	< 2e-16
	s(REW):clay	3.74	4.62	14.9	< 2e-16
	s(REW):sand	3.77	4.64	28.1	< 2e-16
Random effects	s(site)	1.38	2	12.9	0.0736
	s(site,tree)	12.1	18	2.26	0.00666

Adjusted model R^2 : 0.822

^a Standard error

^b Autoregressive term of order 1 (value on the previous day)

^c Estimated degrees of freedom

^d Reference degrees of freedom for test statistic computation

Table S5: Parameters of the generalized additive mixed model of relative maximum tree water deficit in trembling aspen

	Parameter	Estimate	SE^a	t-value	p-value
Parametric terms	intercept	-0.00841	0.00386	-2.18	0.0299
	AR1 ^b	0.475	0.0222	21.4	< 2e-16
	Parameter	edf^c	Ref. df^d	F	p-value
Smooth terms	s(VPD)	2.13	2.52	301	< 2e-16
	s(REW)	3.43	4.25	21.9	< 2e-16
Random effects	s(site)	0.713	1	23.8	0.0596
	s(site,tree)	6.81	9	4.13	0.000691

Adjusted model R^2 : 0.871

^a Standard error

^b Autoregressive term of order 1 (value on the previous day)

^c Estimated degrees of freedom

^d Reference degrees of freedom for test statistic computation

Table S6: Parameters of the generalized additive mixed model of relative minimum tree water deficit in trembling aspen

	Parameter	Estimate	SE^a	t-value	p-value
Parametric terms	intercept	-0.00188	0.00404	-0.464	0.643
	AR1 ^b	0.698	0.026	26.9	< 2e-16
	Parameter	edf^c	Ref. df^d	F	p-value
Smooth terms	s(VPD)	2.14	2.52	72.6	< 2e-16
	s(REW)	3.43	4.25	8.08	1.81e-06
Random effects	s(site)	0.912	1	22.4	0.000628
	s(site,tree)	3.52	9	0.68	0.0897

Adjusted model R^2 : 0.818

^a Standard error

^b Autoregressive term of order 1 (value on the previous day)

^c Estimated degrees of freedom

^d Reference degrees of freedom for test statistic computation

Table S7: Parameters of the generalized additive mixed model of relative maximum tree water deficit in jack pine

	Parameter	Estimate	SE^a	t-value	p-value
Parametric terms	intercept	0.00851	0.00586	1.45	0.147
	AR1 ^b	0.64	0.0178	35.8	< 2e-16
	sand	-0.0298	0.00833	-3.58	0.000362
	Parameter	edf^c	Ref. df^d	F	p-value
Smooth terms	s(VPD)	2.33	2.69	228	< 2e-16
	s(REW):clay	3.72	4.59	22.7	< 2e-16
	s(REW):sand	3.78	4.65	34.2	< 2e-16
Random effects	s(site)	0.992	2	5.81	0.247
	s(site,tree)	13.5	18	3.43	0.00279

Adjusted model R^2 : 0.865

^a Standard error

^b Autoregressive term of order 1 (value on the previous day)

^c Estimated degrees of freedom

^d Reference degrees of freedom for test statistic computation

Table S8: Parameters of the generalized additive mixed model of relative minimum tree water deficit in jack pine

	Parameter	Estimate	SE^a	t-value	p-value
Parametric terms	intercept	0.00624	0.00523	1.19	0.233
	AR1 ^b	0.715	0.0188	38.1	< 2e-16
	sand	-0.0271	0.00747	-3.63	0.000301
	Parameter	edf^c	Ref. df^d	F	p-value
Smooth terms	s(VPD)	2.33	2.69	125	< 2e-16
	s(REW):clay	3.72	4.59	11.9	< 2e-16
	s(REW):sand	3.78	4.65	28.9	< 2e-16
Random effects	s(site)	1.01	2	3.67	0.175
	s(site,tree)	11.5	18	1.85	0.00296

Adjusted model R^2 : 0.855

^a Standard error

^b Autoregressive term of order 1 (value on the previous day)

^c Estimated degrees of freedom

^d Reference degrees of freedom for test statistic computation

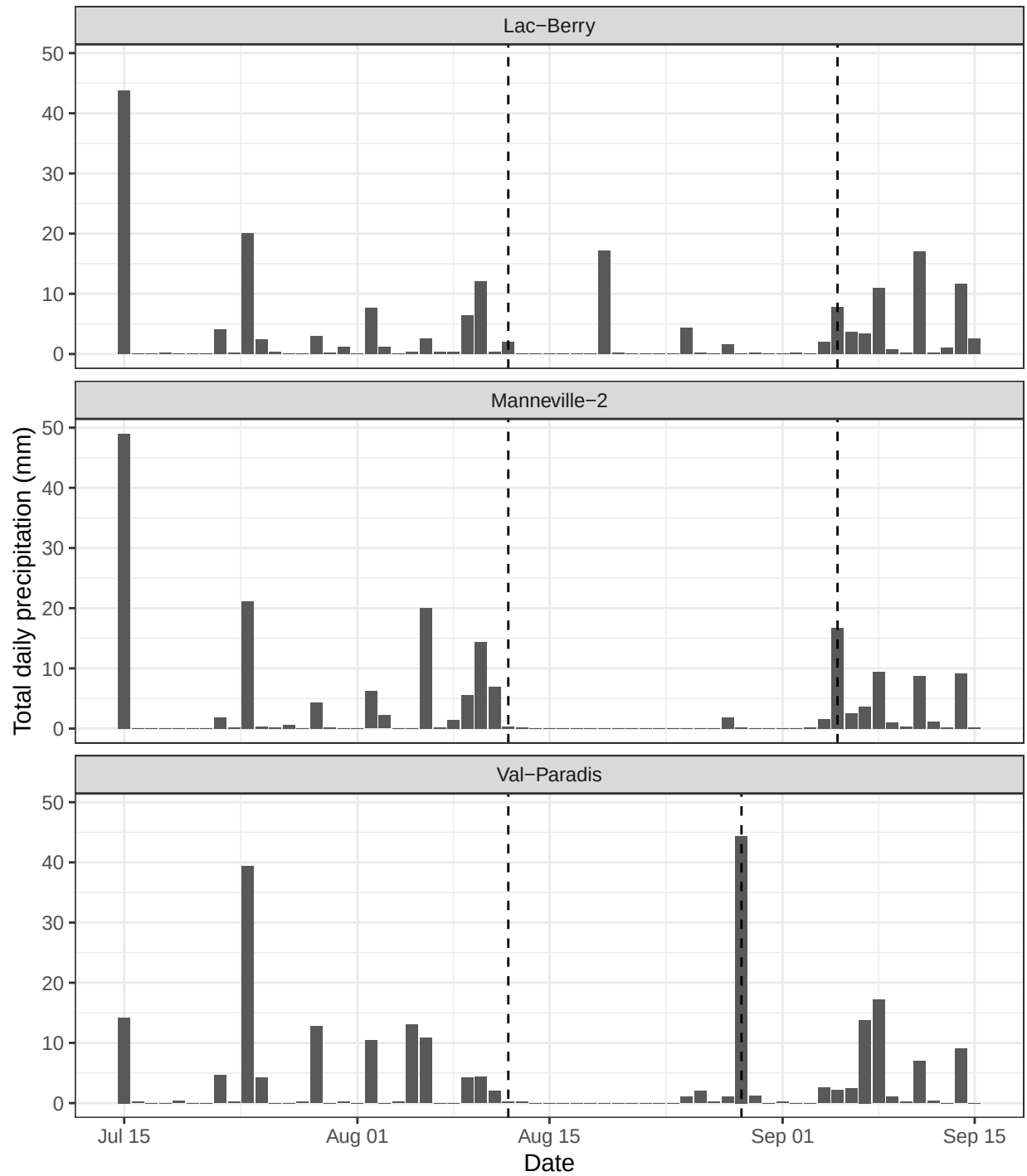


Figure S1: Time series of total daily precipitation at weather stations located near our study sites. Lac-Berry is located near site BEC, Manneville-2 is located near site AMS, and Val-Paradis is located near sites AUC and AUS. The dates of the drought at each site are delineated with dotted vertical lines.

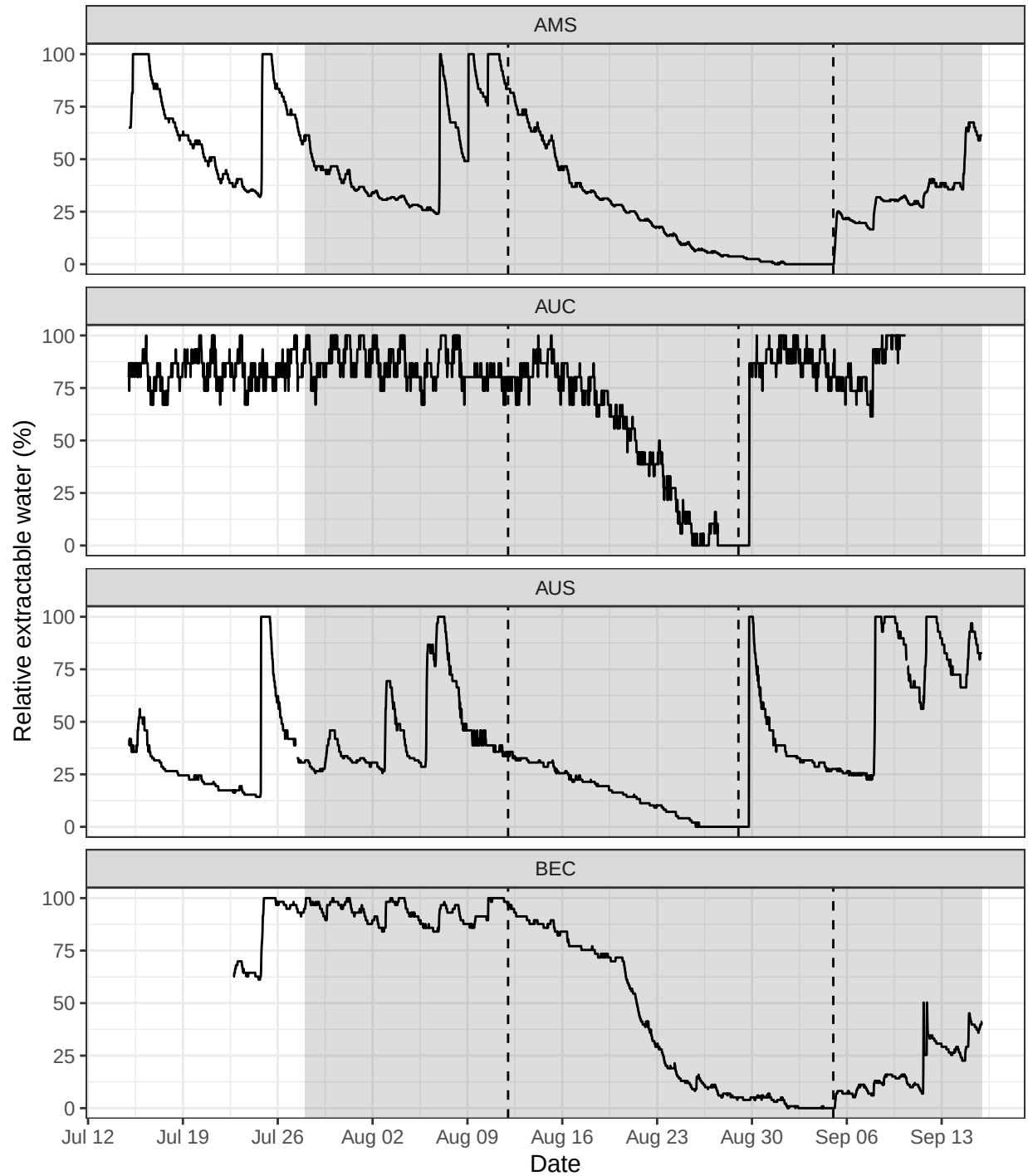


Figure S2: Time series of half-hourly values of relative extractable water (REW) at four study sites in 2021. Vertical dashed lines indicate the beginning and end of the drought at each site, while the shaded gray region delineates the timespan used for fitting statistical models. REW was computed from the volumetric water content at a depth of 20 cm.

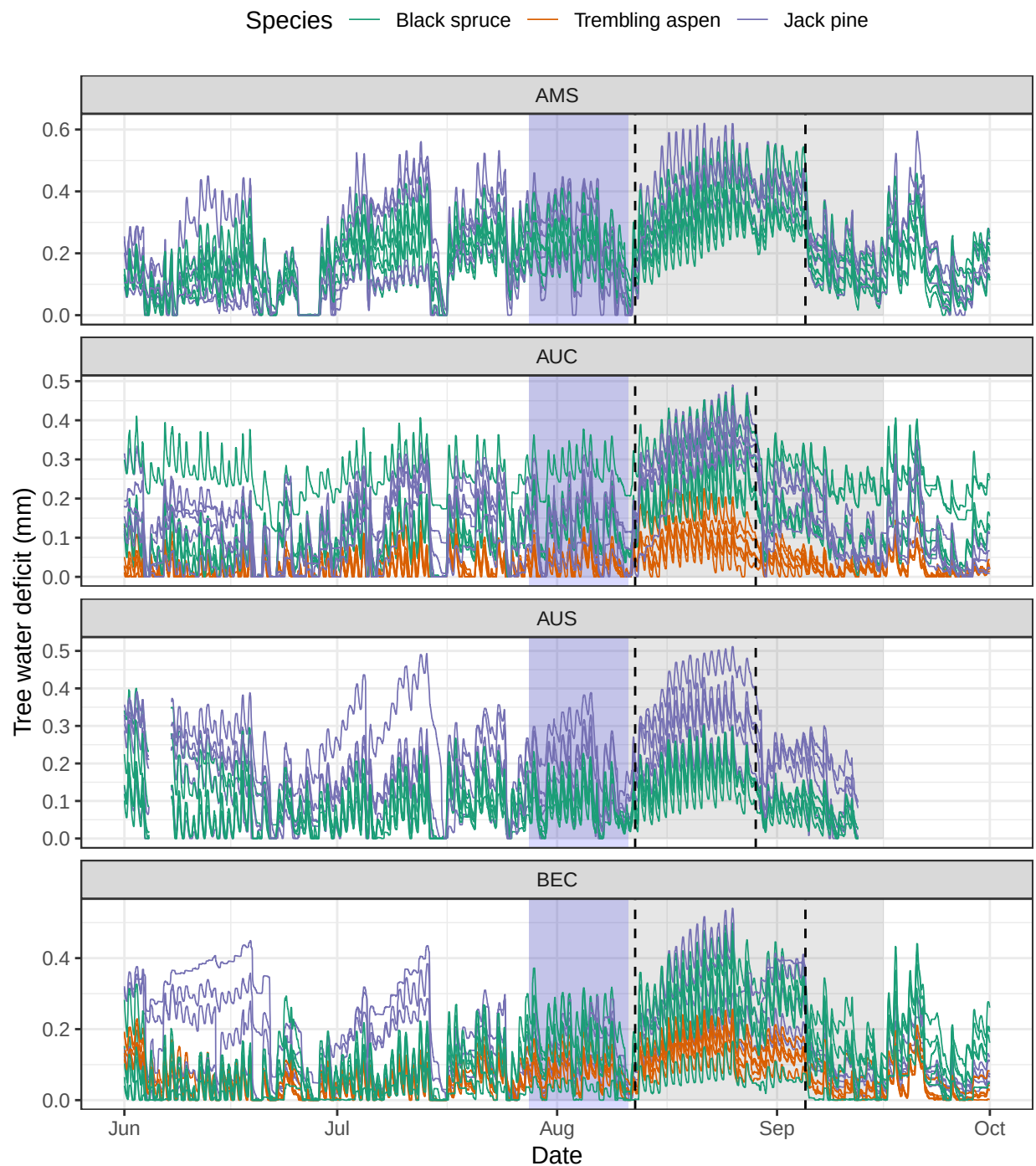


Figure S3: Time series of half-hourly tree water deficit (TWD) measurements derived from point dendrometer data on 50 trees at four different sites in 2021. TWD was computed using the treenetproc R package under the zero-growth model. Vertical dashed lines indicate the beginning and end of the drought at each site, while the shaded gray region delineates the timespan used for fitting statistical models. The blue shaded region (which is entirely contained within the gray region) delineates the control period used to compute relative daily minimum and maximum tree water deficit (RTWD_{min} and RTWD_{max}). Note that the scales on the y-axis differ.

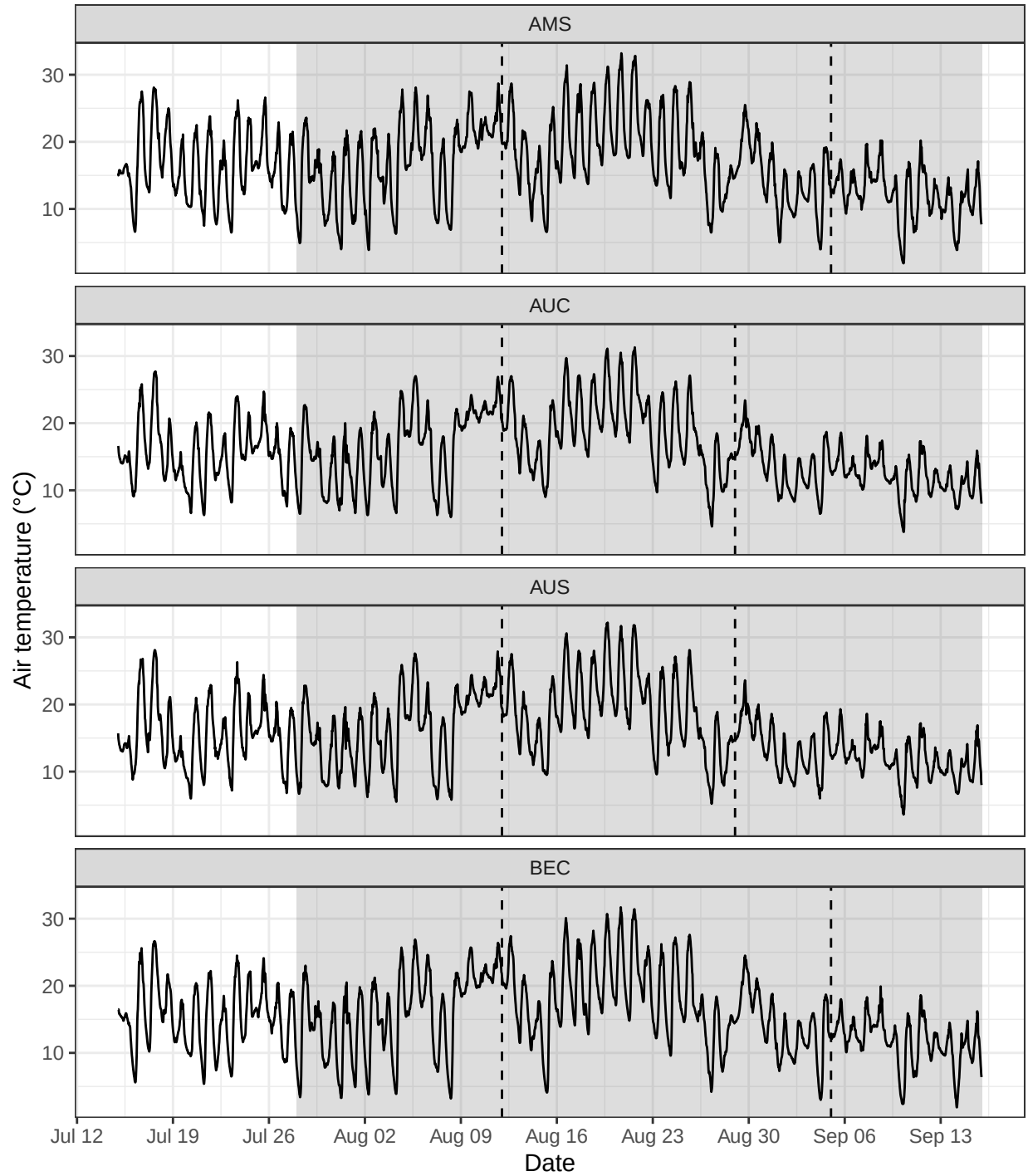


Figure S4: Time series of half-hourly air temperature measurements at four study sites in 2021. Vertical dashed lines indicate the beginning and end of the drought at each site, while the shaded gray region delineates the timespan used for fitting statistical models.

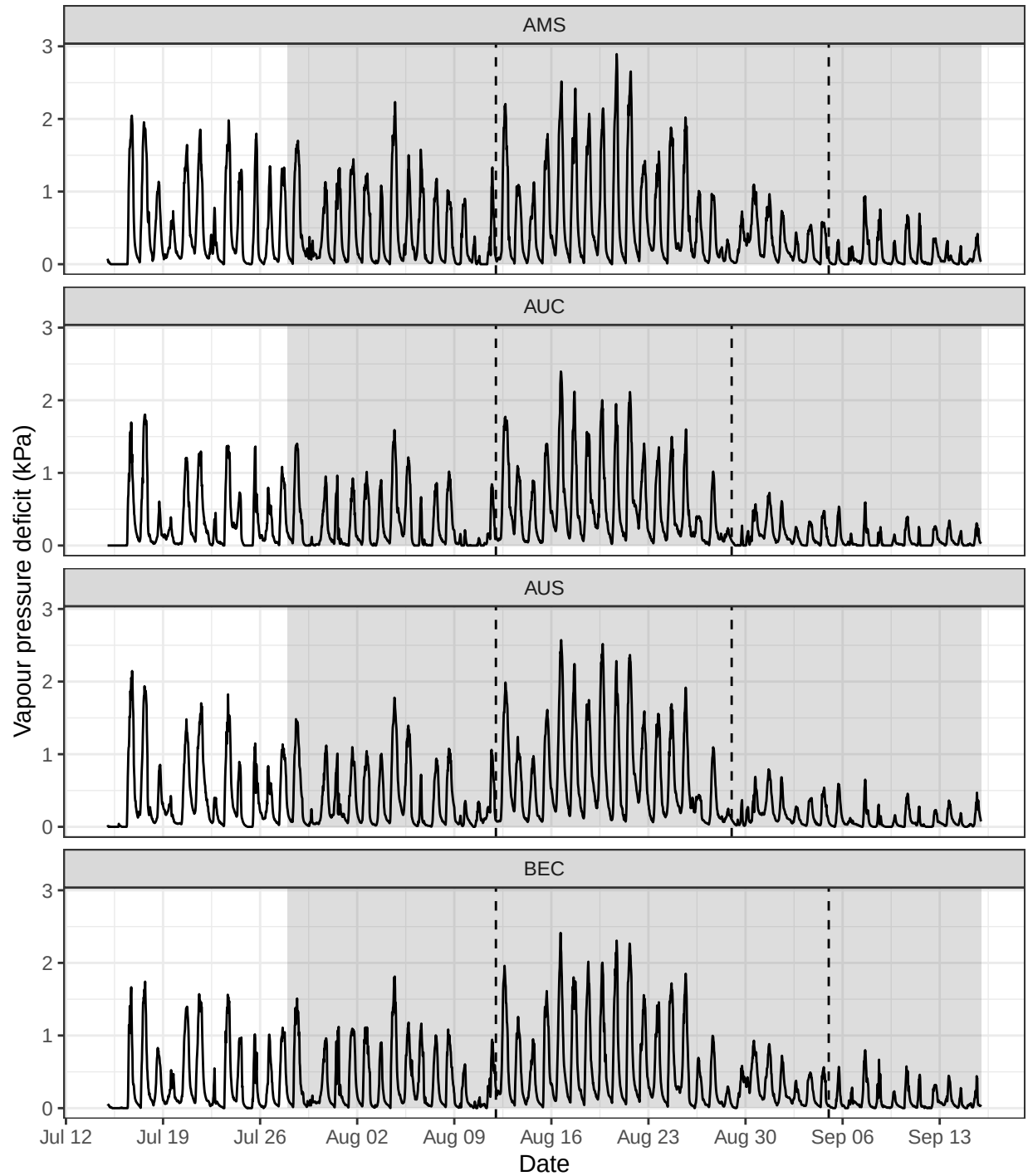


Figure S5: Time series of half-hourly measurements of vapour pressure deficit (VPD) at four study sites in 2021. VPD values were computed from air temperature and relative humidity measurements using the R package plantecophys. Vertical dashed lines indicate the beginning and end of the drought at each site, while the shaded gray region delineates the timespan used for fitting statistical models.

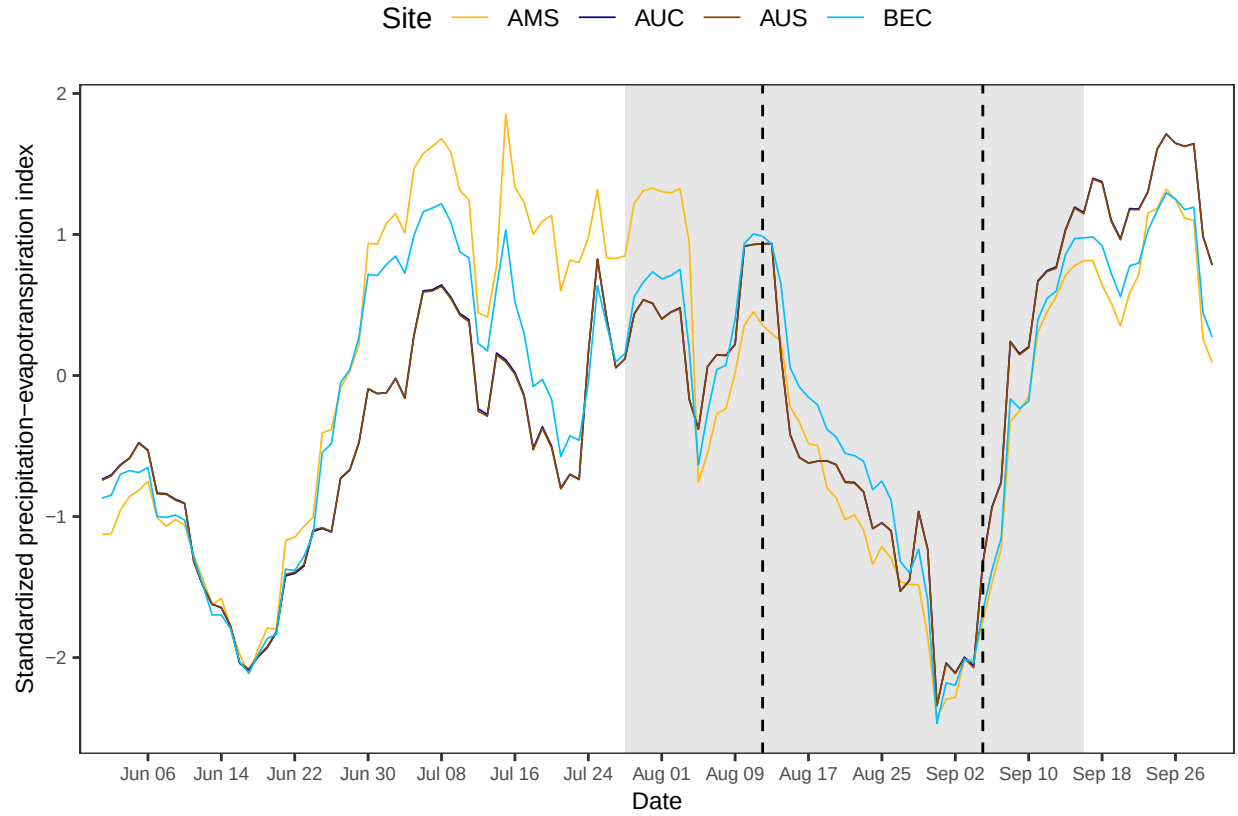


Figure S6: Time-series of standardized precipitation–evapotranspiration index (SPEI) over the summer of 2021 at the study sites. The SPEI was computed from ERA5 reanalysis data using time windows of 21 days ending on the date shown on the x-axis. Vertical dashed lines indicate the beginning and end of the drought at sites AMS and BEC (September 4); the drought ended a few days earlier at AUC and AUS (August 28). The shaded gray region delineates the timespan used for fitting statistical models.

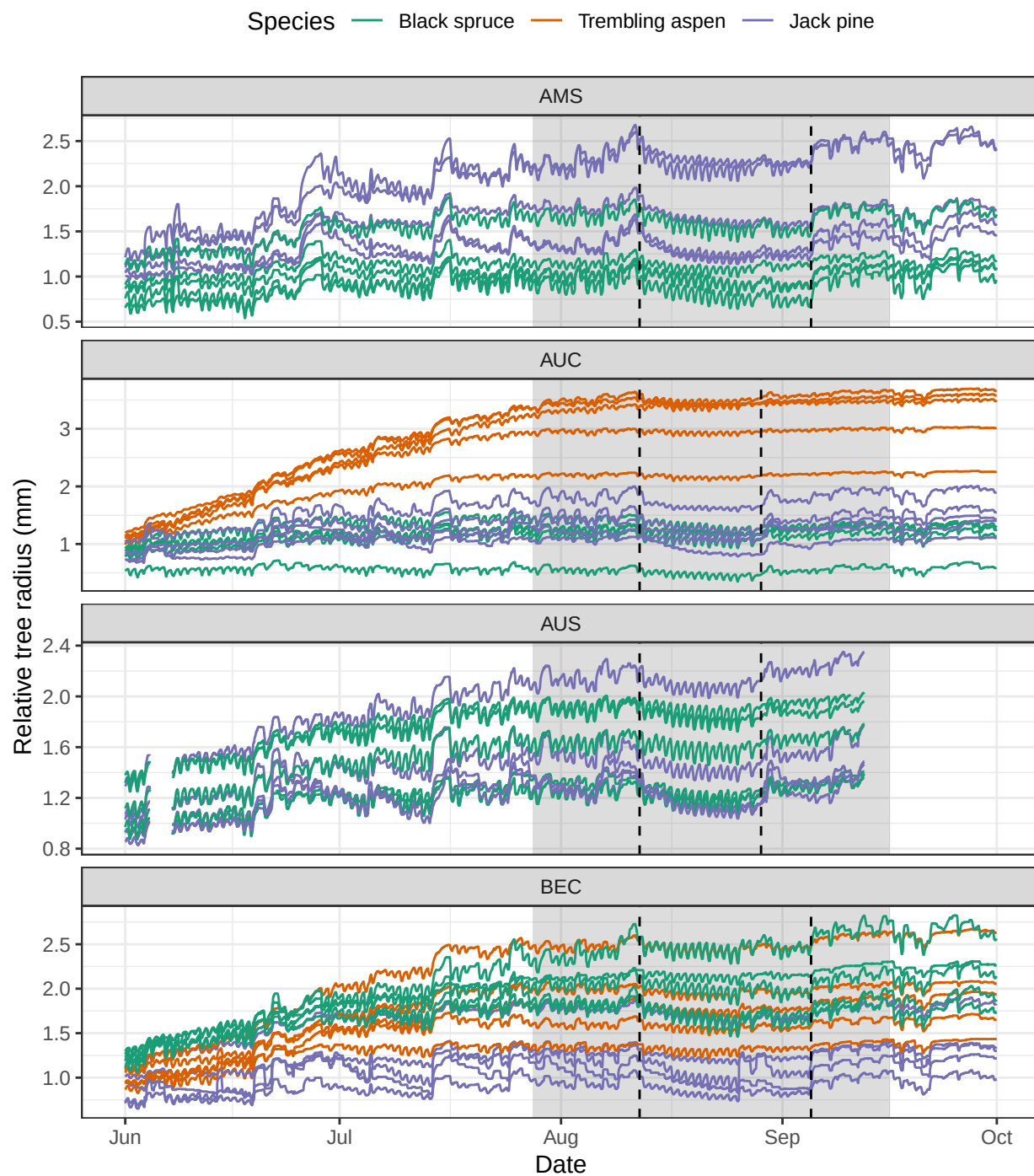


Figure S7: Time series of half-hourly relative tree radius measurements made by point dendrometers on 50 trees at four different sites in 2021. Vertical dashed lines indicate the beginning and end of the drought at each site, while the shaded gray region delineates the timespan used for fitting statistical models. Note that the scales on the y-axis differ.

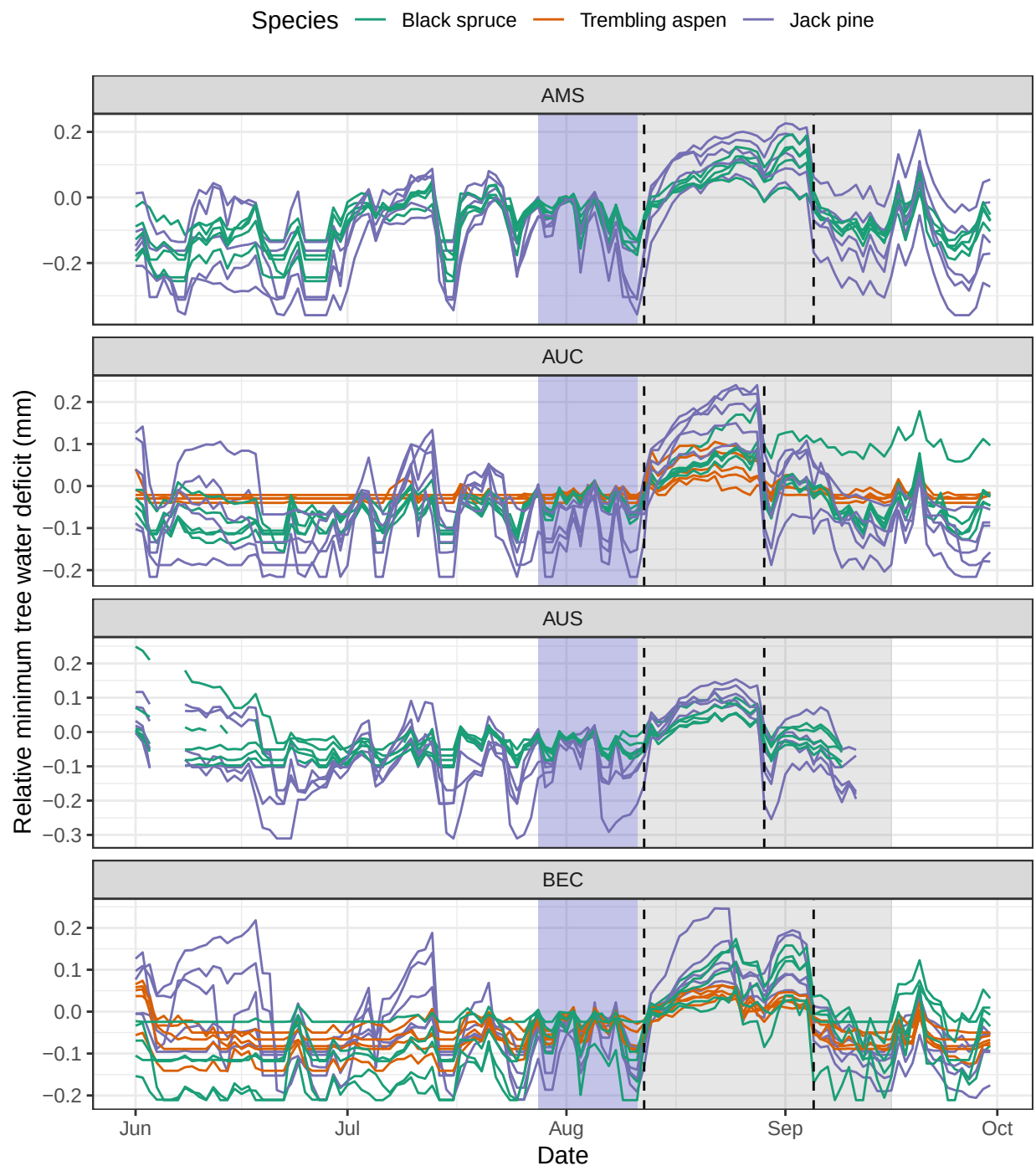


Figure S8: Time series of daily relative minimum tree water deficit ($RTWD_{min}$) values derived from point dendrometer data on 50 trees at four different sites in 2021. $RTWD_{min}$ is computed by subtracting the 95th percentile of the daily minimum TWD over a control period from the minimum TWD of each day. Vertical dashed lines indicate the beginning and end of the drought at each site, while the shaded gray region delineates the timespan used for fitting statistical models. The blue shaded region (which is entirely contained within the gray region) delineates the control period used to compute $RTWD_{min}$. Note that the scales on the y-axis differ.

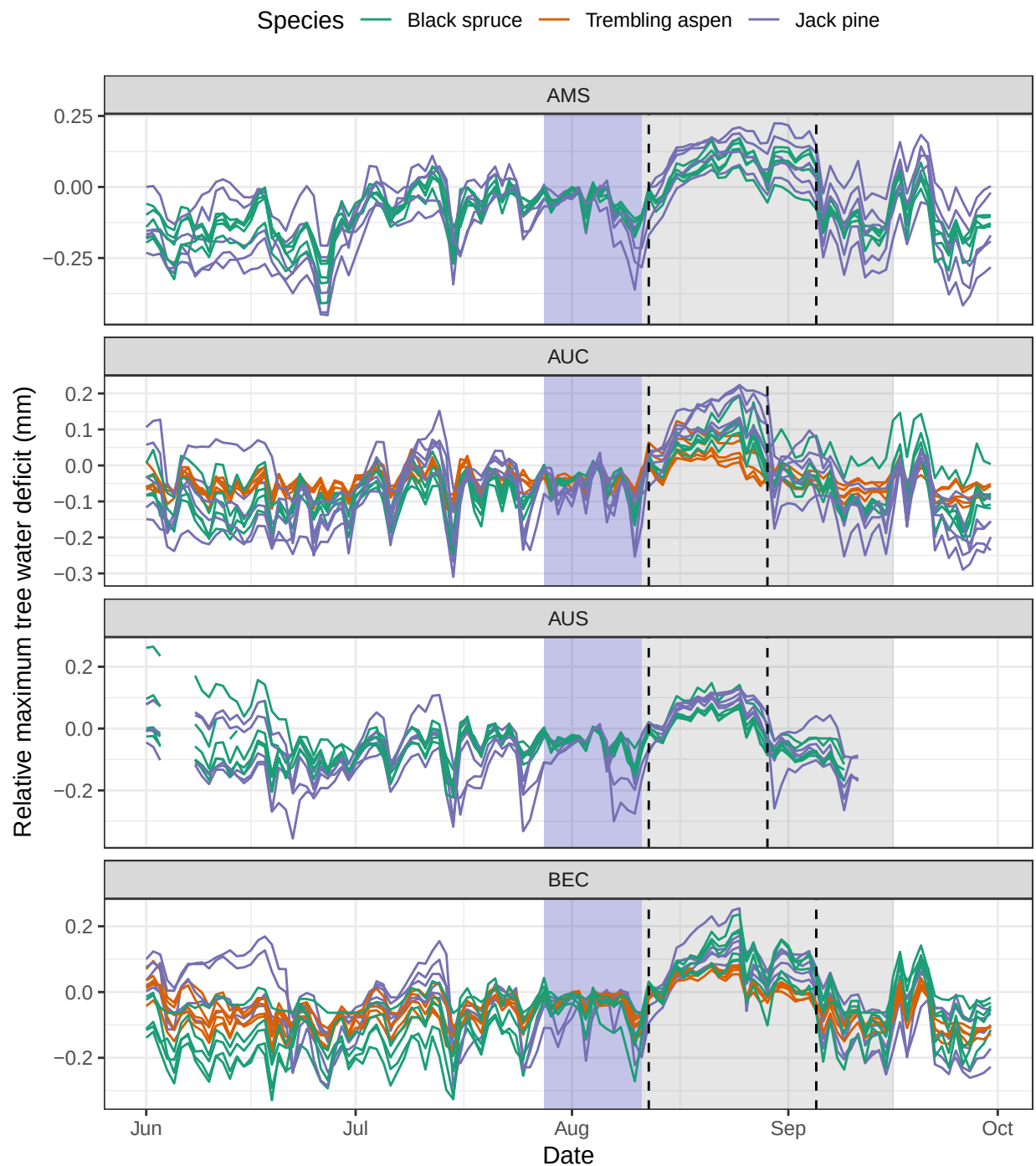


Figure S9: Time series of daily relative maximum tree water deficit ($RTWD_{max}$) values derived from point dendrometer data on 50 trees at four different sites in 2021. $RTWD_{max}$ is computed by subtracting the 95th percentile of the daily maximum TWD over a control period from the maximum TWD of each day. Vertical dashed lines indicate the beginning and end of the drought at each site, while the shaded gray region delineates the timespan used for fitting statistical models. The blue shaded region (which is entirely contained within the gray region) delineates the control period used to compute $RTWD_{max}$. Note that the scales on the y-axis differ.

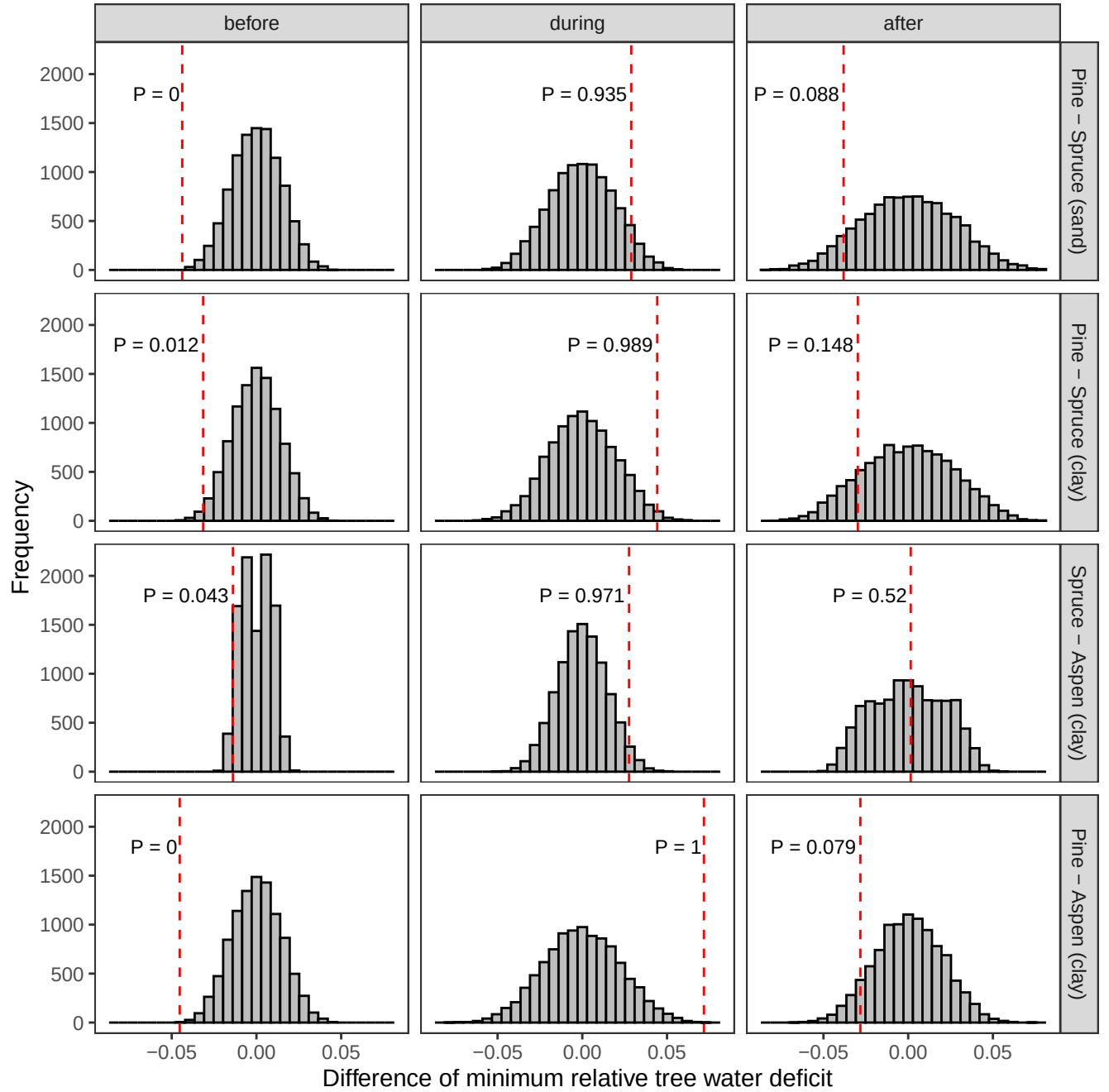


Figure S10: Results of the randomization tests comparing daily relative minimum tree water deficit ($RTWD_{min}$) across species and soil types. Plots are split in columns according to timing relative to the drought (before, during or after) and in rows according to the species and soil type used for comparison. Each plot shows the randomly expected distribution of mean difference in $RTWD_{min}$ between the trees of two species after randomly shuffling the species associated with each time series 10,000 times. The red dotted line indicates the actual mean difference observed in the dataset, while the value of P indicates the proportion of values in the random distribution that are smaller than the observed value. Values of $P < 0.025$ or $P > 0.975$ imply two-tailed statistical significance at a threshold of $\alpha = 0.05$.

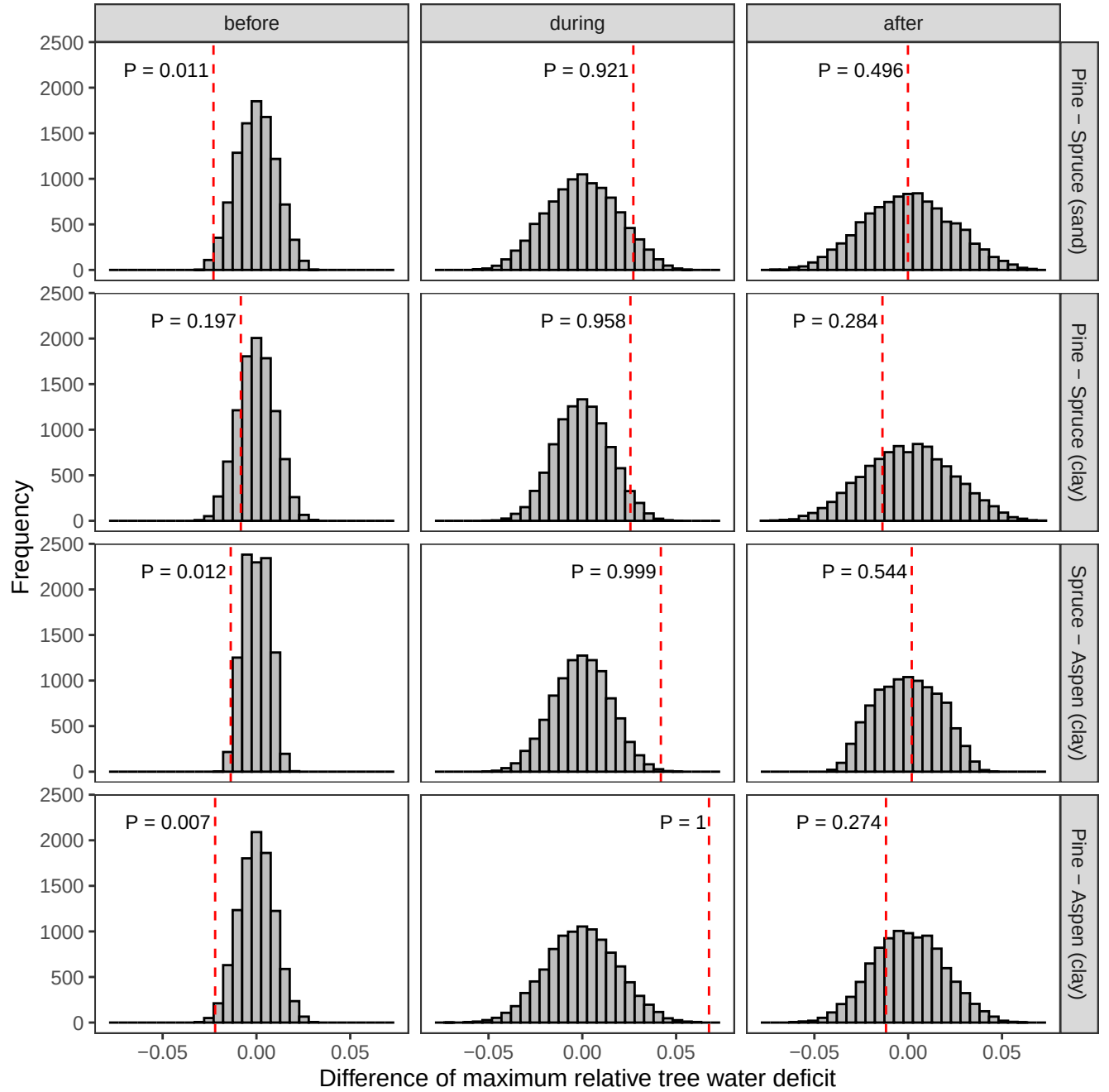


Figure S11: Results of the randomization tests comparing daily relative maximum tree water deficit ($RTWD_{max}$) across species and soil types. Plots are split in columns according to timing relative to the drought (before, during or after) and in rows according to the species and soil type used for comparison. Each plot shows the randomly expected distribution of mean difference in $RTWD_{max}$ between the trees of two species after randomly shuffling the species associated with each time series 10,000 times. The red dotted line indicates the actual mean difference observed in the dataset, while the value of P indicates the proportion of values in the random distribution that are smaller than the observed value. Values of $P < 0.025$ or $P > 0.975$ imply two-tailed statistical significance at a threshold of $\alpha = 0.05$.

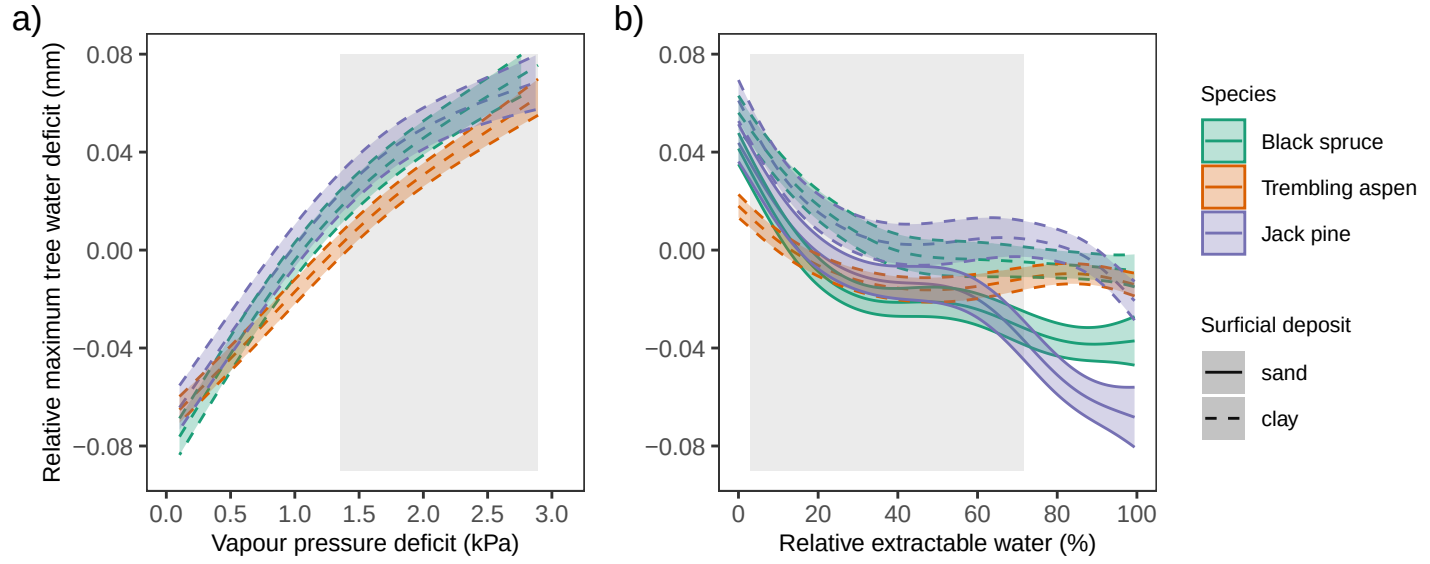


Figure S12: Predicted responses ($\pm$ standard error) of relative maximum tree water deficit ($RTWD_{max}$) to varying (a) vapour pressure deficit (VPD) and (b) relative extractable water (REW) according to the fitted generalized additive mixed models. Results are presented for each species and soil surficial deposit type. The gray shaded areas indicate the range of daily maximum VPD and average REW values observed at the height of the drought, from August 19 to 25, 2021.

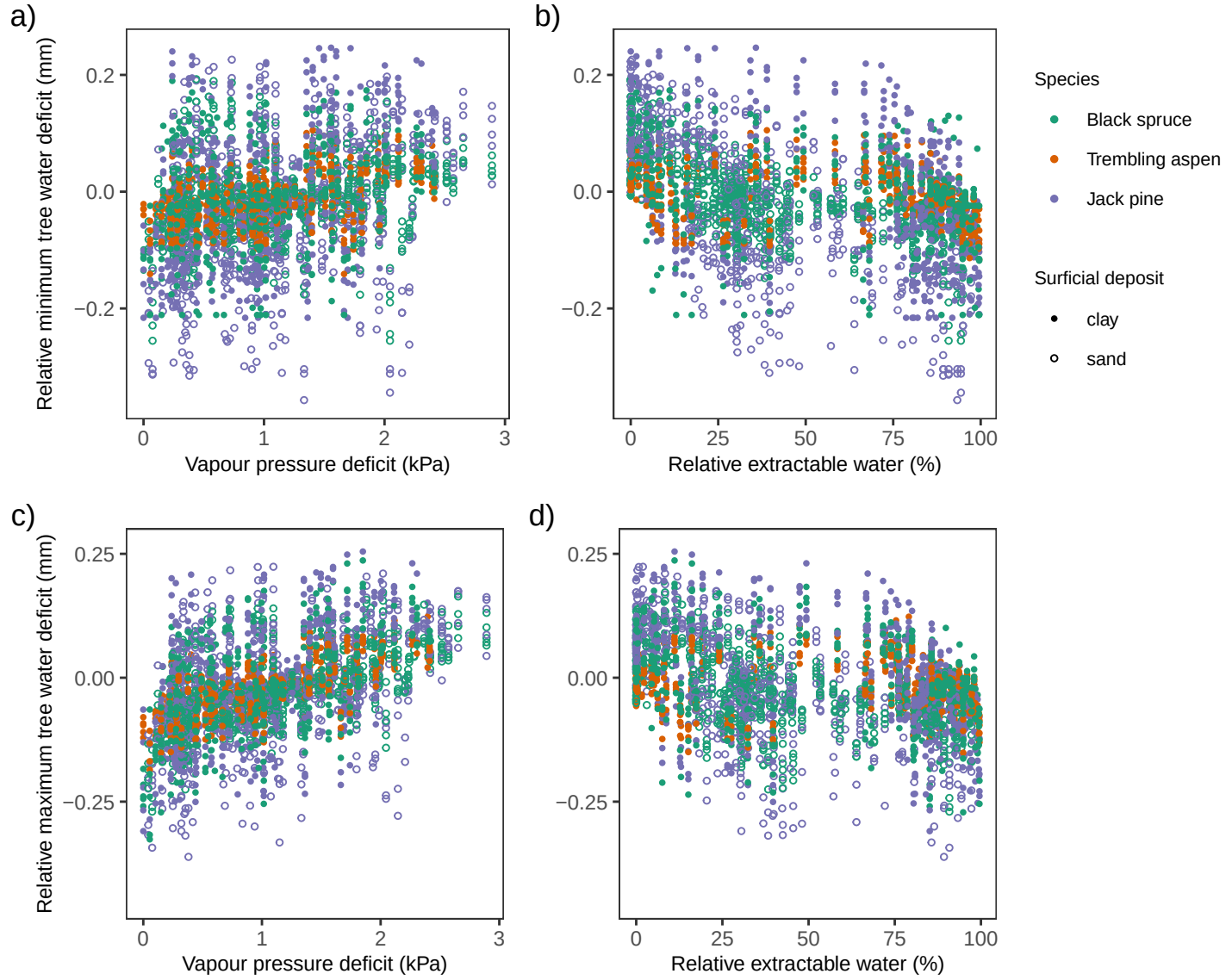


Figure S13: Daily relative minimum tree water deficit ($RTWD_{min}$) as a function of (a) maximum vapour pressure deficit and (b) relative extractable water, and daily relative maximum tree water deficit ($RTWD_{max}$) as a function of (c) vapour pressure deficit and (d) relative extractable water. These are the data used as input for fitting generalized additive mixed models.