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Supplementary information

Table S1. Site information including elevation, mean annual precipitation (MAP, mm) and standard deviation (SD) of monthly total precipitation, winter (December-March) precipitation and SD, summer (July-September) precipitation, and mean maximum temperature. Numbers of trees and cores collected, crossdated, and measured are also shown for each site.

					MAP	Winter	Summer	Mean		
No	Code	Site name	State	Elevation	(SD)	precip (SD)	precip (SD)	tmax (SD)	Trees	Cores
1	RCP	Rock Creek	UT	2315	569 (28)	206 (28)	147 (29)	10.6 (8.7)	19	37
2	MFP	Millers Flat	UT	2435	591 (31)	256 (35)	119 (23)	10.5 (8.4)	21	42
3	KPP	Kaibab Plateau	AZ	2271	490 (33)	176 (35)	154 (33)	15.6 (8.4)	29	57
4	LMP	Lockett Meadow	AZ	2608	701 (51)	283 (58)	229 (44)	13.7 (7.6)	12	25
5	SAP	Sierra Ancha Exper. Forest	AZ	2218	743 (63)	353 (78)	223 (43)	18.6 (7.3)	5	11
6	WCP	Santa Catalina Mountains	AZ	2317	765 (63)	294 (66)	320 (59)	17.6 (6.7)	8	23
7	CPP	Pinaleno Mountains	AZ	2682	816 (65)	281 (63)	338 (68)	14.8 (6.5)	9	19
8	SLS	Sacramento Mountains	NM	2551	692 (54)	170 (34)	333 (62)	13.8 (6.8)	12	27
9	GHP	Gallinas Mountains	NM	2426	453 (32)	98 (19)	206 (33)	15.8 (7.7)	4	8
10	SPP	Sandia Mountains	NM	2716	565 (35)	189 (32)	212 (36)	13.3 (8.2)	4	7
11	CDT	Mt Taylor	NM	2767	811 (54)	231 (38)	340 (68)	11.9 (7.8)	5	10
Total									128	266

Table S2. Coefficients of determination (R^2) obtained from linear regressions of observed versus predicted ring-width values for each site, for both the log-transformed growth data, $r = \log(\text{ring width} + 1)$, and the raw ring widths. See Table S1 and Fig. 1 for a description of the sites.

Site	log(ring width + 1)			Raw ring widths		
	Whole ring	Earlywood	Latewood	Whole ring	Earlywood	Latewood
1	0.82	0.81	0.64	0.82	0.81	0.59
2	0.92	0.88	0.85	0.92	0.88	0.84
3	0.88	0.87	0.72	0.86	0.86	0.71
4	0.81	0.78	0.71	0.81	0.79	0.67
5	0.74	0.72	0.55	0.69	0.68	0.52
6	0.78	0.73	0.56	0.75	0.72	0.52
7	0.84	0.81	0.61	0.80	0.76	0.57
8	0.74	0.72	0.57	0.73	0.72	0.52
9	0.85	0.85	0.65	0.83	0.82	0.63
10	0.76	0.76	0.43	0.72	0.73	0.40
11	0.75	0.74	0.55	0.72	0.72	0.53

Table S3. Coefficient of determination (R^2) for univariate regressions between posterior means of site-level P^{ant} , T^{ant} , and $P^{ant} \times T^{ant}$ main effects ($a_{s,k}$ terms in Eqn (7)) versus site characteristics (covariates), including summary climate variables, latitude, and elevation. Darkest gray shading indicates $p < 0.01$, light gray indicates $0.01 \leq p < 0.05$, and no shading indicates $0.05 \leq p < 0.1$ (when value reported) or non-significant (n.s.). All relationships were negative except for the relationships between the P^{ant} main effects and latitude.

Covariate*	P^{ant} effect			T^{ant} effect			$P^{ant} * T^{ant}$ effect		
	Whole ring	EW	LW	Whole ring	EW	LW	Whole ring	EW	LW
MAP (mm)	0.60	0.48	0.72	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Summer P (JAS; mm)	0.27	n.s.	0.54	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Winter P (DJFM; mm)	0.69	0.70	0.46	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
% summer P	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Yearly P variability (sd)	0.76	0.60	0.77	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Summer P variability (sd)	0.31	n.s.	0.56	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Winter P variability (sd)	0.89	0.84	0.62	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Yearly T	0.35	0.29	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Summer T	n.s.	n.s.	n.s.	0.34	0.31	n.s.	n.s.	n.s.	n.s.
Winter T	0.44	0.36	0.27	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Latitude	0.32	n.s.	0.42	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Elevation	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

*MAP = mean annual precipitation, P = precipitation, T = maximum temperature, sd = standard deviation

Table S4. Coefficient of determination (R^2) for univariate regressions between M50 (the month into the past at which the cumulative weights first exceed 0.5 for P^{ant} and T^{ant}) versus site characteristics (covariates), including summary climate variables, latitude, and elevation. Darkest gray shading indicates $p < 0.01$, light gray indicates $0.01 \leq p < 0.05$, and no shading indicates $0.05 \leq p < 0.1$ (when value reported) or non-significant (n.s.).

Covariate*	<i>M50_precipitation</i>			<i>M50_temperature</i>		
	Whole ring	EW	LW	Whole ring	EW	LW
MAP (mm)	0.33	0.32	0.28	n.s.	n.s.	n.s.
Summer P (JAS; mm)	n.s.	n.s.	0.46	n.s.	n.s.	n.s.
Winter P (DJFM; mm)	0.41	0.52	n.s.	n.s.	n.s.	n.s.
% summer P	n.s.	n.s.	0.27	n.s.	n.s.	n.s.
Yearly P variability (sd)	0.60	0.50	0.30	n.s.	n.s.	n.s.
Summer P variability (sd)	n.s.	n.s.	0.53	n.s.	n.s.	n.s.
Winter P variability (sd)	0.69	0.74	n.s.	n.s.	n.s.	n.s.
Yearly T	0.51	0.31	n.s.	n.s.	n.s.	n.s.
Summer T	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Winter T	0.63	0.41	n.s.	n.s.	n.s.	n.s.
Latitude	0.29	n.s.	n.s.	n.s.	n.s.	n.s.
Elevation	n.s.	n.s.	0.33	n.s.	n.s.	n.s.

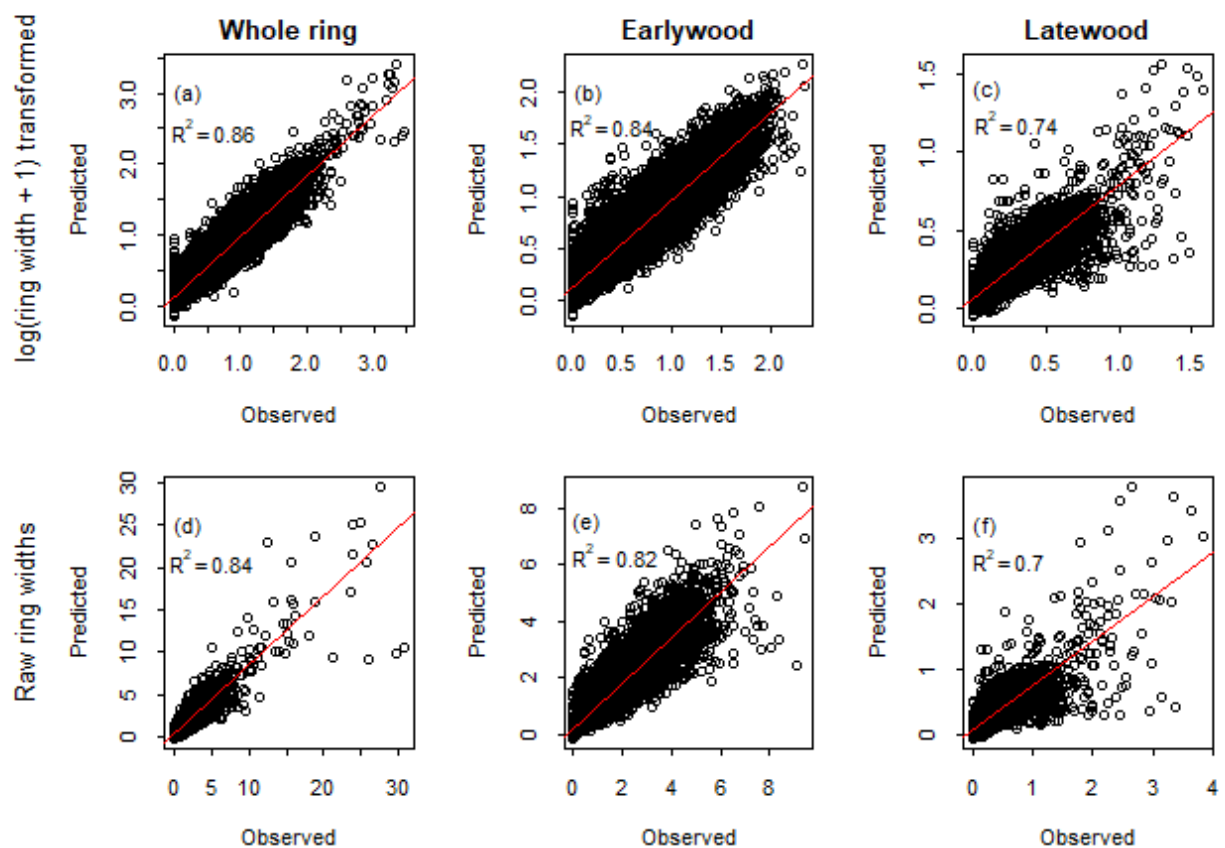


Figure S1. Top: Observed vs. predicted log(ring width + 1) values for (a) the whole ring, (b) earlywood, and (c) latewood. Bottom: Observed vs. predicted raw ring width values for (d) the whole ring, (e) earlywood, and (f) latewood. The red diagonal line is the best-fit regression line.

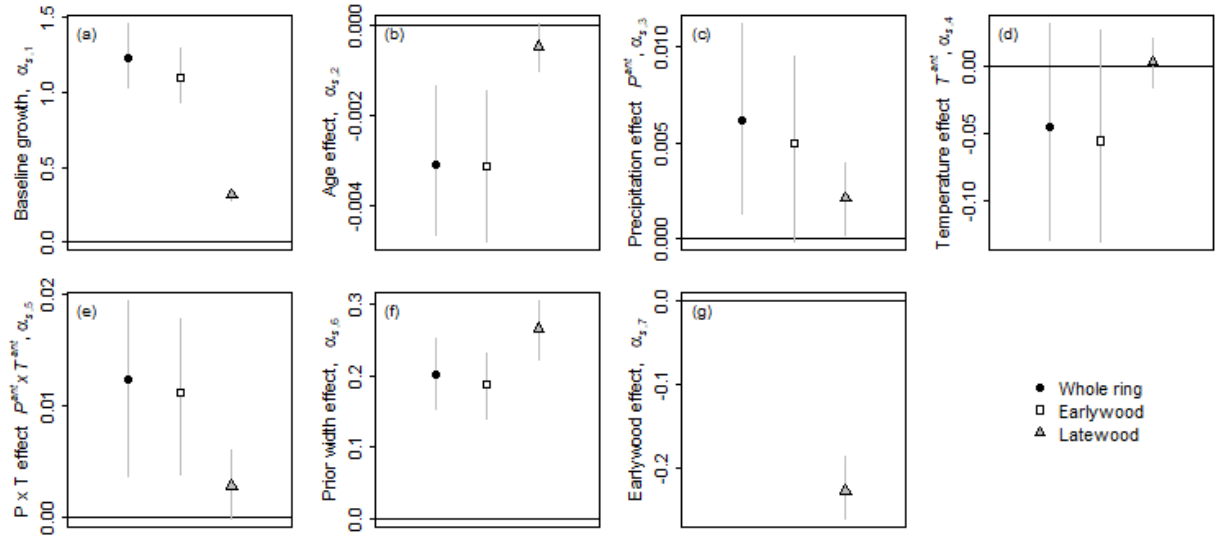


Figure S2. Posterior means (symbols) and 95% Bayesian credible intervals (whiskers) for study-level parameters, including (a) baseline growth (intercept; $a_{s,1}$), the effects of (b) antecedent precipitation (P^{ant} ; $a_{s,3}$), (c) the $P^{ant} \times T^{unt}$ interaction ($a_{s,5}$), (d) prior ring-width ($a_{s,6}$), (e) age (A ; $a_{s,2}$), (f) antecedent temperature (T^{unt} ; $a_{s,4}$), and (g) earlywood width for latewood ($a_{s,7}$); see Eqn (2) for model notation. Parameters with CIs not crossing zero are interpreted as reflecting important (“significant”) effects.

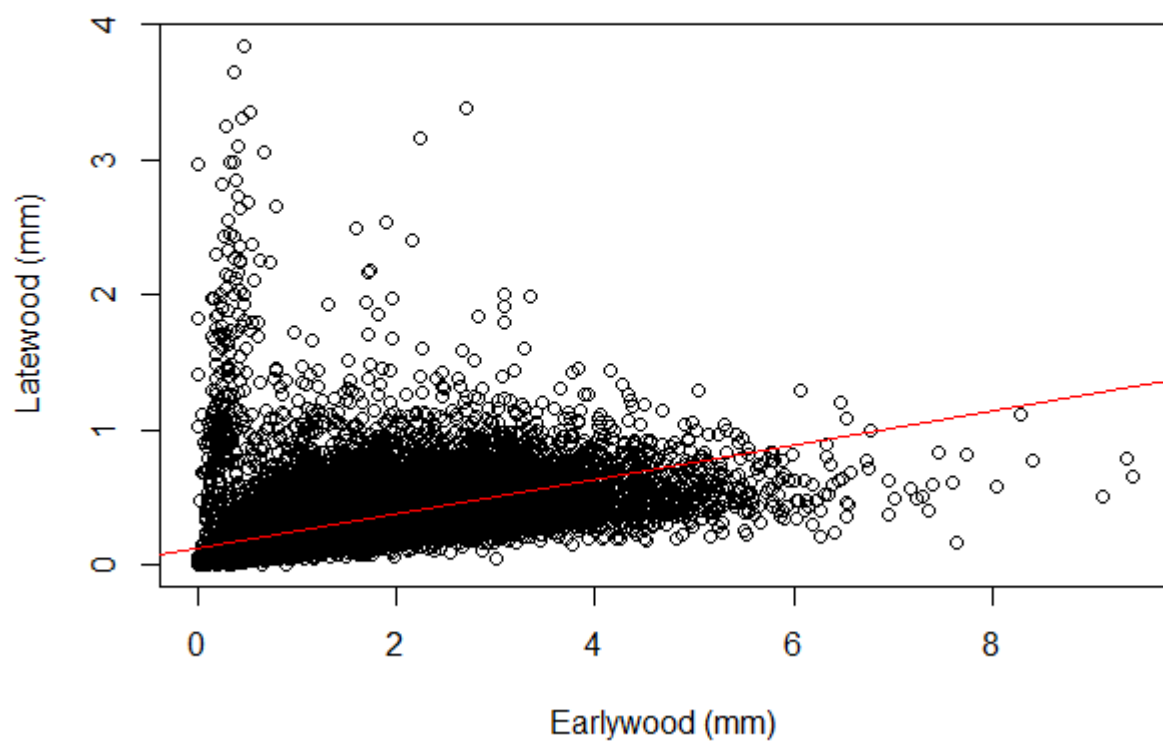


Figure S3. Raw earlywood and latewood widths are positively correlated ($R^2 = 0.27$, $p < 0.01$).

Data from all sites, trees, and rings are shown. Red line is best-fit regression line.

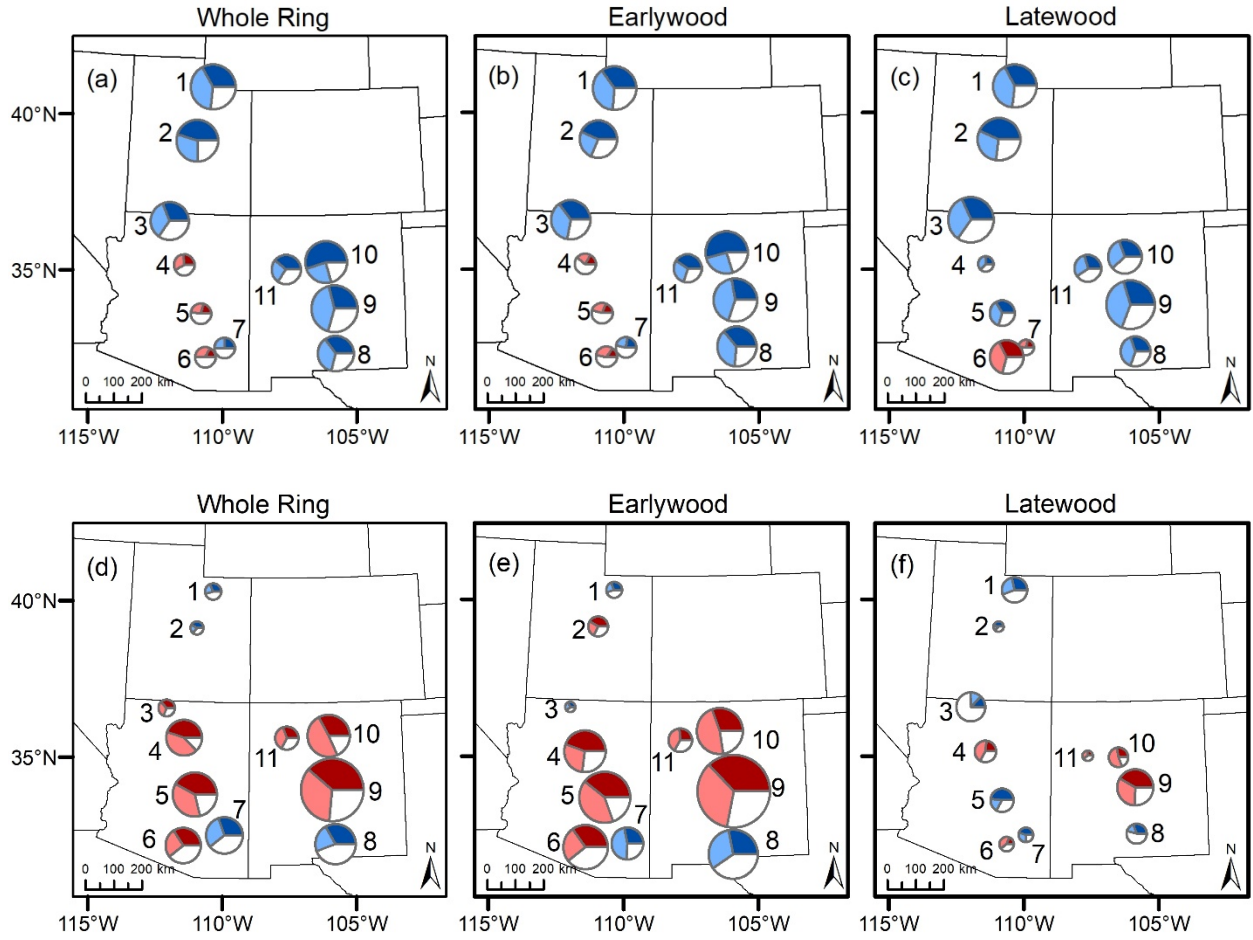


Figure S4. Annual importance weights (sum of $\omega_{j,m,s,X}$ across all months, m , within each year) for antecedent precipitation (top row; P^{ant}) and temperature (bottom row, T^{ant}) for (a, d) whole-rings, (b, e) earlywood, and (c, f) latewood. Within each panel, symbols are sized according to the P^{ant} or T^{ant} effect size (see Fig. 2c,d); blue indicates positive effects of P^{ant} or T^{ant} and red indicates negative effects. The color shading represents the time period associated with the annual weights, with the darkest color representing the year of growth, the lighter color for the year prior to growth, and white for the summed weights from years 2, 3, and 4 years prior to growth.

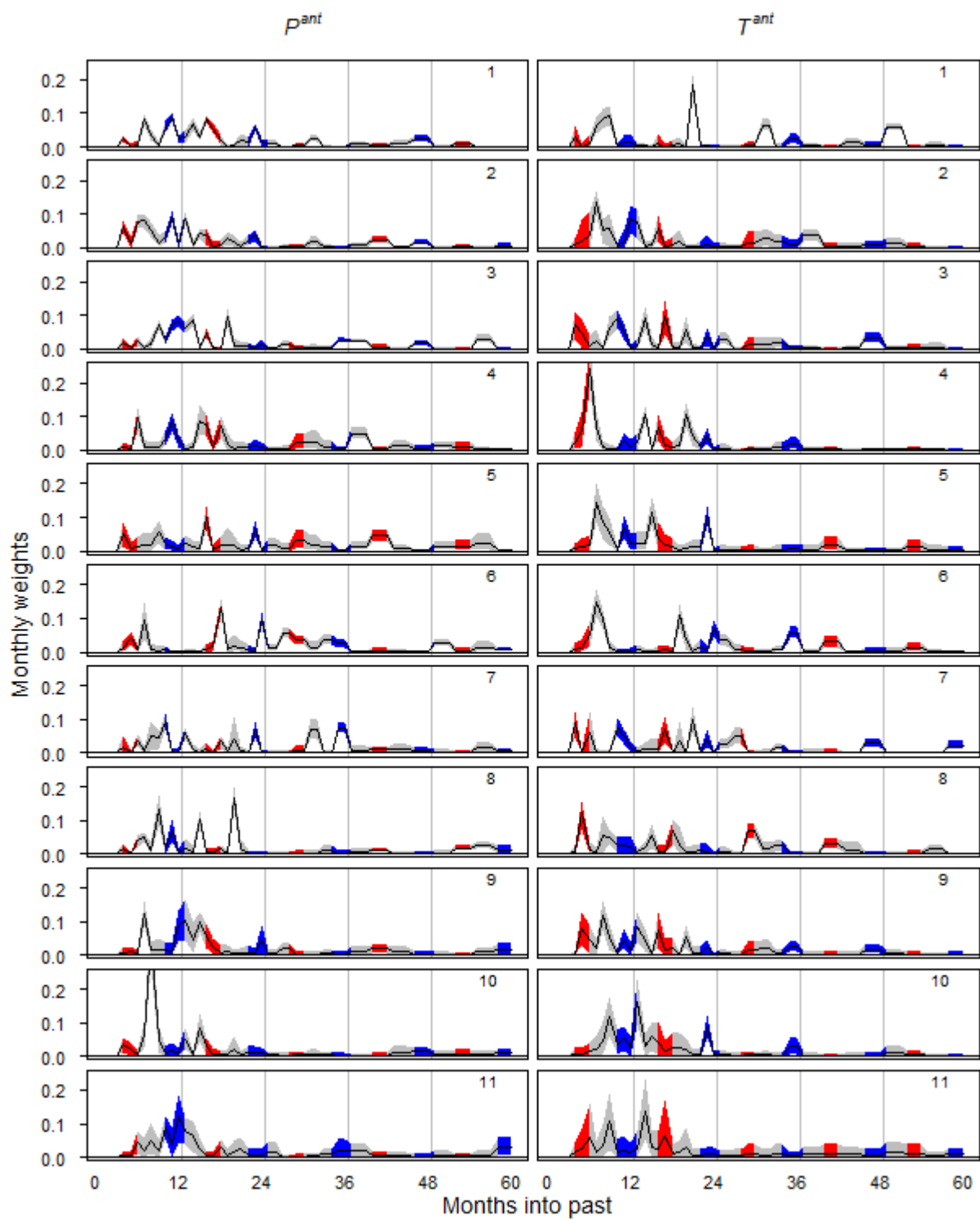


Figure S5a. Monthly mean antecedent weights for P^{ant} (left) and T^{ant} (right) for the whole ring model (thin black lines), with 95% Bayesian credible intervals (shading). Red shading covers the

summer months (July, August, September), blue shading covers winter months (December, January, February, March), and gray shading covers fall and spring months. The months and years are ordered from ‘most recent’ such that, for example, month $m = 12$ and year $y = 0$ corresponds to December of the current year (‘months into the past’ = 1) and month $m = 1$ and year $y = 4$ corresponds to January four years prior to the current year (‘months into the past’ = 60).

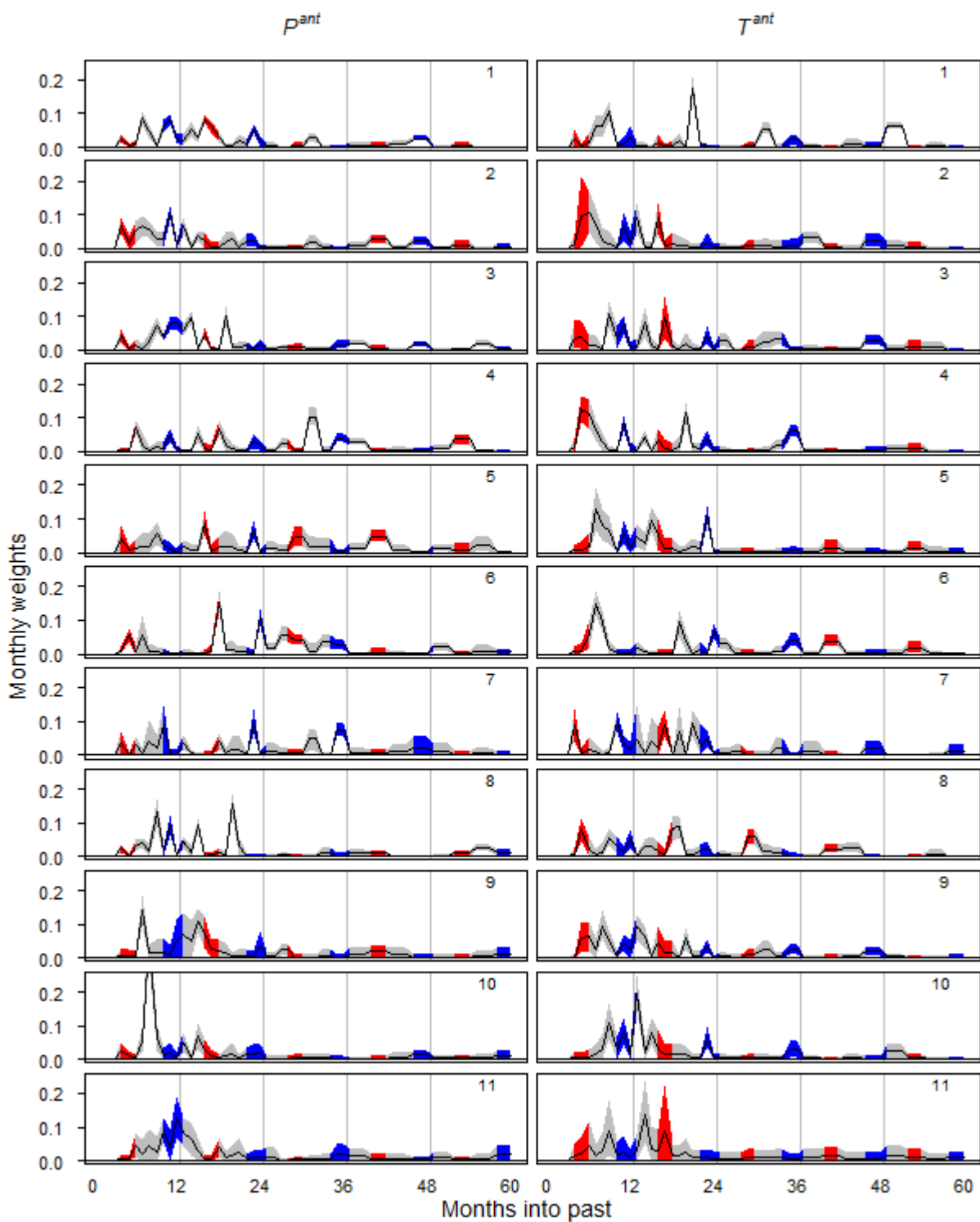


Figure S5b. Monthly mean antecedent weights for P^{ant} (left) and T^{ant} (right) for the earlywood model (thin black lines), with 95% Bayesian credible intervals (shading). Red shading covers the

summer months (July, August, September), blue shading covers winter months (December, January, February, March), and gray shading covers fall and spring months. The months and years are ordered from ‘most recent’ such that, for example, month $m = 12$ and year $y = 0$ corresponds to December of the current year (‘months into the past’ = 1) and month $m = 1$ and year $y = 4$ corresponds to January four years prior to the current year (‘months into the past’ = 60).

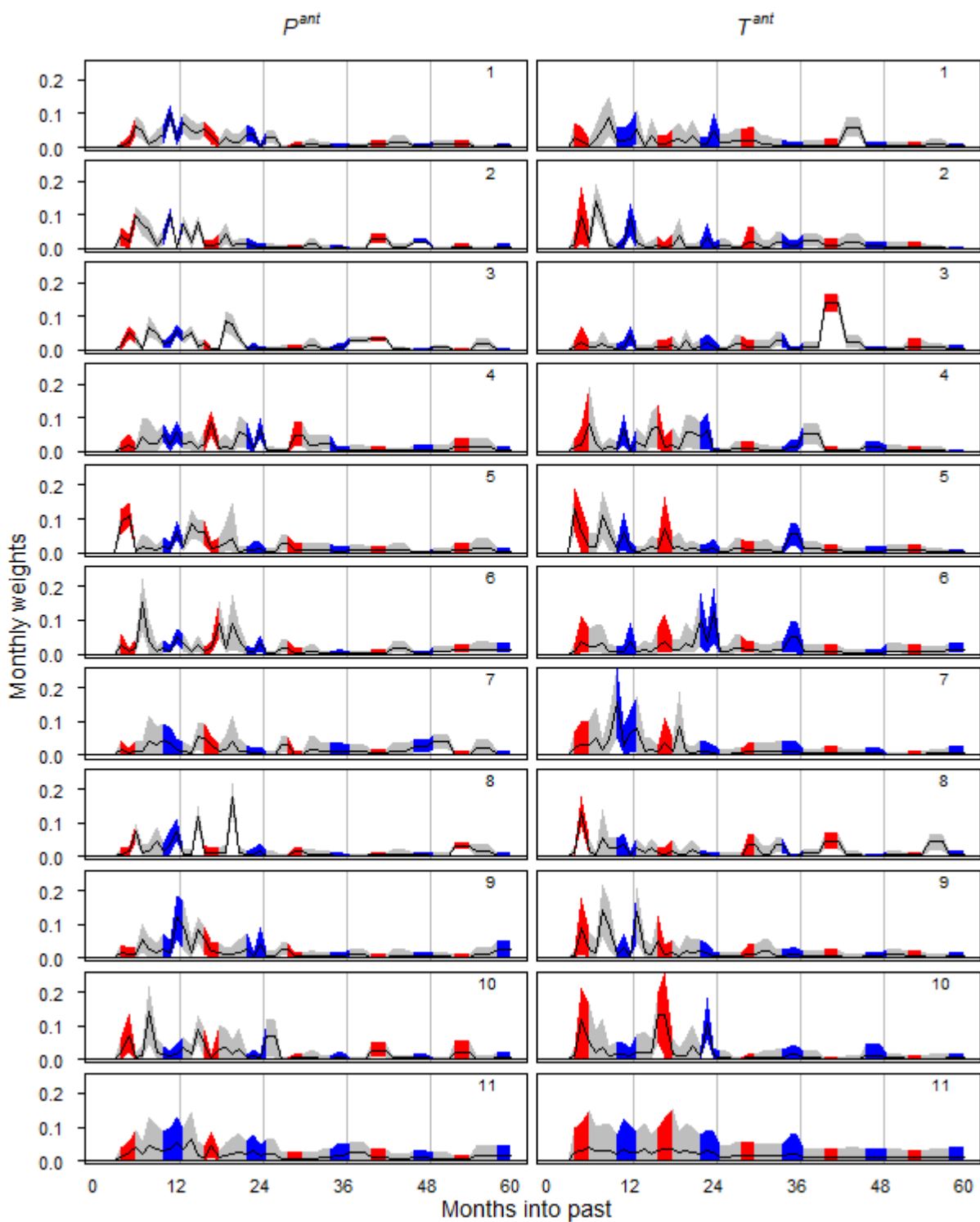


Figure S5c. Monthly mean antecedent weights for P^{ant} (left) and T^{ant} (right) for the latewood model (thin black lines), with 95% Bayesian credible intervals (shading). Red shading covers the

summer months (July, August, September), blue shading covers winter months (December, January, February, March), and gray shading covers fall and spring months. The months and years are ordered from ‘most recent’ such that, for example, month $m = 12$ and year $y = 0$ corresponds to December of the current year (‘months into the past’ = 1) and month $m = 1$ and year $y = 4$ corresponds to January four years prior to the current year (‘months into the past’ = 60).

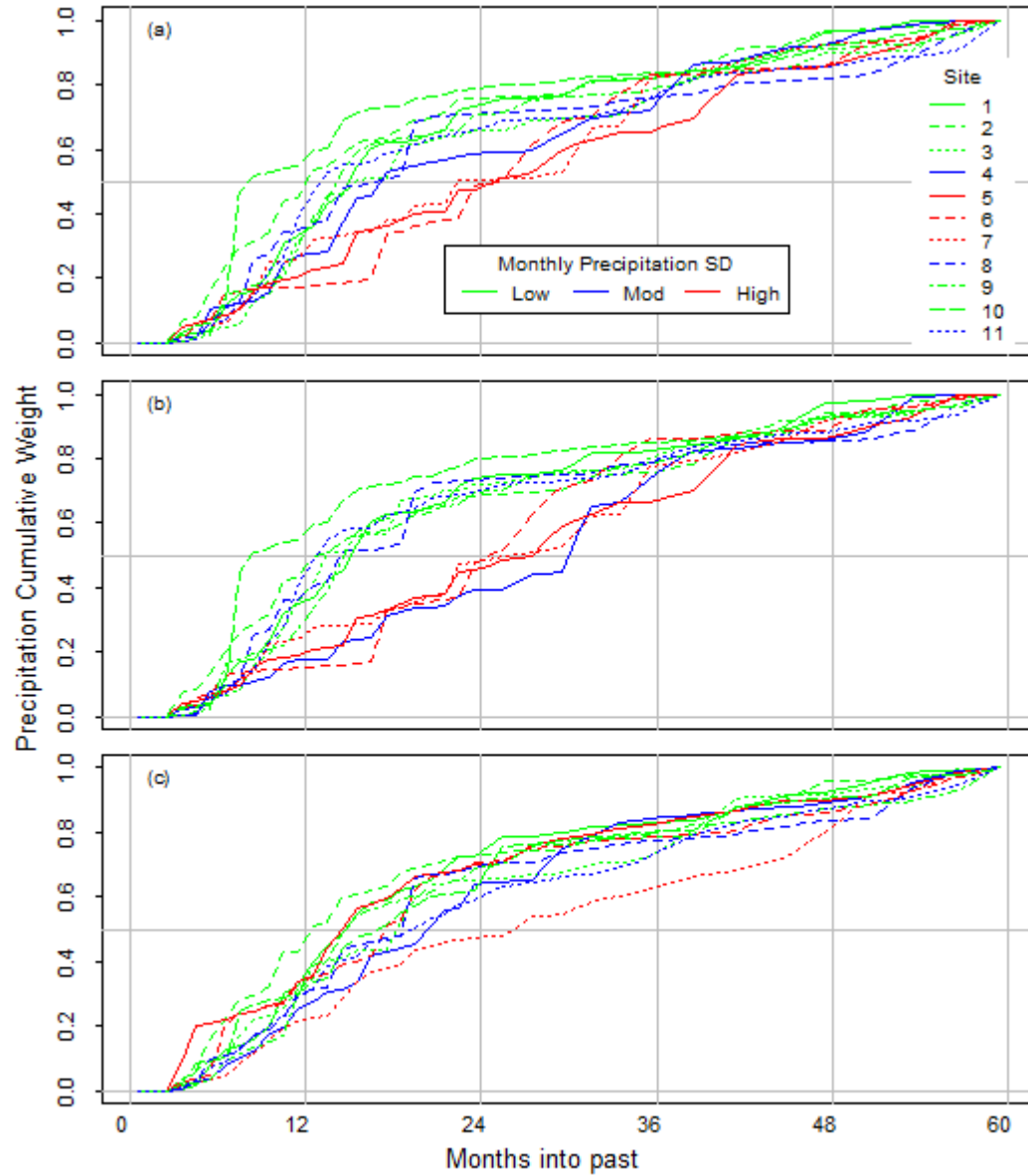


Fig. S6. Posterior means of cumulative monthly weights ($\omega_{j,m,s,X}$ summed from most recent month, $m = 12$ [December] and year $y = 0$, to specific “Months into past”) for antecedent precipitation (P^{ant}) for (a) whole-ring widths, (b) earlywood, and (c) latewood. Sites with red lines have highest variability in monthly precipitation (standard deviation, $SD > 60$ mm), sites with blue lines have moderate variability ($SD = 50$ - 55 mm), and sites with green lines have least variability ($SD = 25$ - 35 mm). An index of climatic memory is given by M_{50} , which is defined as the month into the past at which the cumulative weights first exceed 0.5 (horizontal gray line).

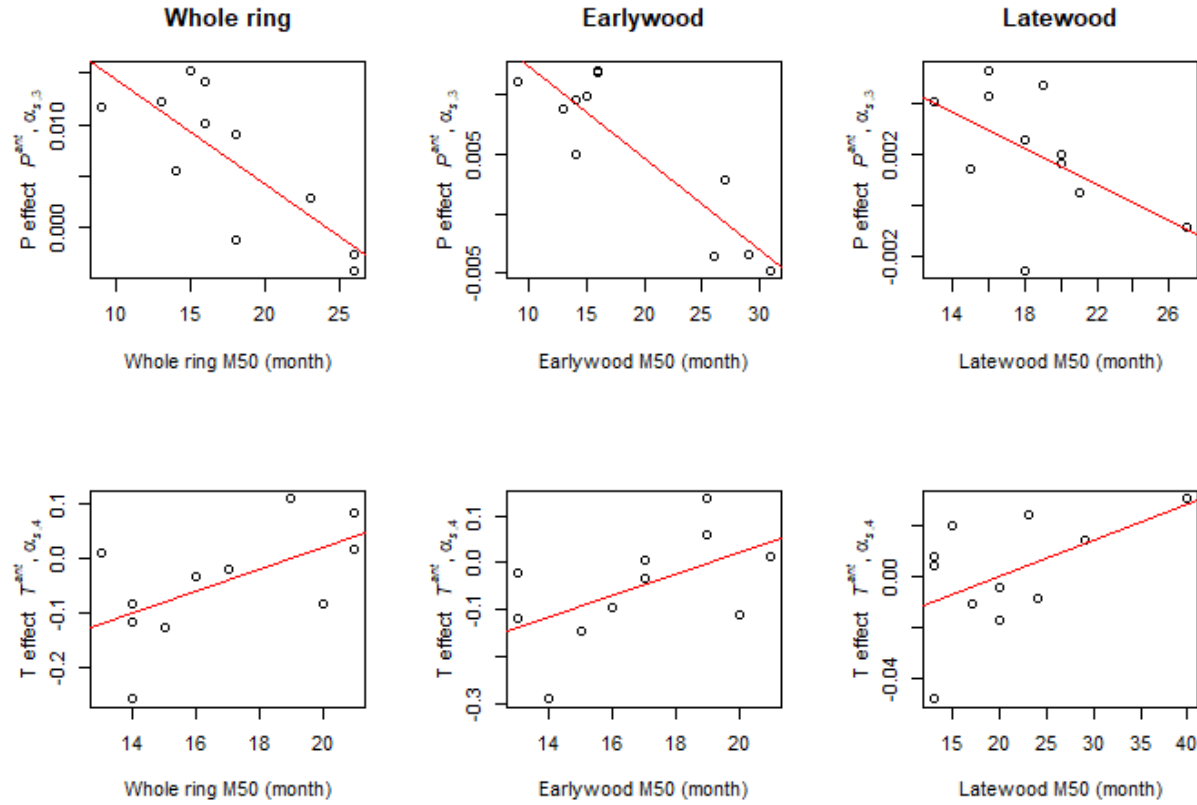


Figure S7. Relationships between climatic memory (M_{50}) and site-level P^{ant} ($\alpha_{s,3}$; top) and T^{ant} ($\alpha_{s,4}$; below) main effects. Left: whole ring, middle: earlywood, right: latewood. The M_{50} values are derived from the data used to create Fig. 3 in the main text. Regression lines are shown for significant relationships ($p < 0.05$).

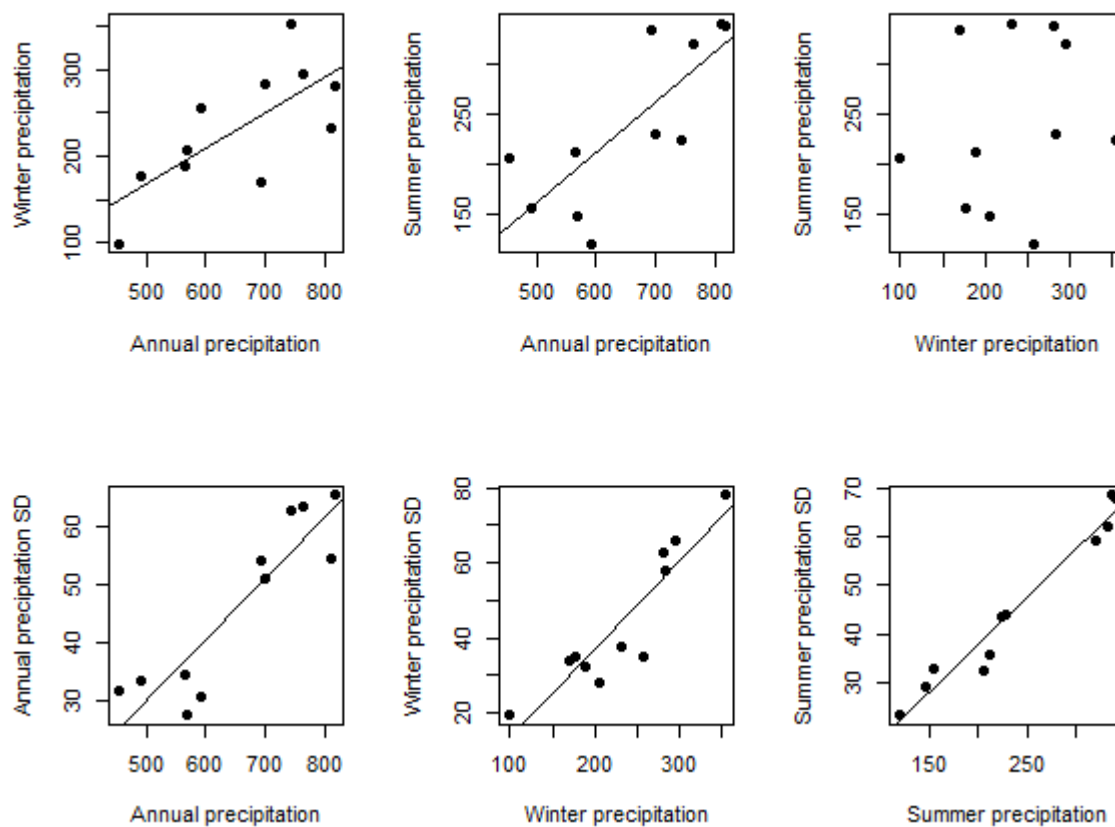


Figure S8. Relationships between season and annual total precipitation (top row), and between precipitation variability (standard deviation, SD) and amount (bottom row). Points represent individual sites. Regression lines are shown for significant relationships ($p < 0.05$).