Supplementary information

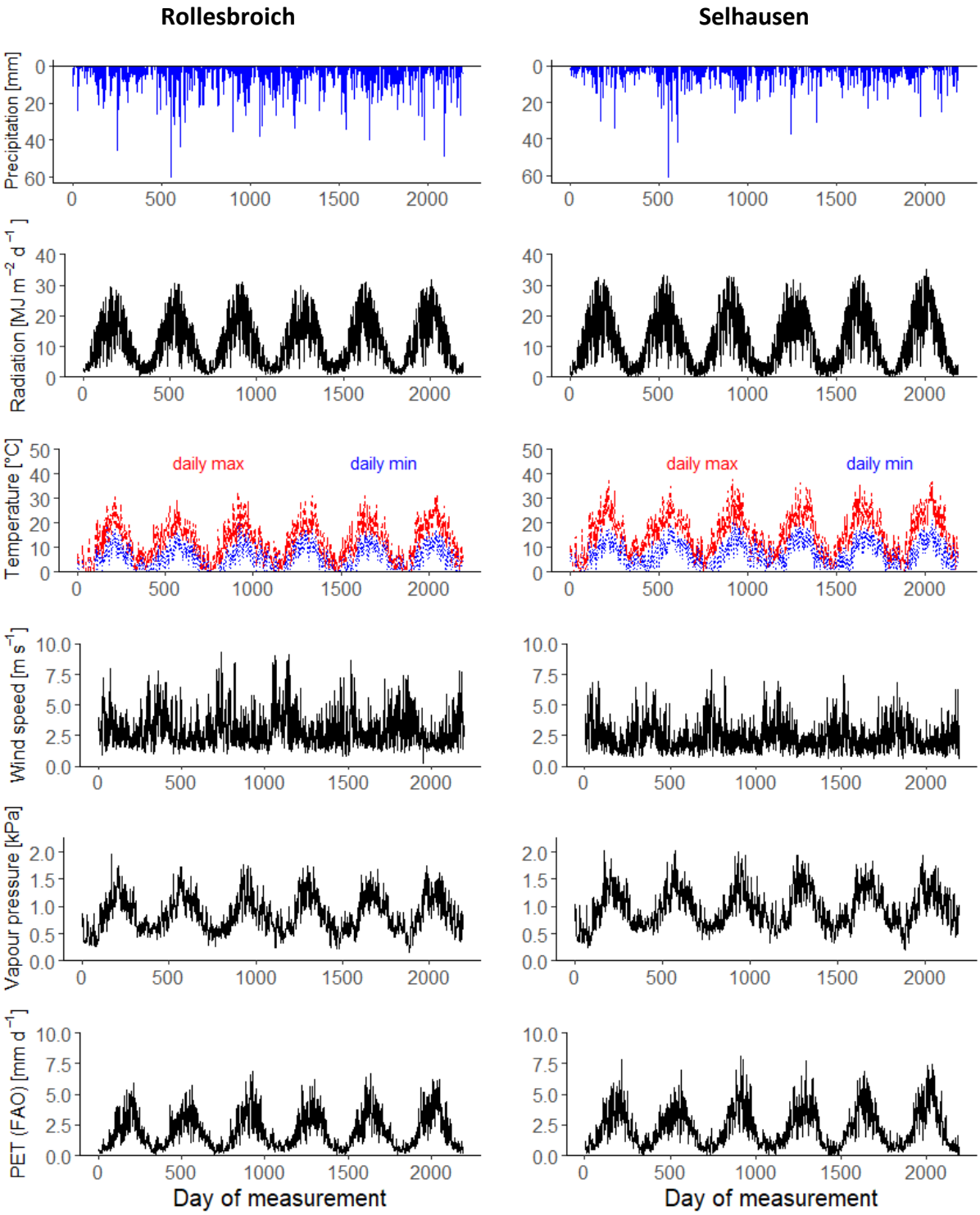

Figure S1: Meteorological variables recorded at Rollesbroich and Selhausen (2013-2018; aggregated to a daily time resolution) and calculated potential evapotranspiration using the FAO version of the Penman-Monteith equation (Allen et al., 1998).

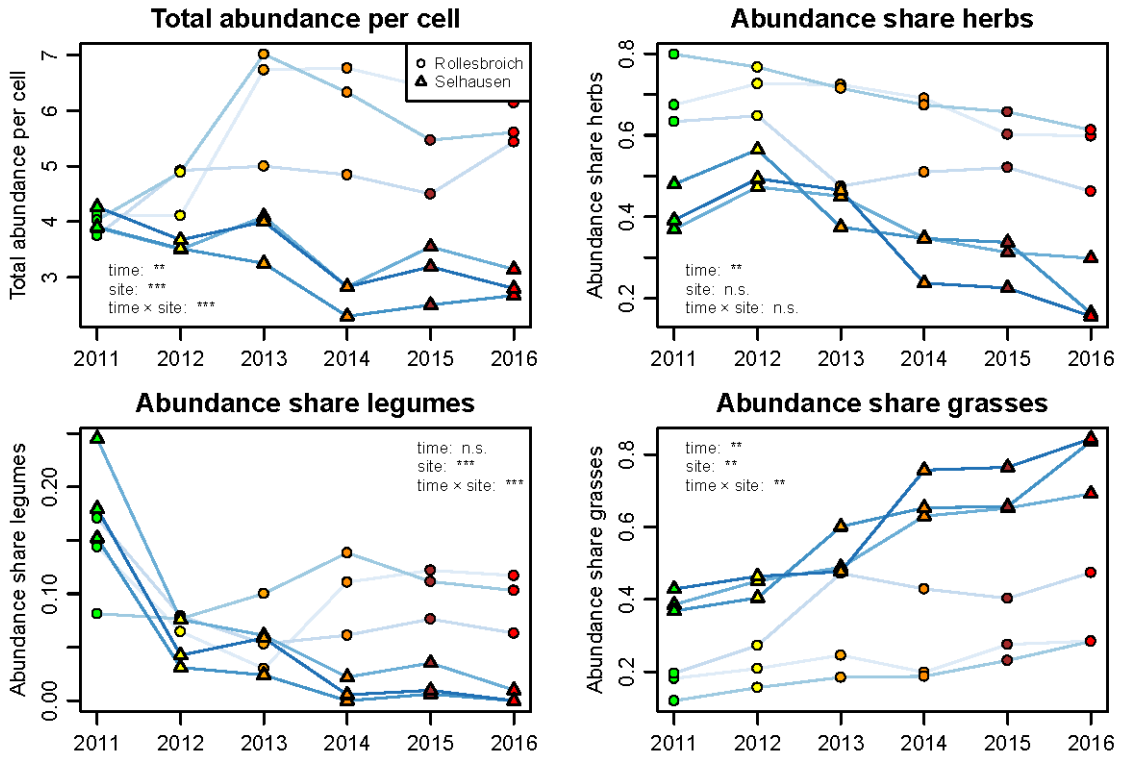

Figure S2. Total species abundance per cell and relative abundances of functional plant types. The results of a linear model analysis are depicted in each figure to indicate the significance of the effects of time, site (Rollesbroich vs. Selhausen) and the interaction of time and site: n.s. $p > 0.1$, $p < 0.1$, * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

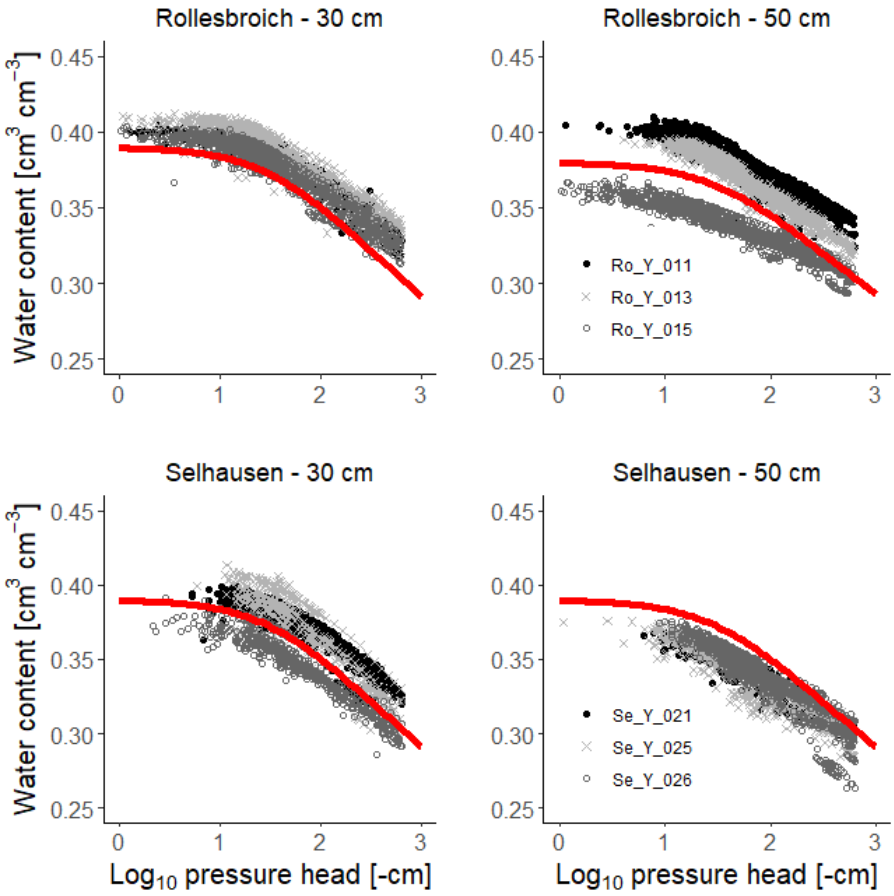

Figure S3. Paired measurements of soil water content and pressure head at 30 and 50 cm depth at Selhausen and Rollesbroich in the period 2013-2018. The red lines show the common water retention curves used in the modelling for the two sites at each depth (the equivalent parameter values are shown in table 3 in the paper). Table S1 below shows parameter values derived from least-squares fits to the individual data series for each lysimeter/depth combination.

Table S1. van Genuchten parameters derived from fits to individual data sets

Depths (cm)	Lysimeter	θ_s (m^3 m^{-3})	α (cm^{-1})	n (-)
30	Se_Y_021 Se_Y_025 Se_Y_026	0.391 0.391 0.379	0.005 0.003 0.030	1.17 1.33 1.09
50	Ro_Y_011 Ro_Y_013 Ro_Y_015	0.402 0.409 0.400	0.020 0.030 0.030	1.06 1.07 1.05

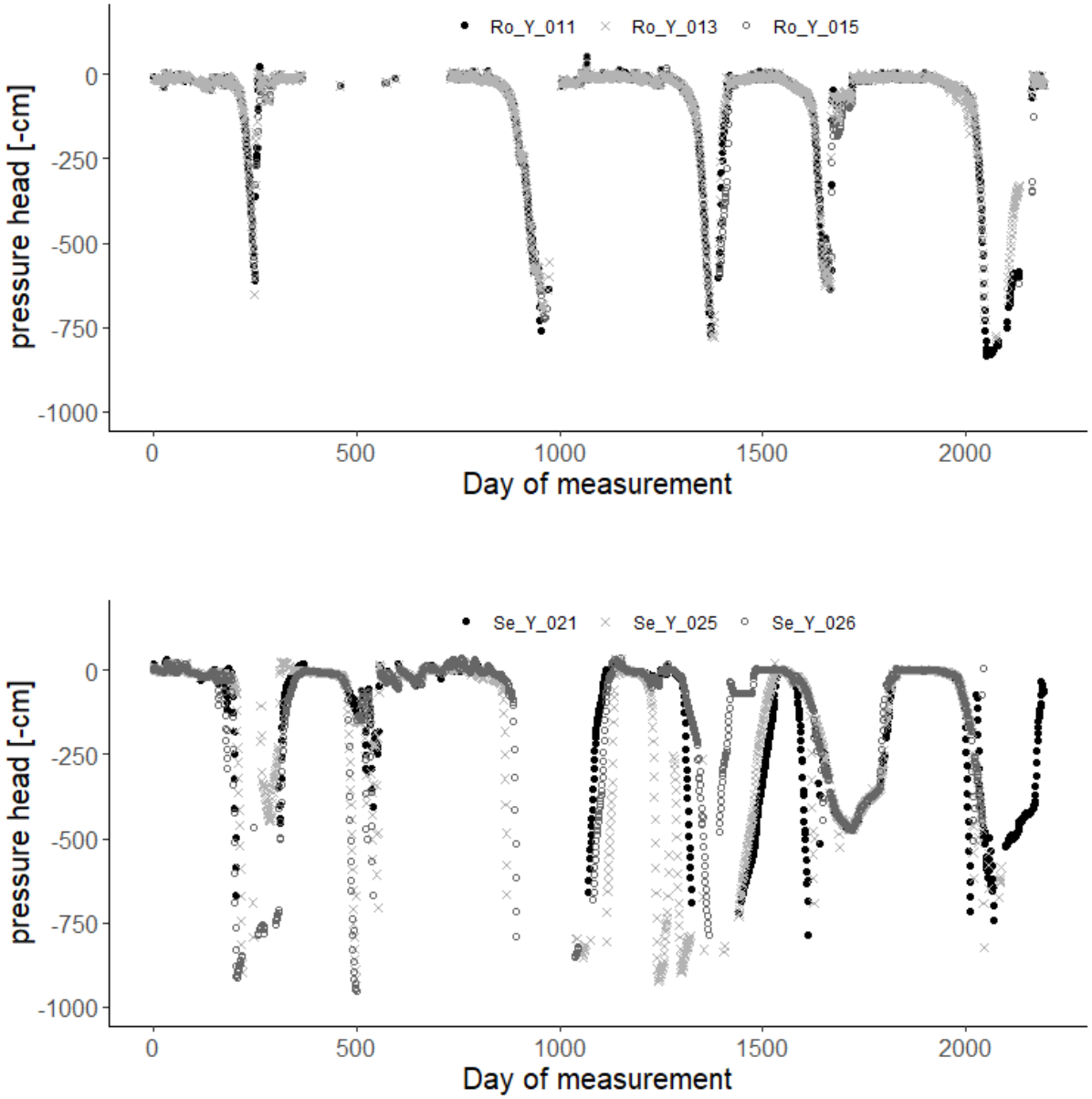

Figure S4. Pressure heads measured in the surrounding soil at 1.4 m depth at the two sites in the period 2013-2018 (day zero is 1st January 2013).

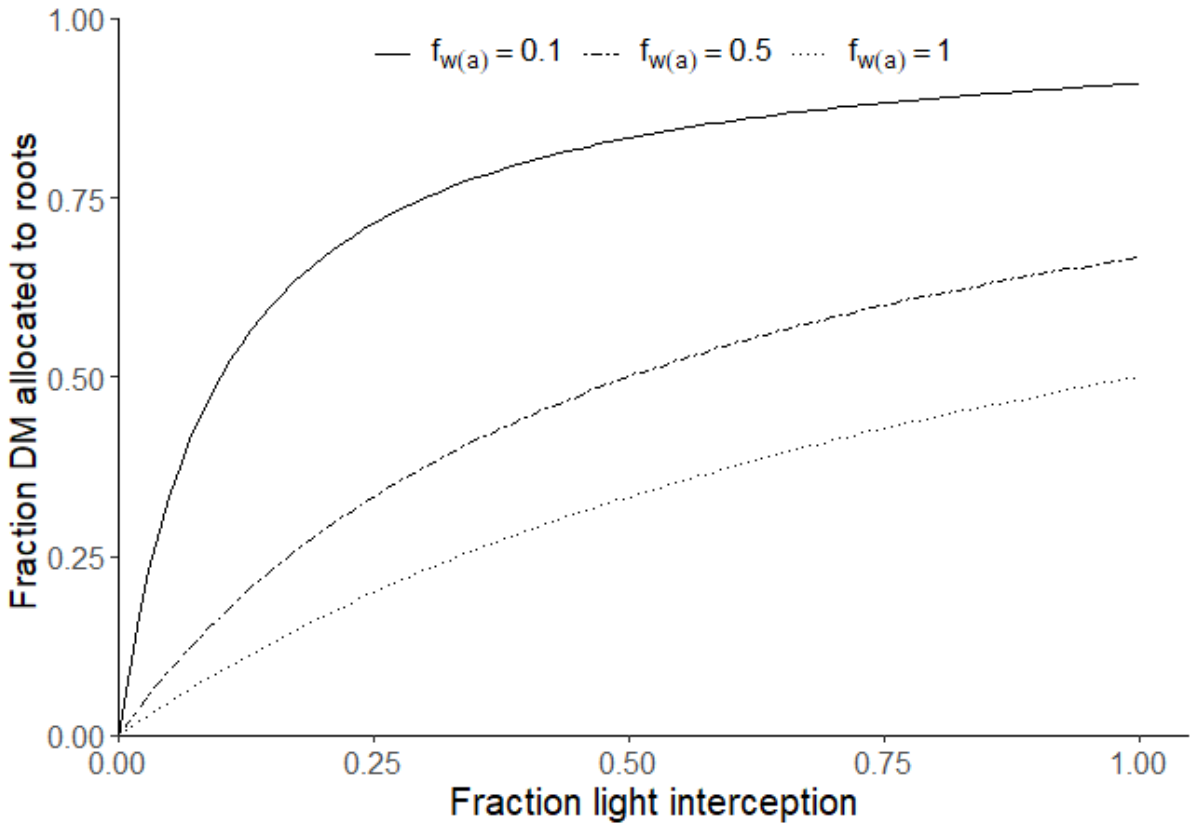

Figure S5. Illustration of equation 30, showing how DM allocation in the model varies as a function of light interception (f_{int} in equation 12) and soil water stress ($f_{w(a)}$ in equation 35). In this example, the proportion of DM allocated to roots under optimal conditions, $f_{bg(opt)}$, is set to 0.5, while air temperature is within the optimum range (i.e. $f_{t(a)}$ = 1, equation 36).

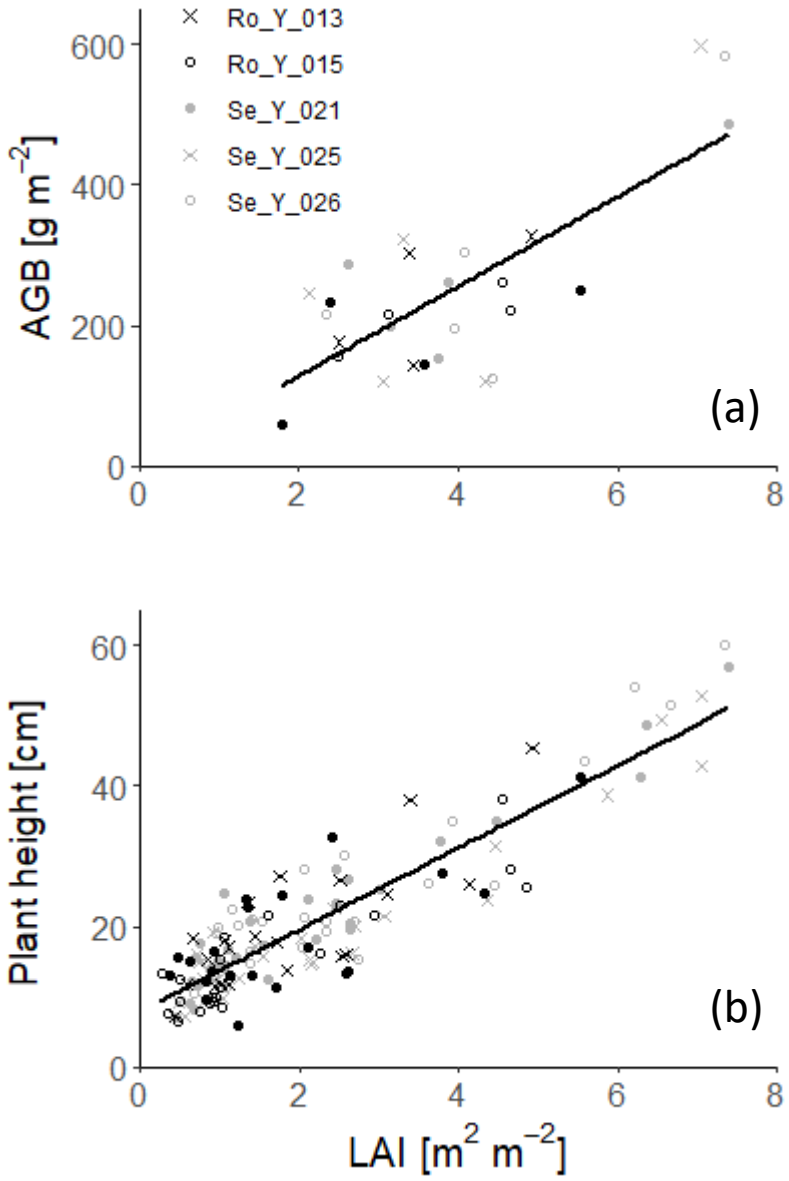

Figure S6. Relationships between leaf area index (LAI) at Rollesbroich and Selhausen (data from 2013-2018) and (a) above-ground biomass (linear regression forced through origin, AGB (g m^{-2}) = 63.8 LAI; p<0.0001, RMSE=86.7 g m^{-2}) and (b) plant height. A bi-linear function was used in the model to describe this relationship; the linear regression equation shown on the figure was used for LAI > 0.2; Height (cm) = 7.84 + 5.85 LAI; R^2=0.81, p<0.0001, RMSE=4.8 cm, while for LAI < 0.2, Height (cm) = 45 LAI.

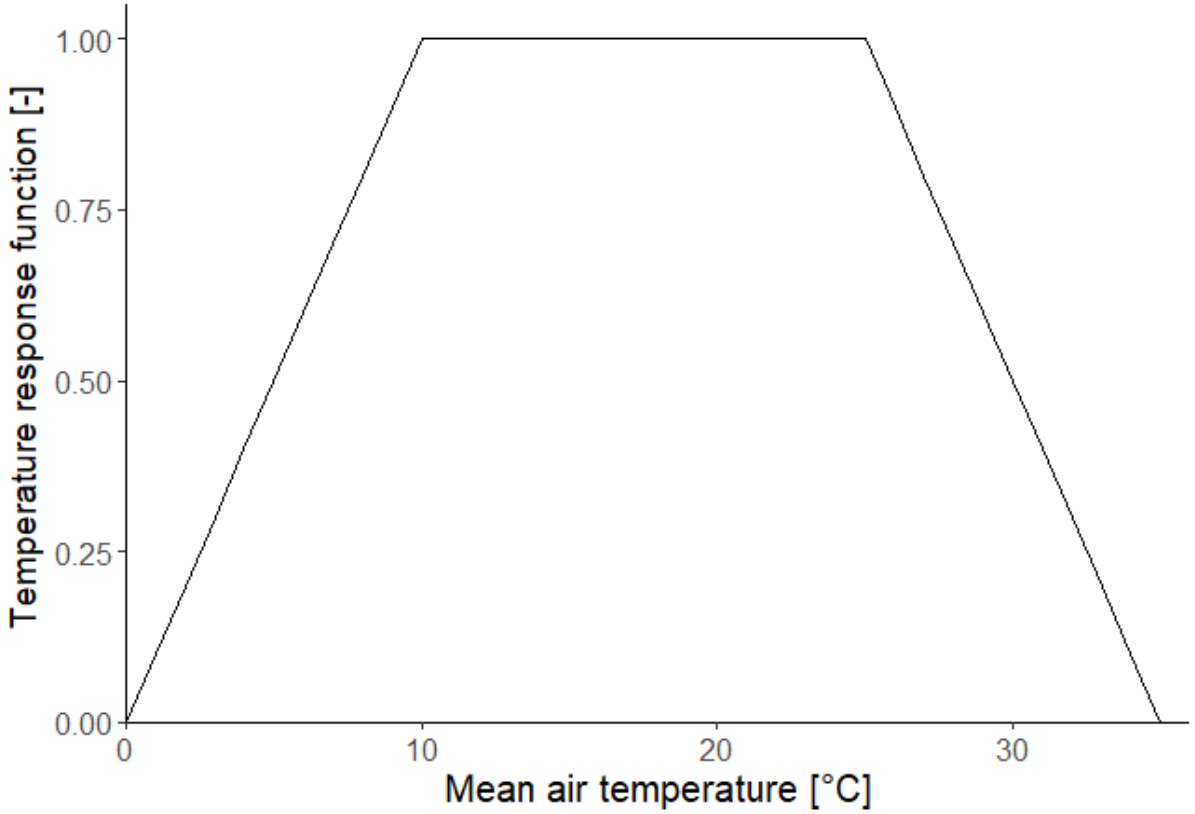

Figure S7. Illustration of the temperature response function in the model (equation 36). In this example, T_b = 0°C, $T_{o(low)}$ = 10°C, $T_{o(high)}$ = 25°C and T_c = 35°C.

Table S2. Sensitivity analysis: sampled parameter ranges and Spearman rank partial correlation coefficients (**p<0.01; *p<0.05)

Parameter	Sampled range	Selhausen		Rollesbroich	
		Evapotranspiration	Harvest	Evapotranspiration	Harvest
Soil parameters					
van Genuchten's α (cm^{-1})	0.02 to 0.03	**-0.39****	0.01	-0.15*	**0.17****
Scaling factor for van Genuchten's *n* (-)	0.95 to 1.05	**0.39****	**0.37****	**0.36****	**0.20****
Scaling factor for hydraulic conductivity, K_{10} (-)	0.8 to 1.2	**0.41****	0.12	0.10	-0.10
Surface resistance of wet soil, r_s^s (s m^{-1})	5 to 25	**-0.34****	0.04	**-0.60****	0.03
Above-ground plant parameters					
Maximum radiation use efficiency, RUE_{max} (MJ m^{-2} d^{-1})	1.4 to 1.8	**0.55****	**0.66****	**0.57****	**0.74****
Radiation extinction coefficient, β (-)	0.4 to 0.8	**0.68****	**0.72****	**0.64****	**0.87****
Light saturation constant, R_{50} (MJ m^{-2} d^{-1})	0 to 10	**-0.48****	**0.28****	**-0.63****	0.15*
Leaf loss coefficient, k_{ag} (d^{-1})	0.005 to 0.05	**-0.54****	**-0.65****	**-0.60****	**-0.72****
Maximum stomatal conductance, $k_{sto(max)}$ (cm s^{-1})	0.5 to 1.5	**0.66****	**-0.66****	**0.77****	**-0.39****
Specific leaf area, S_{leaf} (cm^2 g^{-1})	130-150	**0.32****	0.01	**0.29****	**0.23****
Base temperature (for leaf loss and allocation), T_b (°C)	3 to 6	-0.07	-0.11	**-0.22****	**-0.34****
Optimum temperature, $T_{o(low)}$ (°C)	9 to 15	**-0.64****	**-0.59****	**-0.71****	**-0.81****
Optimum temperature, $T_{o(high)}$ (°C)	20 to 30	0.04	0.00	-0.09	-0.05
Ceiling temperature, T_c (°C)	30 to 40	0.11	0.06	0.02	0.06
Limiting potential for transpiration cessation, ψ_w (m)	100 to 150	0.02	0.04	0.08	0.01
Limiting potential (DM allocation, leaf loss), $\psi_{o(crit)}$ (cm)	100 to 2000	**0.56****	**0.80****	**0.39****	**0.67****
DM allocation to roots under optimal conditions $f_{bg(opt)}$ (-)	0.4 to 0.6	**-0.38****	**-0.74***	**-0.34****	**-0.78****
Root parameters					
Root decay constant, k_{bg} (d^{-1})	0 to 0.02	**-0.37****	-0.17*	**-0.37****	-0.02
Root radius, r_o (cm)	0.01 to 0.03	-0.01	0.04	0.05	0.03
Effective root fraction, ε (-)	0 to 0.2	**0.62****	**0.44****	**0.56****	**0.19****
Specific root length, S_{root} (m g^{-1})	100 to 140	0.15*	0.13	0.12	0.07
Shape factor for root distribution, *c* (-)	-2 to -1	-0.07	0.09	-0.10	0.02
Maximum root depth, D_r (cm)	40 to 90	**0.92****	**0.71****	**0.79****	**0.33****

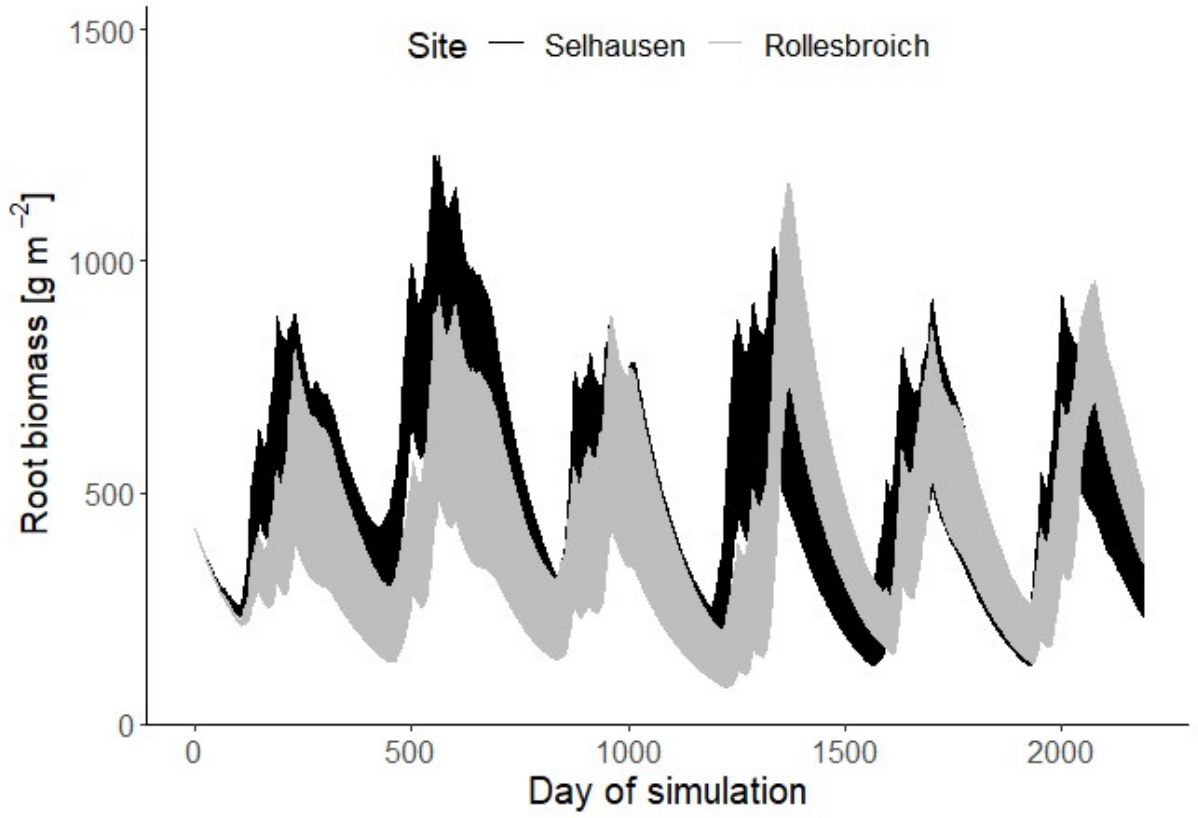

Figure S8. Temporal dynamics of root biomass at Rollesbroich and Selhausen simulated by the model for the 30 acceptable parameterizations