Global ecological drivers of transpiration regulation in woody plants

DOCTORADO EN ECOLOGIA TERRESTRE

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Abstract

Understanding how climate affects species' distribution and performance is a central issue in ecology since its origins. In last decades, however, the interest in this question has been reactivated by the current context of climate change. Species Niche Modelling has been widely used to assess shifts in species distribution and to test the relationship between species' climatic niche and species physiological and demographic performance, implicitly assuming that species occurrence portrays the environmental and biotic species' suitable conditions. Nevertheless it is still largely undetermined whether these models can portray population and community responses, particularly in relation to extreme climatic episodes.

In this thesis I aim at exploring the capacity of niche modelling to predict species decay under extreme climatic conditions, particularly droughts, addressing some constraints of this approach and proposing possible solutions. To achieve this goal, I counted with 3 vegetation decay datasets measured in the Spanish SE after the extreme drought year 2013-2014. Two of these datasets were based on defoliation sampling of individual plants belonging to more than 40 semiarid shrubland species (chapters 2, 4 and 5), while the other one was based on regional compiled data of *Pinus halepensis* L. affectation in plots of $1km^2$ (chapter 3). In second chapter I used different Species Distribution Model (SDMs) algorithms to estimate species' climatic suitability before (1950-2000) and during the extreme drought, in order to test the possible correlation between suitability and decay, and whether the existence of this relationship depended on the applied SDM algorithm. I consistently found a

positive correlation between remaining green canopy and species' climatic suitability before the event, suggesting that populations historically living closer to their species' tolerance limits are more vulnerable to drought. Contrastingly, decreased climatic suitability during the drought period did not correlate with remaining green canopy, likely because of extremely low climatic suitability values achieved during the exceptional climatic episode. In order to test whether this extremely low suitability values could derive as a consequence of only considering climatic averages when calibrating SDMs, in the third chapter I developed a method to include inter-annual climatic variability into niche characterization. I then compared the respective capacities of climatic suitabilities obtained from averaged-based and from inter-annual variability-based niches to explain demographic responses to extreme climatic events. I found that climatic suitability obtained from both niches quantifications significantly explained species demographic responses. However, climatic suitability from inter-annual variability-based niches showed higher explanatory capacity, especially for populations that tend to be more geographically marginal. In the fourth chapter I tried to overcome the inability of the SDMs to predict populations decay during extreme conditions, as observed in the second chapter, by using Euclidean distances to species' niche in the environmental space. I compared the capacities of both population distances in the climatic environmental space and population climatic suitability derived from SDMs to explain population observed physiological and demographic responses to an extreme event. Additionally, I tested such relationship in populations located in three different bedrock sites, corresponding to a gradient of water availability. I found that SDMs-derived suitability failed to explain population decay while distances to the niche centroid and limit significantly explained population die-off, highlighting that population displaced farther from species' niche during the extreme episode showed higher vulnerability to drought. The results also suggested a relevant role of some bedrocks buffering species decay responses to extreme drought events mainly according to soil water holding capacity. Finally, in the fifth chapter, I used species niche characterizations in the environmental space and demographic data to address the impact of extreme events at community level. Particularly, I estimated the community climatic disequilibrium before and after a drought episode along a gradient of water availability in three bedrock types. Disequilibrium was computed as the difference between observed climate and community-inferred climate, which was calculated as the mean of species' climatic optimum weighted by species abundance collected in field surveys. I found that extreme drought nested within a decadal trend of increasingly aridity led to a reduction in community climatic disequilibrium, particularly when combined with low water-retention bedrocks. In addition, community climatic disequilibrium also varied before the extreme event across bedrock types, according to soils water-retention capacity. In conclusion, by developing different techniques, derived from species distribution, that characterize climatic accuracy at population and community level, this work reveals the capacity of species climatic niche to explain demographic responses under climate change-induced episodes of extreme drought.

“No one will protect what they don’t care about;
and no one will care about what they have never experiened”

David Attenborough

1

division: 'Biology'

Placeholder

1.0.1 Sap flow calibration datasets

1.0.2 Calibration assessment

1.0.3 Statistical analyses

1.0.4 Calibration performance compared among methods and families of methods

1.0.5 Influence of wood traits

A

Appendix Chapter 2

A.1 Figures A

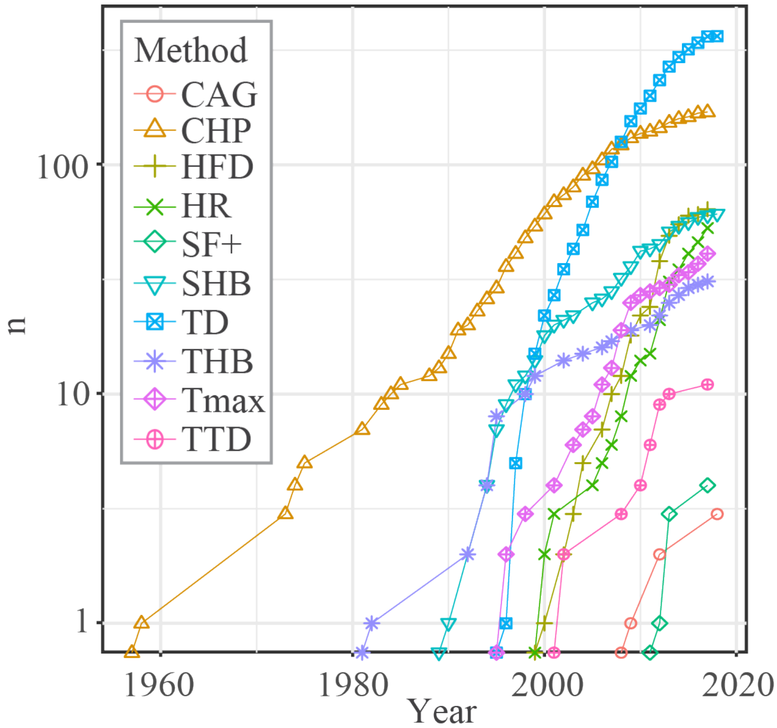


Figure A.1: Representation of the cumulative number of studies using different sap flow methods between 1957 and 2017 (adapted and updated from Poyatos et al. 2016). CAG: calibrated average gradient; CHP: compensation heat pulse (early heat pulse methods have been considered CHP, Edwards et al. 1997); HFD: head field deformation; HR: heat ratio, SF+: sapflow+; SHB: stem heat balance; TD: thermal dissipation; THB: trunk heat balance; Tmax: T-max heat pulse; TTD: transient thermal dissipation. Notice the logarithmic scale on the y-axis.

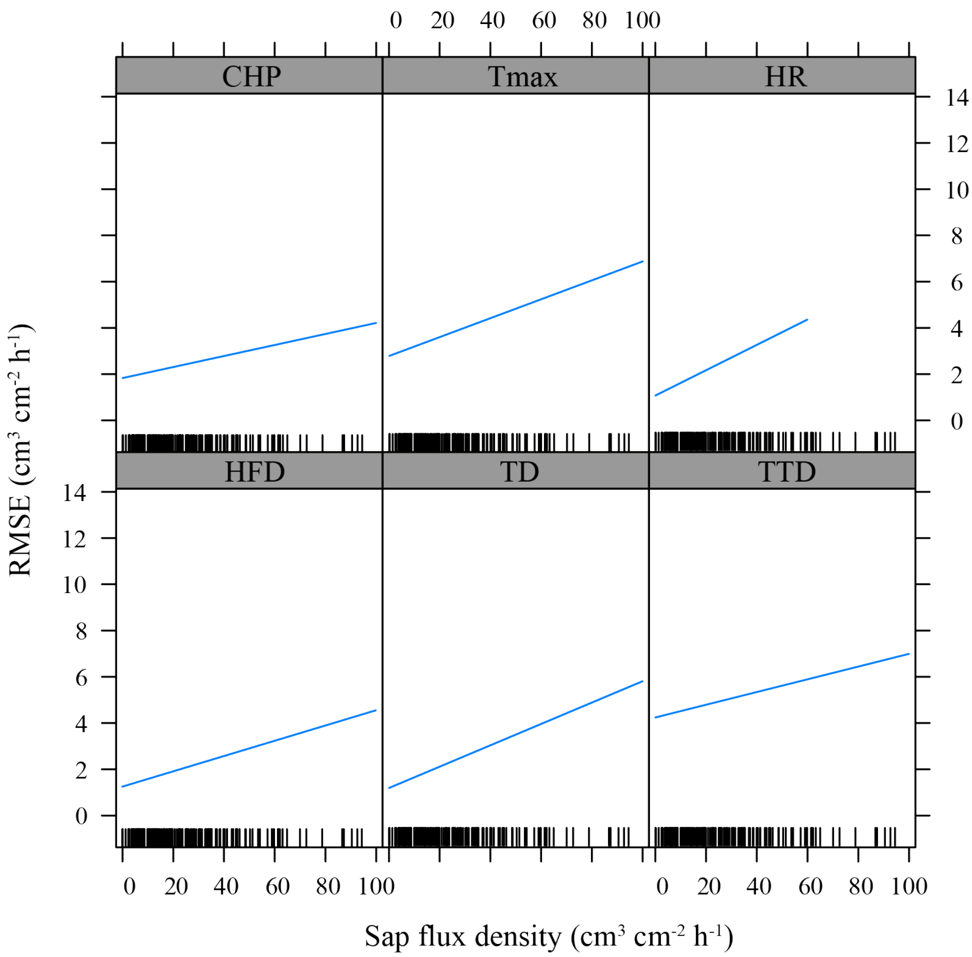


Figure A.2: Relationship between root mean square error (RMSE) and sap flux density (mean calibration range) and for different sap flux density methods, as predicted by the LMM model presented in Table 3.

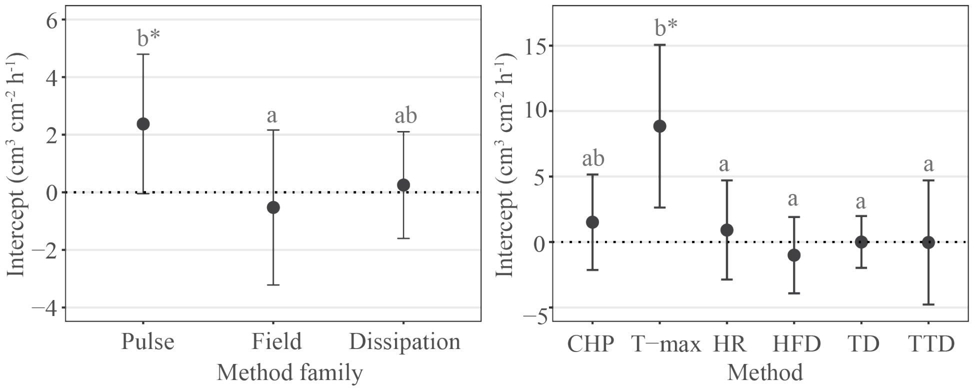


Figure A.3: Predictions of the LMM models calculated from least-squares means of the intercept (β_0) of the linear model (Eq. 3). Different letters indicate significant differences between factors levels evaluated with Tukey's test. Horizontal, dotted lines indicate reference, perfect calibration values for a given metric. Asterisks (*) indicate significant (p<0.05) departure from those reference values.

A.2 Tables A

Table A.1: Summary table of the studies used in the analyses presented in the paper. Sap flow method, species, calibration material, porosity and average stem/tree diameter are reported.

Study	Method	Species	Calibration material	Wood porosity	Diameter (cm)
Alarcon *et al.* 2005	CHP	*Citrus limon*	whole plant	Diffuse porous	2.50
Ballester et al 2011	CHP	*Citrus clementina*	whole plant	Diffuse porous	NA
Barret *et al.* 1995	CHP	*Corymbia maculata*	without roots	Diffuse porous	NA
Bleby *et al.* 2004	CHP	*Eucalyptus marginata*	whole plant	Diffuse porous	10.00
Bleby *et al.* 2004	HR	*Eucalyptus marginata*	whole plant	Diffuse porous	10.00
Braun and Schmid 1999	TD	*Vitis vinifera*	whole plant	Ring porous	3.75
Burgess *et al.* 2001	HR	*Eucalyptus marginata*	whole plant	Diffuse porous	NA
Bush *et al.* 2010	TD	*Populus fremontii*	stem segment	Diffuse porous	5.08
Bush *et al.* 2010	TD	*Tilia cordata*	stem segment	Diffuse porous	4.83
Cain 2009	TD	*Macaranga hypoleuca*	stem segment	Diffuse porous	82.00
Cain 2009	TD	*Macaranga pearsonii*	stem segment	Diffuse porous	67.00
Caspari *et al.* 1993	CHP	*Pyrus serotina*	whole plant	Diffuse porous	6.62
Caterina *et al.* 2013	TD	*Juniperus virginiana*	stem segment	Tracheids	8.00
Chan 2015	TD	*Abies concolor*	stem segment	Tracheids	6.00
Cohen *et al.* 1981	T-max	*Platanus orientalis*	stem segment	Diffuse porous	6.70
Cohen *et al.* 1981	T-max	*Populus alba*	stem segment	Diffuse porous	6.70
Cohen *et al.* 1998	T-max	*Malus domestica*	whole plant	Diffuse porous	NA
Dragoni *et al.* 2005	CHP	*Malus domestica*	whole plant	Diffuse porous	6.50
Dye *et al.* 1996	CHP	*Pinus patula*	without roots	Tracheids	NA
Fernandez *et al.* 1999	CHP	*Olea europaea*	stem segment	Diffuse porous	8.80
Fernandez *et al.* 1999	CHP	*Olea europaea*	without roots	Diffuse porous	NA
Fernandez *et al.* 2006	CHP	*Citrus sinensis*	stem segment	Diffuse porous	7.80
Fernandez *et al.* 2006	CHP	*Citrus sinensis*	without roots	Diffuse porous	10.40
Fernandez *et al.* 2006	CHP	*Olea europaea*	stem segment	Diffuse porous	8.20
Fernandez *et al.* 2006	CHP	*Olea europaea*	without roots	Diffuse porous	9.80
Fernandez *et al.* 2006	CHP	*Prunus domestica*	stem segment	Diffuse porous	8.00
Fernandez *et al.* 2006	CHP	*Prunus domestica*	without roots	Diffuse porous	7.00
Fuchs *et al.* 2017	HFD	*Acer pseudoplatanus*	stem segment	Diffuse porous	10.56
Fuchs *et al.* 2017	HFD	*Fagus sylvatica*	stem segment	Diffuse porous	9.42
Fuchs *et al.* 2017	HFD	*Tilia cordata*	stem segment	Diffuse porous	9.29
Fuchs *et al.* 2017	HR	*Acer pseudoplatanus*	stem segment	Diffuse porous	NA
Fuchs *et al.* 2017	HR	*Fagus sylvatica*	stem segment	Diffuse porous	NA
Fuchs *et al.* 2017	HR	*Tilia cordata*	stem segment	Diffuse porous	NA
Fuchs *et al.* 2017	TD	*Acer campestre*	stem segment	Diffuse porous	11.81
Fuchs *et al.* 2017	TD	*Acer pseudoplatanus*	stem segment	Diffuse porous	10.80
Fuchs *et al.* 2017	TD	*Fagus sylvatica*	stem segment	Diffuse porous	9.83
Fuchs *et al.* 2017	TD	*Populus nigra*	stem segment	Diffuse porous	10.77
Fuchs *et al.* 2017	TD	*Tilia cordata*	stem segment	Diffuse porous	9.41
Gonzalez-Altozano *et al.* 1998	CHP	*Citrus reticulata*	whole plant	Diffuse porous	11.50
Gonzalez-Altozano *et al.* 1998	T-max	*Citrus reticulata*	whole plant	Diffuse porous	11.50
Granier 1985	TD	*Pinus nigra*	stem segment	Tracheids	4.50
Granier 1985	TD	*Pseudotzuga menziesii*	stem segment	Tracheids	4.50
Granier 1985	TD	*Quercus pedunculata*	stem segment	Ring porous	4.50

Table A.1: Summary table of the studies used in the analyses presented in the paper. Sap flow method, species, calibration material, porosity and average stem/tree diameter are reported. *(continued)*

Study	Method	Species	Calibration material	Wood porosity	Diameter (cm)
Green *et al.* 1988	CHP	*Actinidia chinensis*	stem segment	Diffuse porous	5.25
Green *et al.* 1988	CHP	*Actinidia chinensis*	whole plant	Diffuse porous	5.40
Green *et al.* 1988	CHP	*Malus sylvestris*	whole plant	Diffuse porous	5.60
Gutierrez *et al.* 1994	SHB	*Acacia koa*	whole plant	Diffuse porous	NA
Gutierrez *et al.* 1994	SHB	*Coffea arabica*	whole plant	Diffuse porous	NA
Gutierrez Soto *et al.* 2012	HR	*Carica papaya*	whole plant	Monocot	NA
Hatton *et al.* 1995	CHP	*Eucalyptus populnea*	without roots	Diffuse porous	5.40
Heilman *et al.* 1990	SHB	*Ligustrum japonicum*	whole plant	Diffuse porous	1.00
Herbs *et al.* 2007	TD	*Acer campestre*	stem segment	Diffuse porous	NA
Herbs *et al.* 2007	TD	*Crataegus monogina*	stem segment	Diffuse porous	NA
Hultine *et al.* 2010	TD	*Tamarix ramossisima*	stem segment	Ring porous	4.16
Intrigliolo *et al.* 2009	T-max	*Vitis vinifera*	whole plant	Ring porous	NA
Isarangkool *et al.* 2009	TTD	*Abies concolor*	stem segment	Diffuse porous	5.14
Isarangkool *et al.* 2009	TTD	*Hevea brasiliensis*	stem segment	Diffuse porous	4.69
Isarangkool *et al.* 2009	TTD	*Mangifera indica*	stem segment	Diffuse porous	4.35
Johan Uddling *et al.* 2009	TD	*Betula papyrifera*	stem segment	Diffuse porous	NA
Lu 2002	TD	*Garcinia mangostana*	whole plant	Diffuse porous	4.00
Lu 2002	TD	*Mangifera indica*	whole plant	Diffuse porous	2.30
Lu 2002	TD	*Musa spp.*	whole plant	Monocot	12.00
Lu and Chacko 1998	TD	*Mangifera indica*	whole plant	Diffuse porous	2.30
Madurapperuma *et al.* 2009	HR	*Syagrus romanzoffiana*	whole plant	Monocot	NA
Michell *et al.* 2009	HR	*Eucalyptus capillosa*	without roots	Diffuse porous	6.50
Montague *et al.* 2006	TD	*Liquidambar styraciflua*	whole plant	Diffuse porous	5.30
Montague *et al.* 2006	TD	*Populus deltoides*	whole plant	Diffuse porous	5.60
Montague *et al.* 2006	TD	*Pyrus calleryana*	whole plant	Diffuse porous	6.60
Montague *et al.* 2006	TD	*Quercus robur x Q. Bicolor*	whole plant	Ring porous	5.70
Nadezhdina *et al.* 1998	HFD	*Tilia cordata*	without roots	Diffuse porous	12.00
Nortes *et al.* 2009	CHP	*Prunus dulcis*	whole plant	Diffuse porous	15.00
Paudel *et al.* 2013	TD	*Malus domestica*	stem segment	Diffuse porous	4.01
Paudel *et al.* 2013	TD	*Peltophorum dubium*	stem segment	Diffuse porous	3.70
Paudel *et al.* 2013	TD	*Prunus persica*	stem segment	Diffuse porous	4.00
Paudel *et al.* 2013	TTD	*Malus domestica*	stem segment	Diffuse porous	4.01
Paudel *et al.* 2013	TTD	*Peltophorum dubium*	stem segment	Diffuse porous	3.70
Paudel *et al.* 2013	TTD	*Prunus persica*	stem segment	Diffuse porous	4.00
Peters *et al.* 2017	TD	*Larix decidua*	stem segment	Tracheids	16.50
Peters *et al.* 2017	TD	*Picea abies*	stem segment	Tracheids	15.90
Prendergast *et al.* 2007	T-max	*Actinidia chinensis*	stem segment	Diffuse porous	9.50
Shackel *et al.* 1992	SHB	*Prunus persica*	whole plant	Diffuse porous	6.25
Smith *et al.* 1995	CHP	*Acacia holosericea*	stem segment	Diffuse porous	NA
Smith *et al.* 1995	CHP	*Acacia holosericea*	without roots	Diffuse porous	NA
Smith *et al.* 1995	CHP	*Acacia nilotica*	stem segment	Diffuse porous	NA
Smith *et al.* 1995	CHP	*Azadirachta indica*	stem segment	Diffuse porous	NA
Smith *et al.* 1995	CHP	*Azadirachta indica*	without roots	Diffuse porous	NA
Sperling *et al.* 2012	TD	*Phoenix datylifera*	whole plant	Monocot	60.00
Steppe *et al.* 2010	CHP	*Fagus grandifolia*	stem segment	Diffuse porous	18.00
Steppe *et al.* 2010	HFD	*Fagus grandifolia*	stem segment	Diffuse porous	18.12
Steppe *et al.* 2010	TD	*Fagus grandifolia*	stem segment	Diffuse porous	18.00

Table A.1: Summary table of the studies used in the analyses presented in the paper. Sap flow method, species, calibration material, porosity and average stem/tree diameter are reported. *(continued)*

Study	Method	Species	Calibration material	Wood porosity	Diameter (cm)
Sun *et al*. 2012	TD	*Liquidambar styraciflua*	without roots	Diffuse porous	7.50
Sun *et al*. 2012	TD	*Pinus echinata*	without roots	Tracheids	7.50
Sun *et al*. 2012	TD	*Pinus taeda*	without roots	Tracheids	7.50
Sun *et al*. 2012	TD	*Populus deltoides*	without roots	Diffuse porous	7.50
Sun *et al*. 2012	TD	*Quercus alba*	without roots	Ring porous	7.50
Sun *et al*. 2012	TD	*Ulmus americana*	without roots	Ring porous	7.50
Swanson and Whitfield 1981	CHP	*Nothofagus solandri*	whole plant	Diffuse porous	11.00
Swanson and Whitfield 1981	CHP	*Pinus radiata*	whole plant	Tracheids	5.00
Urban *et al*. 2012	SHB	*Humulus lupulus*	without roots	Ring porous	NA
Vellame *et al*. 2010	SHB	*Citrus sinensis*	whole plant	Diffuse porous	1.40

Table A.2: Anova summary of the LMM models, using the same structure as objective 1, comparing calibrations reported in SFD and SF units (Units) for CHP and TD. CM (Calibration material).

Method	Calibration metric	Variable	Sum sq	Mean Sq	NumDF	DenDF	F.value	Pr(>F)
CHP	Ln-Ratio	Units	0.09	0.09	1	52.05	1.09	0.302
		CM	0.20	0.10	2	44.43	1.24	0.299
	Slope	Units	0.07	0.07	1	25.27	0.37	0.55
		CM	0.24	0.12	2	40.07	0.59	0.558
	Slope (ln-ln)	Units	0.00	0.00	1	12.35	0.02	0.89
		CM	0.14	0.07	2	22.13	0.91	0.416
	Z-Cor	Units	1.07	1.07	1	20.77	4.30	0.051 .
		CM	4.63	2.32	2	34.98	9.28	0.001 ***
TD	Ln-Ratio	Units	0.05	0.05	1	26.72	0.41	0.529
		CM	0.14	0.07	2	16.64	0.58	0.571
	Slope	Units	0.16	0.16	1	44.72	2.28	0.138
		CM	0.17	0.08	2	14.84	1.17	0.338
	Slope (ln-ln)	Units	0.22	0.22	1	72.67	2.18	0.144
		CM	0.14	0.07	2	29.27	0.71	0.501
	Z-Cor	Units	0.08	0.08	1	26.07	0.28	0.598
		CM	0.02	0.01	2	17.41	0.03	0.969

Table A.3: Summary of the LMM models of Ln-Ratio (accuracy), Slope (proportional bias), Slope (ln-ln) (linearity) and Z-Cor (precision) as a function of Methods and Calibration material (CM; Whole plant: whole plant on a container or lysimeter; No-roots: whole plant without roots). CHP is the reference level for the variable Method and Stem segment is the reference level for CM, corresponding to the model intercept. All other coefficient estimates indicate the difference relative to the intercept. σ^2 is the within-groups random variability (residuals of the model). τ_{00} is the between-group random variability. N is the number of levels within random groups. ICC is the Intraclass Correlation Coefficients of each random group. R^2m and R^2c are the variability explained by the fixed and the random factors, respectively.

Coefficients	Estimate	Conf. Int.	p-value	Estimate	Conf. Int.	p-value	Estimate	Conf. Int.	p-value	Estimate	Conf. Int.	p-value
Fixed effects												
(Intercept)	0.19	-0.052 , 0.425	0.129	0.96	0.779 , 1.135	<0.001	0.85	0.719 , 0.976	<0.001	2.32	1.982 , 2.653	2.32
Method (T-max)	-0.19	-0.611 , 0.240	0.395	-0.27	-0.584 , 0.038	0.089	-0.08	-0.312 , 0.142	0.463	-0.08	-0.669 , 0.506	-0.08
Method (HR)	-0.28	-0.510 , -0.047	0.019	-0.04	-0.247 , 0.162	0.683	0.06	-0.106 , 0.221	0.488	0.16	-0.205 , 0.525	0.16
Method (HFD)	-0.21	-0.409 , -0.003	0.048	0.01	-0.167 , 0.193	0.886	0.00	-0.143 , 0.143	1	0.54	0.220 , 0.862	0.54
Method (SHB)	-0.37	-0.843 , 0.095	0.124	-0.04	-0.365 , 0.285	0.809	0.18	-0.058 , 0.427	0.139	0.45	-0.170 , 1.070	0.45
Method (TD)	-0.65	-0.847 , -0.457	<0.001	-0.20	-0.368 , -0.041	0.015	0.28	0.160 , 0.406	<0.001	-0.12	-0.423 , 0.173	-0.12
Method (TTD)	-0.62	-0.941 , -0.310	<0.001	-0.22	-0.503 , 0.066	0.134	0.20	-0.016 , 0.421	0.072	-0.37	-0.877 , 0.133	-0.37
CM (Whole plant)	-0.03	-0.300 , 0.245	0.841	-0.13	-0.317 , 0.064	0.197	-0.14	-0.276 , -0.003	0.05	-0.67	-1.034 , -0.301	-0.67
CM (No-roots)	-0.13	-0.394 , 0.128	0.319	-0.08	-0.298 , 0.135	0.463	-0.06	-0.213 , 0.104	0.503	-0.78	-1.172 , -0.379	-0.78
Random effects												
σ^2		0.091			0.1			0.076			0.278	
τ_{00} Species		0.013			0.004			0.013			0.04	
τ_{00} Study		0.159			0.041			0.004			0.184	
$N_{Species}$		65			65			65			65	
N_{Study}		48			48			48			48	
$ICC_{Species}$		0.049			0.029			0.137			0.08	
ICC_{Study}		0.604			0.284			0.048			0.366	
Observations		290			290			290			290	

B

Appendix Chapter 4

B.1 Figures C

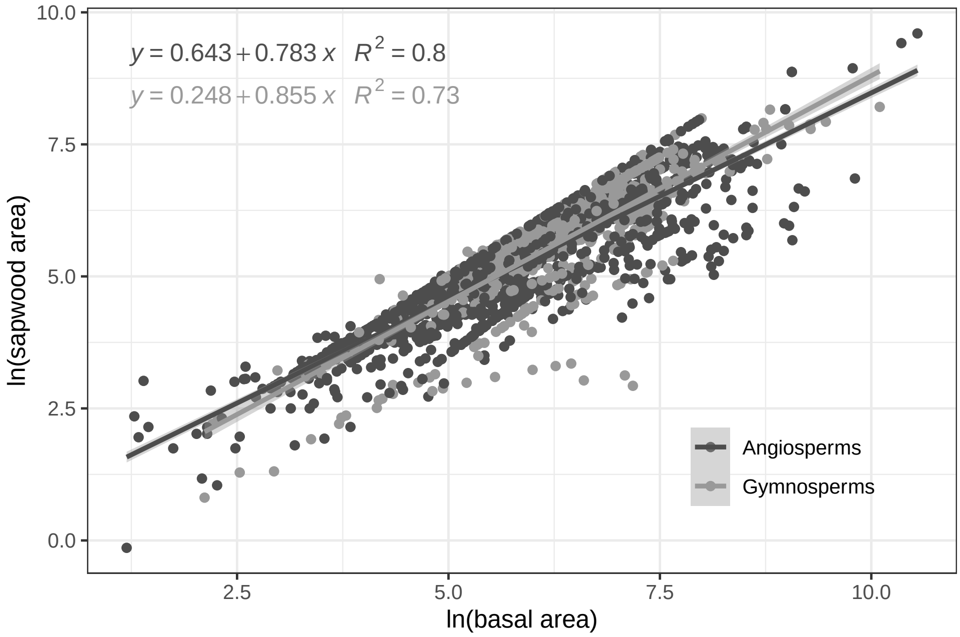


Figure B.1: SAPFLUXNET global scaling relationship between basal area and sapwood area. Shaded areas are 95% model confidence interval.

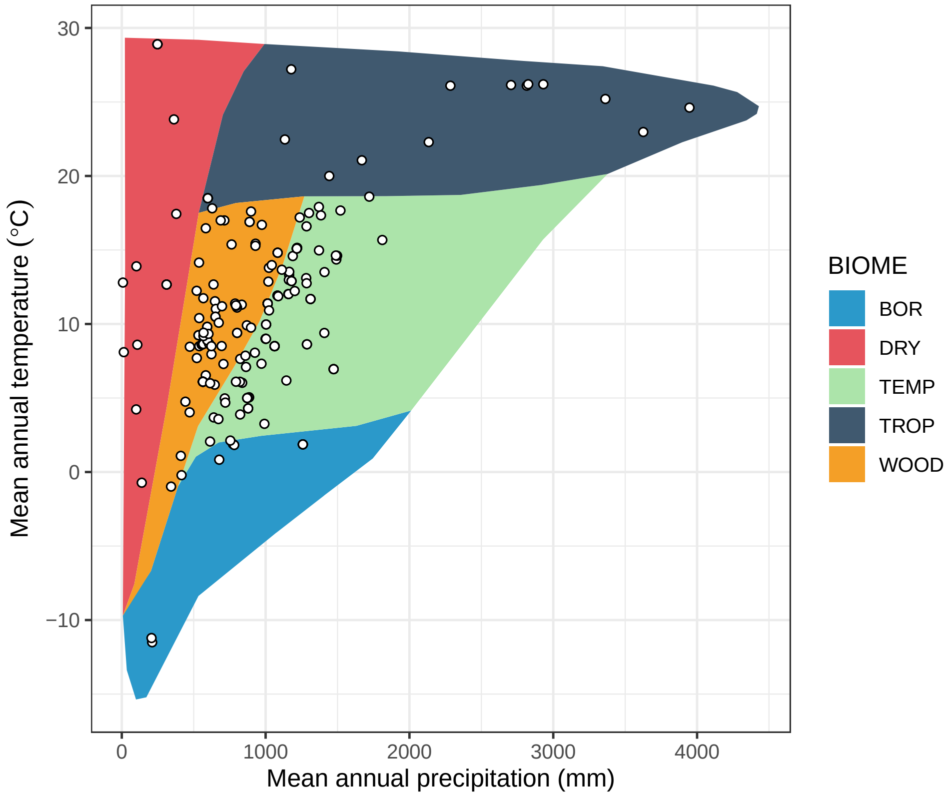


Figure B.2: Bioclimatic distribution of the SAPFLUXNET datasets used in the study. Points show the different datasets in a Whittaker diagram showing the classification of the aggregated biomes used in the study.

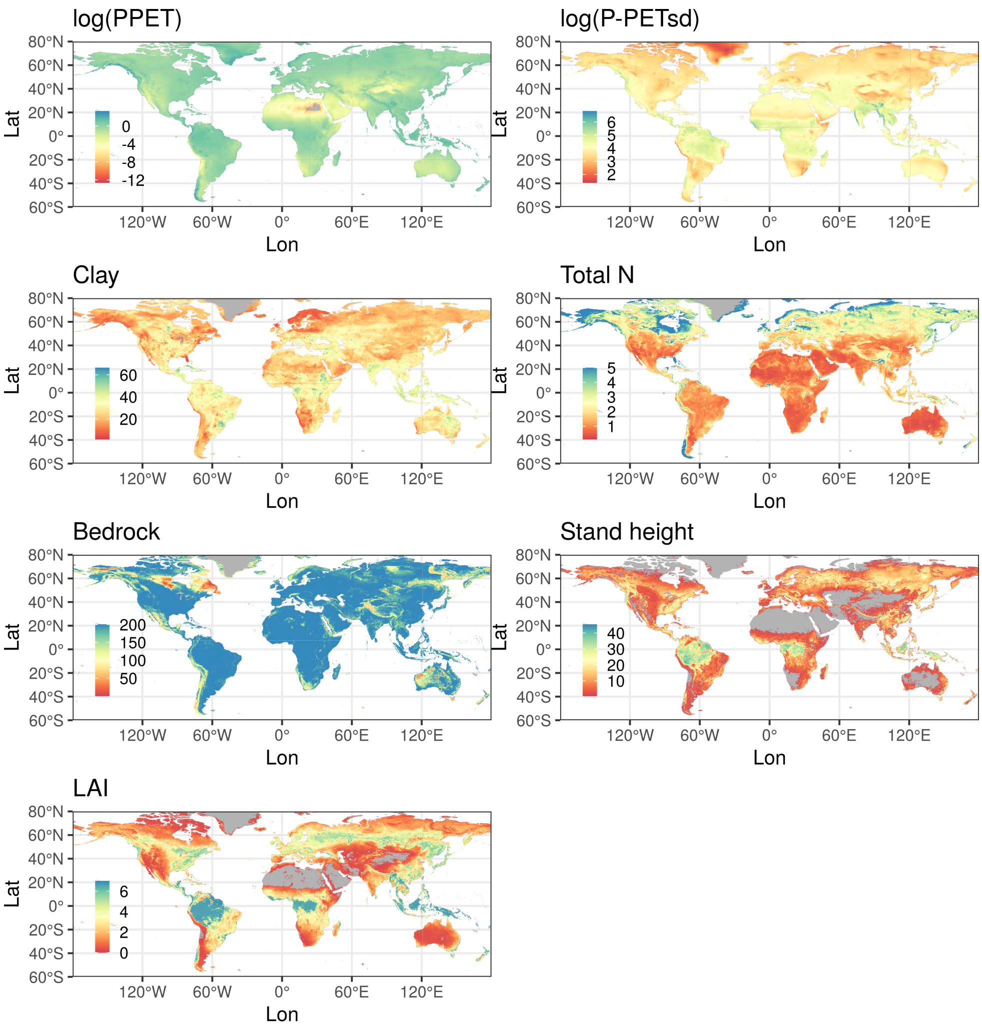


Figure B.3: Global projection of climatic, soil and stand structure variables. log(PPET): logarithm of precipitation over potential evapotraspiration [log(mm mm^{-1})]; log($P - PET_{sd}$): logarithm of the standard deviation of the difference between precipitation and potential evapotranspiration [log(mm)]; Clay: percentage of clay in the soil; Total N: total nitrogen in the soil [g kg^{-1}]; Bedrock [cm]; Stand height [m]; LAI: leaf area index [m^2 m^{-2}]. Total N values above 5 g kg^{-1} were truncated.

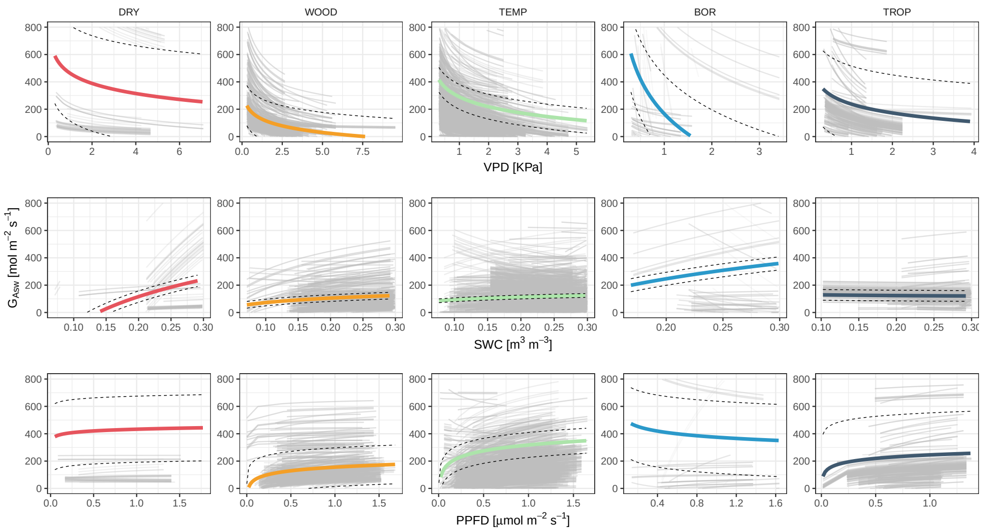


Figure B.4: Log relationships of the three environmental variables estimated with the TOTAL model (VPD + SWC + PPFD) and grouped by biome. Coloured lines are biome average models calculated from the Log-linear models predictions using LMM with Gs as response variable and the neperian logarithm of the environmental constrains as explanatory variables. Dashed line shows standard error of the average models calculated with bootstrap prediction using 100 simulations.

B.2 Tables C

Table B.1: SAPFLUXNET sites included in the study. Biome was calculated using Whittaker diagram. *Indicates that the biome was manually adjusted and confirmed by SAPFLUXNET contributors.

Site code	Latitude	Longitude	Biome	# Tree-days	# Species	# Trees
AUS_CAN_ST1_EUC	-37.58	149.17	WOOD	337	1	12
AUS_CAN_ST2_MIX	-37.58	149.17	WOOD	712	2	22
AUS_CAN_ST3_ACA	-37.58	149.17	WOOD	409	1	12
AUS_CAR_THI_CON	-38.38	146.68	TEMP	54	1	7
AUS_ELL_UNB	-36.78	146.58	TEMP	105	1	2
AUS_MAR_UBD	-37.69	145.56	TEMP	50	3	5
AUS_MAR_UBW	-37.89	145.57	TEMP	105	3	5
AUS_WOM	-37.42	144.09	TEMP	2130	2	11
AUT_PAT_FOR	47.21	11.45	BOR	149	1	3
AUT_PAT_KRU	47.21	11.45	BOR	70	1	3
AUT_PAT_TRE	47.21	11.45	BOR	81	1	3
BRA_CAM	-22.69	-45.52	TROP	79	1	5
BRA_CAX_CON	-1.79	-51.43	TROP	525	8	15
CAN_TUR_P39_PRE	42.71	-80.36	TEMP	1021	1	18
CAN_TUR_P74	42.71	-80.35	TEMP	1997	1	16
CHN_ARG_GWS	41.38	89.94	DRY	174	1	2
CHN_HOR_AFF	42.72	122.37	WOOD	1366	1	16
CHN_YIN_ST1	42.45	85.72	DRY	105	1	5
CRI_TAM_TOW	10.39	-84.63	TROP	666	17	26
CZE_BIL_BIL	49.25	16.69	TEMP	238	1	6
CZE_KRT_KRT	49.32	16.75	TEMP	238	1	6
CZE_LAN	48.68	16.95	TEMP	1093	3	17
CZE_RAJ_RAJ	49.44	16.70	TEMP	274	1	6
CZE_SOB_SOB	49.25	16.69	TEMP	655	1	6
CZE_STI	49.04	17.97	TEMP	263	1	8
CZE_UTE_BPO	49.28	16.65	TEMP	234	1	6
DEU_HIN_OAK	53.33	13.19	TEMP	482	1	8
DEU_HIN_TER	53.33	13.19	TEMP	1052	2	16
DEU_MER_BEE_NON	49.27	7.81	TEMP	495	1	8
DEU_MER_DOU_NON	49.27	7.81	TEMP	491	1	7
DEU_MER_MIX_NON	49.27	7.81	TEMP	1108	2	17
DEU_STE_2P3	53.10	13.00	TEMP	722	1	10
DEU_STE_4P5	53.10	13.00	TEMP	327	1	10
ESP_ALT_ARM	40.78	-2.33	WOOD	1990	3	15
ESP_ALT_HUE	40.79	-2.29	WOOD	967	2	8
ESP_ALT_TRI	40.80	-2.23	WOOD	1522	2	12
ESP_CAN	41.43	2.07	WOOD	2317	4	21
ESP_GUA_VAL	40.90	-4.03	WOOD	2100	1	24
ESP_LAS	28.31	-16.57	WOOD	1778	1	10
ESP_MAJ_MAI	39.94	-5.77	WOOD	978	1	6
ESP_MON_SIE_NAT	41.12	-3.50	WOOD	1250	3	20
ESP_RIN	40.60	-6.02	WOOD	502	1	8
ESP_RON_PIL	36.69	-5.02	TEMP	911	2	12
ESP_TIL_MIX	41.33	1.01	WOOD	3434	2	32
ESP_TIL_OAK	41.33	1.01	WOOD	717	1	10
ESP_TIL_PIN	41.33	1.01	WOOD	589	1	9

Table B.1: SAPFLUXNET sites included in the study. Biome was calculated using Whittaker diagram. *Indicates that the biome was manually adjusted and confirmed by SAPFLUXNET contributors. *(continued)*

Site code	Latitude	Longitude	Biome	# Tree-days	# Species	# Trees
ESP_VAL_BAR	42.20	1.82	WOOD	837	1	12
ESP_VAL_SOR	42.20	1.81	WOOD	1109	1	13
ESP_YUN_C1	36.72	-4.97	WOOD	619	1	6
ESP_YUN_C2	36.72	-4.97	WOOD	288	1	6
FIN_HYY_SME	61.85	24.29	TEMP	34	2	4
FIN_PET	69.49	27.23	BOR	118	1	7
FRA_FON	48.48	2.78	TEMP	276	1	3
FRA_HES_HE1_NON	48.67	7.06	TEMP	620	1	10
FRA_HES_HE2_NON	48.67	7.06	TEMP	1347	1	10
FRA_PUE	43.74	3.60	WOOD	5229	1	25
GBR_ABE_PLO	56.62	-3.80	TEMP	486	1	15
GBR_DEV_CON	56.03	-3.72	TEMP	133	1	4
GBR_GUI_ST1	57.27	-4.82	TEMP	398	1	15
GBR_GUI_ST2	57.27	-4.82	TEMP	298	1	9
GBR_GUI_ST3	57.27	-4.82	TEMP	249	1	8
GUF_GUY_GUY	5.28	-52.92	TROP	246	6	6
GUF_GUY_ST2	5.28	-52.91	TROP	369	7	11
GUF_NOU_PET	4.08	-52.68	TROP	562	10	22
HUN_SIK	47.93	20.44	WOOD	365	2	4
ISR_YAT_YAT	31.34	35.05	DRY	3704	1	24
ITA_FEI_S17	46.69	10.61	TEMP	244	1	6
ITA_KAE_S20	46.70	10.61	BOR	325	1	6
ITA_MUN	46.68	10.58	TEMP	384	1	6
ITA_REN	46.59	11.43	TEMP	247	3	8
ITA_RUN_N20	46.70	10.64	BOR	331	2	8
MEX_COR_YP	19.49	-97.04	TEMP	119	1	8
NLD_LOO	52.17	5.74	TEMP	621	1	6
NLD_SPE_DOU	52.25	5.69	TEMP	107	1	3
NZL_HUA_HUA	-36.80	174.49	TEMP	243	1	6
PRT_LEZ_ARN	38.83	-8.82	WOOD	403	1	4
PRT_MIT	38.54	-8.00	WOOD	494	1	4
PRT_PIN	38.25	-8.76	WOOD	1233	2	20
RUS_CHE_Y4	68.74	161.41	BOR	447	1	11
RUS_FYO	56.46	32.92	TEMP	1132	3	17
RUS_POG_VAR	56.36	92.95	TEMP	603	3	9
SEN_SOU_PRE	16.34	-15.43	DRY	466	1	3
SWE_NOR_ST1_BEF	60.09	17.48	TEMP	653	2	22
SWE_NOR_ST2	60.09	17.48	TEMP	175	2	12
SWE_NOR_ST3	60.09	17.48	TEMP	810	2	37
SWE_NOR_ST5_REF	60.08	17.48	TEMP	712	3	35
SWE_SKO_MIN	58.36	12.15	TEMP	533	1	11
SWE_SKY_38Y	60.13	17.84	TEMP	326	1	12
SWE_SKY_68Y	60.10	17.83	TEMP	664	2	12
SWE_SVA_MIX_NON	64.26	19.77	TEMP	861	2	20
THA_KHU	15.27	103.08	TROP	411	1	6
USA_BNZ_BLA	64.70	-148.32	BOR	797	1	6
USA_CHE_ASP	45.94	-90.27	TEMP	3548	6	149
USA_CHE_MAP	45.95	-90.26	TEMP	2651	2	153
USA_DUK_HAR	36.98	-79.09	TEMP	495	6	34

Table B.1: SAPFLUXNET sites included in the study. Biome was calculated using Whittaker diagram. *Indicates that the biome was manually adjusted and confirmed by SAPFLUXNET contributors. *(continued)*

Site code	Latitude	Longitude	Biome	# Tree-days	# Species	# Trees
USA_HIL_HF2	36.22	-78.86	TEMP	228	5	23
USA_INM	39.32	-86.41	TEMP	766	6	9
USA_MOR_SF	39.32	-86.41	TEMP	285	4	6
USA_NWH	34.58	-91.26	TEMP	248	2	10
USA_ORN_ST1_AMB	35.90	-84.33	TEMP	247	1	8
USA_PAR_FER	35.80	-76.67	TEMP	467	1	8
USA_PER_PER	30.21	-83.87	TROP	6269	1	80
USA_PJS_P04_AMB	34.39	-106.53	DRY	2313	2	10
USA_PJS_P08_AMB	34.39	-106.53	DRY	2262	2	10
USA_PJS_P12_AMB	34.39	-106.53	DRY	2350	2	10
USA_SIL_OAK_1PR	39.92	-74.60	TEMP	1210	4	18
USA_SIL_OAK_2PR	39.92	-74.60	TEMP	2275	4	22
USA_SMI_SER	38.89	-76.56	TEMP	1045	5	31
USA_SWH	34.11	-91.13	TEMP	511	2	16
USA_SYL_HL1	46.24	-89.35	TEMP	3130	3	48
USA_SYL_HL2	46.24	-89.35	TEMP	1631	4	20
USA_TNB	36.47	-84.70	TEMP	583	4	8
USA_TNO	35.97	-84.28	TEMP	680	5	9
USA_TNP	35.96	-84.29	TEMP	806	5	9
USA_UMB_CON	45.56	-84.71	TEMP	5840	5	57
USA_UMB_GIR	45.56	-84.70	TEMP	5867	4	57
USA_WIL_WC1	45.81	-90.09	TEMP	639	5	16
USA_WVF	39.06	-79.69	TEMP	488	5	8
ZAF_FRA_FRA	-33.88	19.06	WOOD	220	1	3
ZAF_RAD	-34.08	19.11	WOOD	303	1	3
ZAF_SOU_SOU	-34.09	19.09	WOOD	198	1	2
ZAF_WEL_SOR	-33.48	18.96	WOOD	356	1	3

Table B.2: SAPFLUXNET stand treatments included in the this study (Poyatos *etal*. 2020).

Plot treatment
None
Control
control
Ambient Control
Control - Unthinned
natural conditions
Reference
1Premortality
2premortality
distructive sampling
Girdling early successional
Pre-thinning
Before thinning
Before Thinning
non thinned
none (periodict thinning every 5-6 years 20 to 25% of basal area)
Radiation Level
AMBIENT CO2 FACE rings
fertilization at plantation
AcaciaMonoculture
MixtureEucalyptusAndAcacia
EucalyptusMonoculture
Pre Irrigation

Table B.3: Summary table of site level R^2_{VPD}, R^2_{SWC}, R^2_{PPFD}, climate, soil properties and vegetation structure data. PPET is in [mm mm^{-1}]; $P - PET_{sd}$ is in [mm]; Clay and Sand are in [%]; Total N is in [g kg^{-1}]; Stand height is in [m]; LAI is in [m^2_{leaves} m^2_{soil}]. Letters show data source: a = SAPFLUXNET, b = Global rasters, c = SAPFLUXNET plant height.

Site code	R^2_{vpd}	R^2_{swc}	R^2_{ppfd}	Relimp VPD	Relimp SWC	Relimp PPFD	PPET	$P - PET_{sd}$	Clay	Sand	Total N	Bedrock	Stand height	LAI
AUS_CAN_ST1_EUC	0.74	0.44	0.54	0.65	0.35	0.00	1.23	47.52	26.30 b	45.10 b	1.02	184	22.00 a	1.39 a
AUS_CAN_ST2_MIX	0.91	0.65	0.76	0.87	0.13	0.00	1.23	47.52	26.30 b	45.10 b	1.02	184	21.80 a	2.07 a
AUS_CAN_ST3_ACA	0.85	0.67	0.74	0.87	0.12	0.01	1.23	47.52	26.30 b	45.10 b	1.02	184	11.80 a	1.35 a
AUS_CAR_THI_CON	0.67	0.00	0.00	0.99	0.00	0.01	1.36	49.01	27.20 b	44.30 b	2.34	111	17.21 a	4.80 a
AUS_ELL_UNB	0.87	0.44	0.76	0.97	0.00	0.03	1.08	67.16	26.70 b	48.50 b	1.95	63	25.00 a	6.20 b
AUS_MAR_UBD	0.79	0.53	0.69	0.71	0.29	0.00	1.35	70.37	26.60 b	44.60 b	1.90	89	25.00 a	2.10 a
AUS_MAR_UBW	0.90	0.81	0.82	0.90	0.00	0.09	1.21	65.38	27.90 b	43.90 b	2.00	173	40.00 a	2.30 a
AUS_WOM	0.82	0.52	0.49	0.79	0.00	0.20	1.09	69.35	25.90 b	52.90 b	1.97	172	22.00 a	2.20 a
AUT_PAT_FOR	0.78	0.73	0.68	0.82	0.09	0.09	2.17	16.78	5.00 a	60.00 a	3.94	180	12.00 a	4.30 b
AUT_PAT_KRU	0.61	0.45	0.50	0.77	0.06	0.17	2.17	16.78	5.00 a	60.00 a	3.94	180	0.75 a	4.30 b
AUT_PAT_TRE	0.58	0.27	0.19	0.70	0.30	0.00	2.17	16.78	5.00 a	60.00 a	3.94	180	4.00 a	4.30 b
BRA_CAM	0.83	0.68	0.69	0.65	0.28	0.07	1.66	88.82	27.60 b	52.00 b	2.26	200	12.00 a	5.30 a
BRA_CAX_CON	0.79	0.74	0.73	0.70	0.00	0.30	1.90	122.90	8.00 a	79.00 a	1.45	197	38.00 b	5.30 a
CAN_TUR_P39_PRE	0.59	0.37	0.34	0.71	0.08	0.21	1.39	42.08	1.00 a	98.00 a	1.58	200	23.40 a	5.30 a
CAN_TUR_P74	0.26	0.47	0.14	0.32	0.38	0.30	1.39	41.87	1.00 a	98.00 a	1.60	200	16.20 a	6.70 a
CHN_ARG_GWS	0.42	0.32	0.27	0.51	0.47	0.01	0.01	63.51	17.70 b	46.00 b	0.70	172	7.90 a	0.36 a
CHN_HOR_AFF	0.39	0.38	0.34	0.25	0.75	0.00	0.59	31.24	8.00 a	83.00 a	1.00	200	9.05 a	1.61 a
CHN_YIN_ST1	0.47	0.45	0.44	0.63	0.18	0.20	0.19	35.09	20.80 b	32.90 b	2.41	148	10.60 a	0.50 b
CRI_TAM_TOW	0.73	0.73	0.73	0.46	0.11	0.44	3.57	159.99	36.10 b	34.70 b	2.75	200	30.60 a	3.30 a
CZE_BIL_BIL	0.54	0.50	0.41	0.57	0.20	0.23	0.71	28.98	29.60 b	27.40 b	1.91	200	14.00 a	6.00 b
CZE_KRT_KRT	0.57	0.45	0.30	0.58	0.03	0.39	0.85	27.00	26.00 b	27.40 b	2.10	200	17.00 a	5.70 b
CZE_LAN	0.79	0.76	0.72	0.67	0.08	0.25	0.66	37.49	17.80 a	71.80 a	2.46	200	36.00 a	6.04 a
CZE_RAJ_RAJ	0.38	0.40	0.43	0.33	0.07	0.60	0.99	26.14	21.80 b	33.90 b	1.96	200	18.00 a	4.60 b
CZE_SOB_SOB	0.48	0.45	0.14	0.52	0.25	0.23	0.71	28.98	29.60 b	27.40 b	1.91	200	21.00 a	6.00 b
CZE_STI	0.54	0.32	0.39	0.70	0.18	0.12	1.13	27.10	34.20 a	47.60 a	1.65	200	31.00 a	5.50 a
CZE_UTE_BPO	0.62	0.65	0.52	0.46	0.16	0.38	0.75	29.86	26.70 b	23.80 b	2.71	200	18.00 a	6.10 b
DEU_HIN_OAK	0.43	0.19	0.33	0.92	0.07	0.01	0.95	35.10	17.90 b	49.90 b	2.42	200	31.45 c	5.70 b
DEU_HIN_TER	0.31	0.22	0.24	0.76	0.01	0.24	0.95	35.10	18.00 b	50.50 b	2.05	200	24.43 c	5.60 b

Table B.3: Summary table of site level R^2_{VPD}, R^2_{SWC}, R^2_{PPFD}, climate, soil properties and vegetation structure data. PPET is in [mm mm^{-1}]; $P - PET_{sd}$ is in [mm]; Clay and Sand are in [%]; Total N is in [g kg^{-1}]; Stand height is in [m]; LAI is in [m^2_{leaves} m^2_{soil}]. Letters show data source: a = SAPFLUXNET, b = Global rasters, c = SAPFLUXNET plant height. *(continued)*

Site code	R^2_{vpd}	R^2_{swc}	R^2_{ppfd}	Relimp VPD	Relimp SWC	Relimp PPFD	PPET	$P - PET_{sd}$	Clay	Sand	Total N	Bedrock	Stand height	LAI
DEU_MER_BEE_NON	0.47	0.27	0.29	0.76	0.06	0.18	1.48	47.33	4.00 a	71.00 a	2.56	200	23.00 a	5.90 a
DEU_MER_DOU_NON	0.45	0.25	0.22	0.60	0.31	0.10	1.48	47.33	4.00 a	71.00 a	2.56	200	29.00 a	5.30 a
DEU_MER_MIX_NON	0.41	0.23	0.26	0.82	0.02	0.16	1.48	47.33	4.00 a	71.00 a	2.56	200	30.00 a	6.10 a
DEU_STE_2P3	0.56	0.15	0.30	0.86	0.09	0.05	0.90	37.45	2.50 a	92.50 a	3.28	200	27.20 a	4.30 b
DEU_STE_4P5	0.48	0.27	0.31	0.64	0.28	0.09	0.90	37.45	2.50 a	92.50 a	3.28	200	27.20 a	4.30 b
ESP_ALT_ARM	0.51	0.30	0.29	0.91	0.01	0.09	0.66	65.80	21.90 b	41.50 b	1.27	187	19.00 b	1.09 a
ESP_ALT_HUE	0.47	0.22	0.18	0.78	0.02	0.21	0.51	63.08	21.60 b	35.90 b	1.46	200	8.64 c	1.50 b
ESP_ALT_TRI	0.58	0.44	0.31	0.80	0.07	0.12	0.57	63.48	21.00 b	40.00 b	1.31	196	4.89 a	1.60 b
ESP_CAN	0.55	0.40	0.34	0.74	0.02	0.24	0.94	46.91	32.90 b	28.30 b	1.76	179	10.80 a	3.30 a
ESP_GUA_VAL	0.51	0.28	0.23	0.69	0.00	0.31	0.68	69.09	24.80 b	40.90 b	1.27	200	12.00 a	3.80 a
ESP_LAS	0.37	0.25	0.07	0.57	0.37	0.06	1.63	37.89	1.00 a	70.00 a	1.65	197	10.30 a	3.60 a
ESP_MAJ_MAI	0.56	0.43	0.28	0.73	0.14	0.12	0.76	97.45	9.00 a	80.00 a	1.18	200	7.00 a	0.30 a
ESP_MON_SIE_NAT	0.25	0.20	0.22	0.49	0.09	0.42	0.62	63.05	20.80 b	41.90 b	1.45	200	22.00 a	3.30 b
ESP_RIN	0.83	0.61	0.59	0.97	0.00	0.03	0.85	76.30	15.00 a	9.00 a	2.17	200	7.40 a	3.40 a
ESP_RON_PIL	0.37	0.25	0.17	0.60	0.07	0.33	1.05	93.66	18.00 a	30.00 a	1.86	200	2.60 a	0.90 b
ESP_TIL_MIX	0.45	0.36	0.22	0.55	0.09	0.36	0.77	48.10	20.00 a	60.00 a	1.44	162	14.20 a	3.27 a
ESP_TIL_OAK	0.31	0.38	0.18	0.45	0.15	0.40	0.77	48.10	20.00 a	60.00 a	1.44	162	5.00 a	4.59 a
ESP_TIL_PIN	0.37	0.45	0.08	0.43	0.37	0.20	0.79	48.10	20.00 a	60.00 a	1.78	188	18.30 a	1.02 a
ESP_VAL_BAR	0.61	0.22	0.29	0.90	0.00	0.10	0.70	34.07	32.63 a	9.81 a	1.94	200	10.60 a	2.10 a
ESP_VAL_SOR	0.58	0.36	0.26	0.73	0.14	0.13	0.78	32.15	20.00 a	60.00 a	2.04	200	11.00 a	2.40 a
ESP_YUN_C1	0.37	0.50	0.24	0.28	0.56	0.16	0.83	93.65	29.00 a	22.00 a	1.37	197	10.60 a	2.20 b
ESP_YUN_C2	0.28	0.62	0.27	0.21	0.43	0.37	0.78	91.33	29.00 a	22.00 a	1.37	188	11.60 a	2.50 b
FIN_HYY_SME	0.57	0.49	0.62	0.12	0.86	0.02	1.20	38.32	6.50 a	37.00 a	1.67	200	18.00 a	1.30 a
FIN_PET	0.59	0.50	0.58	0.47	0.37	0.16	1.13	26.34	7.30 b	60.80 b	5.08	200	3.76 a	0.61 a
FRA_FON	0.78	0.68	0.68	0.70	0.17	0.13	0.89	45.10	19.00 a	37.00 a	1.26	200	28.00 a	6.00 a
FRA_HES_HE1_NON	0.46	0.57	0.41	0.45	0.25	0.30	1.31	47.72	25.00 a	8.00 a	1.41	200	12.80 a	6.00 a
FRA_HES_HE2_NON	0.33	0.50	0.16	0.42	0.27	0.31	1.31	47.72	25.00 a	8.00 a	1.41	200	13.00 a	6.00 a

Table B.3: Summary table of site level R^2_{VPD}, R^2_{SWC}, R^2_{PPFD}, climate, soil properties and vegetation structure data. PPET is in [mm mm^{-1}]; $P - PET_{sd}$ is in [mm]; Clay and Sand are in [%]; Total N is in [g kg^{-1}]; Stand height is in [m]; LAI is in [m^2_{leaves} m^2_{soil}]. Letters show data source: a = SAPFLUXNET, b = Global rasters, c = SAPFLUXNET plant height. *(continued)*

Site code	R^2_{vpd}	R^2_{swc}	R^2_{ppfd}	Relimp VPD	Relimp SWC	Relimp PPFD	PPET	$P - PET_{sd}$	Clay	Sand	Total N	Bedrock	Stand height	LAI
FRA_PUE	0.49	0.52	0.33	0.51	0.18	0.30	1.27	70.16	39.00 a	26.00 a	1.69	195	5.00 a	2.40 a
GBR_ABE_PLO	0.40	0.37	0.35	0.51	0.22	0.27	1.92	47.48	10.00 a	60.00 a	3.70	179	10.00 a	6.00 a
GBR_DEV_CON	0.89	0.45	0.58	0.95	0.01	0.04	1.43	44.38	14.80 b	56.90 b	3.44	200	15.00 a	1.92 a
GBR_GUI_ST1	0.84	0.79	0.78	0.68	0.00	0.32	3.19	68.11	3.70 b	80.40 b	14.26	197	11.00 a	0.92 a
GBR_GUI_ST2	0.64	0.55	0.49	0.59	0.03	0.38	3.19	68.11	3.70 b	80.40 b	14.26	197	13.30 a	0.94 a
GBR_GUI_ST3	0.86	0.82	0.79	0.73	0.03	0.24	3.19	68.11	3.70 b	80.40 b	14.26	197	14.30 a	1.57 a
GUF_GUY_GUY	0.97	0.89	0.94	0.82	0.05	0.12	2.88	135.18	43.00 a	48.00 a	1.53	200	35.00 a	7.00 a
GUF_GUY_ST2	0.80	0.77	0.76	0.61	0.30	0.09	3.02	141.34	43.20 a	47.80 a	1.66	200	35.00 a	6.70 a
GUF_NOU_PET	0.76	0.53	0.66	1.00	0.00	0.00	2.69	158.16	59.20 a	33.20 a	2.22	200	35.00 a	5.50 a
HUN_SIK	0.86	0.42	0.56	0.90	0.00	0.09	0.70	39.64	30.40 b	44.00 b	1.64	200	20.00 a	7.00 a
ISR_YAT_YAT	0.40	0.32	0.18	0.62	0.37	0.01	0.28	83.43	28.00 a	31.00 a	0.71	178	11.00 a	1.70 a
ITA_FEI_S17	0.53	0.37	0.30	0.66	0.14	0.19	1.08	22.97	8.00 a	76.00 a	3.11	117	20.00 a	3.10 b
ITA_KAE_S20	0.68	0.45	0.46	0.75	0.07	0.18	1.24	22.97	17.00 a	50.00 a	3.64	121	14.00 a	2.60 b
ITA_MUN	0.63	0.48	0.42	0.62	0.31	0.06	0.80	29.87	7.00 a	55.00 a	1.93	188	18.00 a	2.20 b
ITA_REN	0.85	0.77	0.79	0.95	0.02	0.04	1.61	12.59	17.70 b	47.90 b	2.73	143	27.00 b	4.60 b
ITA_RUN_N20	0.84	0.73	0.74	0.94	0.02	0.04	1.39	15.28	14.00 a	54.00 a	3.33	123	18.70 a	5.70 b
MEX_COR_YP	0.68	0.24	0.31	0.78	0.05	0.18	1.42	81.77	22.20 b	46.40 b	2.94	200	7.00 a	5.20 a
NLD_LOO	0.55	0.31	0.27	0.74	0.02	0.24	1.33	41.67	1.00 a	99.00 a	2.61	200	18.00 a	2.20 a
NLD_SPE_DOU	0.76	0.60	0.63	0.81	0.09	0.11	1.42	39.80	4.80 b	80.70 b	1.62	200	30.00 a	4.50 a
NZL_HUA_HUA	0.71	0.62	0.61	0.75	0.17	0.08	2.62	42.52	71.20 a	13.20 a	1.73	200	27.00 a	6.60 b
PRT_LEZ_ARN	0.70	0.23	0.25	0.77	0.02	0.21	0.72	77.42	5.04 a	90.38 a	1.52	200	12.00 a	1.50 a
PRT_MIT	0.76	0.47	0.36	0.78	0.18	0.04	0.51	80.80	16.10 b	64.50 b	1.33	200	7.50 a	0.55 a
PRT_PIN	0.65	0.50	0.36	0.66	0.33	0.01	0.76	74.76	16.60 b	61.20 b	1.26	200	12.60 a	1.10 b
RUS_CHE_Y4	0.31	0.21	0.23	0.95	0.01	0.04	0.62	34.23	21.10 b	23.20 b	4.96	200	7.00 a	1.30 b
RUS_FYO	0.72	0.62	0.62	0.88	0.00	0.12	1.24	30.87	18.20 b	48.80 b	3.77	198	23.50 a	3.50 a
RUS_POG_VAR	0.78	0.49	0.61	0.89	0.00	0.11	0.70	33.02	28.60 b	37.50 b	2.64	200	22.00 a	2.80 b
SEN_SOU_PRE	0.75	0.35	0.16	0.79	0.21	0.00	0.13	43.94	6.00 a	90.00 a	0.23	200	7.00 a	0.22 a

Table B.3: Summary table of site level R^2_{VPD}, R^2_{SWC}, R^2_{PPFD}, climate, soil properties and vegetation structure data. PPET is in [mm mm^{-1}]; $P - PET_{sd}$ is in [mm]; Clay and Sand are in [%]; Total N is in [g kg^{-1}]; Stand height is in [m]; LAI is in [m^2_{leaves} m^2_{soil}]. Letters show data source: a = SAPFLUXNET, b = Global rasters, c = SAPFLUXNET plant height. *(continued)*

Site code	R^2_{vpd}	R^2_{swc}	R^2_{ppfd}	Relimp VPD	Relimp SWC	Relimp PPFD	PPET	$P-PET_{sd}$	Clay	Sand	Total N	Bedrock	Stand height	LAI
SWE_NOR_ST1_BEF	0.75	0.62	0.62	0.68	0.19	0.13	1.07	36.70	5.80 a	58.60 a	2.63	185	28.70 a	4.18 a
SWE_NOR_ST2	0.26	0.21	0.17	0.56	0.00	0.44	1.07	36.70	5.80 a	58.60 a	2.63	185	27.70 a	6.15 a
SWE_NOR_ST3	0.62	0.61	0.60	0.67	0.08	0.25	1.07	36.70	5.80 a	58.60 a	2.63	185	27.20 a	4.55 a
SWE_NOR_ST5_REF	0.59	0.62	0.57	0.50	0.20	0.30	1.07	36.55	19.20 b	43.50 b	2.83	190	20.00 a	5.00 a
SWE_SKO_MIN	0.76	0.74	0.70	0.55	0.04	0.41	1.60	45.86	17.30 b	52.00 b	2.48	133	28.00 a	6.50 a
SWE_SKY_38Y	0.38	0.46	0.40	0.12	0.88	0.00	1.39	33.61	21.70 b	43.80 b	3.93	184	13.60 a	3.98 a
SWE_SKY_68Y	0.38	0.57	0.37	0.10	0.76	0.14	1.30	33.80	18.90 b	46.50 b	4.15	184	20.30 a	3.83 a
SWE_SVA_MIX_NON	0.64	0.47	0.54	0.88	0.11	0.00	1.33	34.34	0.50 a	92.50 a	1.67	200	15.00 a	3.80 b
THA_KHU	0.51	0.38	0.39	0.71	0.25	0.05	0.83	84.24	10.00 a	65.00 a	0.75	200	15.00 a	3.90 a
USA_BNZ_BLA	0.66	0.43	0.56	0.78	0.17	0.06	0.69	33.86	10.30 b	36.80 b	2.57	200	3.00 a	3.60 b
USA_CHE_ASP	0.69	0.34	0.30	0.92	0.02	0.06	1.23	20.06	12.00 a	74.00 a	1.52	200	10.00 a	4.50 a
USA_CHE_MAP	0.71	0.62	0.65	0.81	0.02	0.17	1.22	19.85	6.63 a	59.31 a	2.54	200	18.00 a	3.90 a
USA_DUK_HAR	0.72	0.62	0.68	0.86	0.03	0.10	1.12	41.33	33.90 b	31.00 b	0.76	200	25.00 a	7.03 a
USA_HIL_HF2	0.72	0.67	0.71	0.59	0.00	0.41	1.14	37.46	26.00 a	43.00 a	0.71	200	15.00 a	5.50 a
USA_INM	0.52	0.42	0.47	0.53	0.00	0.47	1.18	39.20	26.70 b	8.00 b	1.05	200	30.00 a	4.90 a
USA_MOR_SF	0.73	0.52	0.50	0.89	0.10	0.01	1.18	39.20	30.00 a	10.00 a	1.05	200	27.00 a	5.00 a
USA_NWH	0.87	0.82	0.70	0.84	0.03	0.14	1.05	59.56	36.70 b	4.90 b	0.80	200	22.70 a	5.60 b
USA_ORN_ST1_AMB	0.64	0.62	0.56	0.52	0.08	0.41	1.14	61.36	24.00 a	21.00 a	0.85	200	17.90 a	5.50 a
USA_PAR_FER	0.49	0.16	0.23	0.68	0.03	0.29	1.32	25.96	10.00 a	60.00 a	1.75	200	18.00 a	4.20 a
USA_PER_PER	0.61	0.30	0.33	0.80	0.01	0.19	1.32	34.41	3.40 b	89.20 b	6.13	200	12.00 a	4.10 a
USA_PJS_P04_AMB	0.46	0.15	0.31	0.78	0.12	0.10	0.25	49.32	6.00 a	52.00 a	0.82	186	4.20 a	0.71 a
USA_PJS_P08_AMB	0.50	0.16	0.26	0.93	0.07	0.00	0.25	49.32	3.00 a	49.00 a	0.82	186	4.10 a	0.90 a
USA_PJS_P12_AMB	0.36	0.17	0.11	0.65	0.30	0.05	0.25	49.32	6.00 a	54.00 a	0.82	186	4.00 a	0.72 a
USA_SIL_OAK_1PR	0.44	0.49	0.41	0.33	0.49	0.18	1.36	38.70	1.00 a	98.00 a	0.74	200	9.50 a	3.60 a
USA_SIL_OAK_2PR	0.43	0.33	0.39	0.94	0.06	0.00	1.36	38.70	1.00 a	98.00 a	0.74	200	9.50 a	3.60 a
USA_SMI_SER	0.58	0.46	0.39	0.64	0.29	0.06	1.03	40.05	28.70 b	30.90 b	0.82	200	40.00 a	5.80 b
USA_SWH	0.82	0.56	0.52	0.92	0.02	0.06	1.09	62.29	43.10 b	6.30 b	0.69	200	24.20 a	4.00 b

Table B.3: Summary table of site level R^2_{VPD}, R^2_{SWC}, R^2_{PPFD}, climate, soil properties and vegetation structure data. PPET is in [mm mm^{-1}]; $P - PET_{sd}$ is in [mm]; Clay and Sand are in [%]; Total N is in [g kg^{-1}]; Stand height is in [m]; LAI is in [m^2_{leaves} m^2_{soil}]. Letters show data source: a = SAPFLUXNET, b = Global rasters, c = SAPFLUXNET plant height. *(continued)*

Site code	R^2_{vpd}	R^2_{swc}	R^2_{ppfd}	Relimp VPD	Relimp SWC	Relimp PPFD	PPET	$P - PET_{sd}$	Clay	Sand	Total N	Bedrock	Stand height	LAI
USA_SYL_HL1	0.57	0.42	0.44	0.92	0.08	0.00	1.27	25.01	8.90 b	51.00 b	1.41	200	27.00 a	5.40 b
USA_SYL_HL2	0.53	0.50	0.50	0.66	0.02	0.31	1.27	25.01	8.90 b	51.00 b	1.41	200	27.00 a	5.40 b
USA_TNB	0.31	0.33	0.30	0.37	0.13	0.50	1.39	48.33	21.60 b	34.90 b	0.84	200	25.00 a	4.70 a
USA_TNO	0.38	0.39	0.37	0.41	0.22	0.38	1.41	60.02	29.60 b	30.20 b	0.83	200	30.00 a	6.60 a
USA_TNP	0.34	0.38	0.31	0.50	0.18	0.32	1.41	61.60	31.60 b	26.60 b	0.81	200	25.00 a	4.50 a
USA_UMB_CON	0.61	0.46	0.44	0.76	0.02	0.22	1.30	30.60	1.00 a	92.00 a	2.02	200	29.00 a	3.50 a
USA_UMB_GIR	0.57	0.43	0.39	0.76	0.05	0.19	1.25	30.69	1.00 a	92.00 a	2.49	200	29.00 a	3.50 a
USA_WIL_WC1	0.54	0.30	0.23	0.81	0.18	0.01	1.19	20.23	6.90 b	53.20 b	1.01	200	24.30 a	6.20 b
USA_WVF	0.43	0.35	0.35	0.65	0.02	0.33	1.63	30.35	24.90 b	29.90 b	1.37	200	30.00 a	6.90 a
ZAF_FRA_FRA	0.61	0.08	0.24	0.96	0.01	0.03	0.90	99.17	20.00 b	69.90 b	0.95	200	20.00 a	1.80 a
ZAF_RAD	0.45	0.33	0.32	0.58	0.06	0.37	0.95	82.73	21.30 b	61.40 b	1.18	200	3.50 a	2.70 a
ZAF_SOU_SOU	0.43	0.18	0.17	0.58	0.05	0.38	0.97	86.39	23.00 b	61.90 b	1.13	200	4.00 a	3.00 a
ZAF_WEL_SOR	0.63	0.29	0.32	0.66	0.05	0.29	0.50	79.71	20.00 a	60.00 a	0.81	179	25.00 a	1.80 a

Table B.4: Table of equivalence between Whittaker biomes and the groups of biomes used in the study.

Original biome name	Study biome group
Desert	DRY
Temperate grassland desert	DRY
Subtropical desert	DRY
Woodland/shrubland	WOOD
Temperate forest	TEMP
Boreal forest	BOR
Tundra	BOR
Tropical rainforest	TROP
Tropical seasonal forest/savanna	TROP

Table B.5: Average contribution of the predictors in models of individual coupling (R^2_{VPD}, R^2_{swc}, R^2_{PPFD} and R^2_{TOTAL}) estimated using dominance analysis. log(PPET): logarithm of precipitation over potential evapotraspiration; $\log(P - PET_{sd})$: logarithm of the standard deviation of the difference between precipitation and potential evapotranspiration; LAI: leaf area index. NI means that the variable was not included in the model after model selection.

G_{Asw} coupling	log(PPET)	$\log(P - PET_{sd})$	Clay	Total Nitrogen	Bedrock depth	Stand Height	LAI
R2VPD	0.04	0.003	0.04	0.029	NI	0.06	0.015
R2SWC	0.11	NI	0.05	NI	0.002	0.05	NI
R2PPFD	0.08	0.002	0.04	0.052	NI	0.11	0.017
R2TOTAL	0.04	NI	0.06	0.031	NI	0.01	NI

C
Appendix Chapter 5

C.1 Notes D

Notes S1: Whole-tree stomatal conductance (G'_{Asw}) calculation procedure.

To account for aerodynamic effect on whole-tree canopy conductance (G_{Asw}) in trees were wind speed was available, we substracted from G_{Asw} (calculated with eq. 2 of the main text) the aerodynamic conductance calculated following Tan *et al.* 2019. We first calculate the aerodynamic conductance for momentum (eq. 14 in Tan *et al.* 2019):

$$g_{aM} = \frac{\kappa^2\ u}{ln[(z-d)/z_{0M}]\ ln[(z-d)/z_{0H}]} \tag{C.1}$$

Where κ is the Von Karman constant and equivalent to 0.41 and u is wind speed $[m\ s^{-1}]$ and:

$$z = tree\ height + 2,\ d = 0.6(tree\ height),\ z_{0M} = 0.1(tree\ height),\ z_{0H} = 0.135(z_{0M}) \tag{C.2}$$

Lately, we calculated the boundary layer conductance following eq. 10 in Tan *et al.* (2019):

$$g_{bN} = \frac{\kappa\ u*}{ln\left(\frac{z_{0M}}{z_{0H}}\right)} \tag{C.3}$$

Where $u*$ $[m\ s^{-1}]$ is the friction velocity calculated inverting eq. 2 in Chu *et al.* 2018:

$$u* = \frac{\kappa\ u}{ln[(z-d)/z_{0M}] + ln(1.25)} \tag{C.4}$$

Ultimately, G'_{Asw} was calculated as:

$$G'_{Asw} = G_{Asw}\ - \left(\frac{1}{1/g_{aM} + 1/g_{bN}}\right) \tag{C.5}$$

Being G_{Asw} in $[m\ s^{-1}]$. Finally, G'_{Asw} was transformed to $[mol\ m^{-2}_{Asw}\ s^{-1}]$.

C.2 Figures D

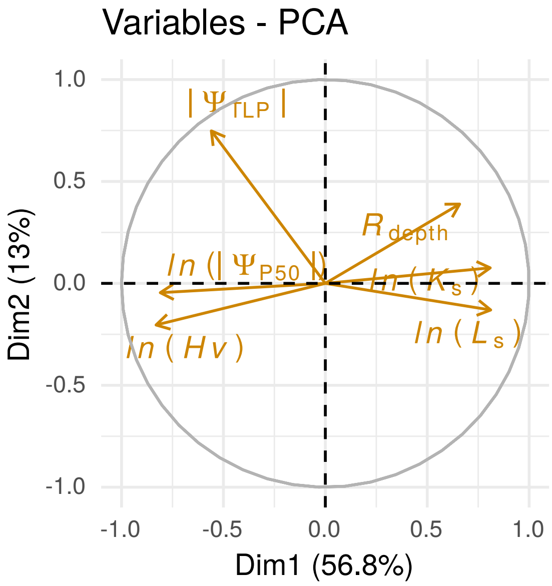


Figure C.1: PCA plot of water relations traits using imputations. $ln(|\Psi_{\mathrm{P50}}|)$: logarithm of absolute water potential at 50% water conductivity loss; $ln(K_{\mathrm{s}})$: logarithm of maximum sapwood water conductivity; $ln(Hv)$: logarithm of Huber value; $|\Psi_{\mathrm{TLP}}|$: absolute water potential at turgor-loss point; R_{depth}: rooting depth; $ln(L_{\mathrm{s}})$: logarithm of individual leaf area.

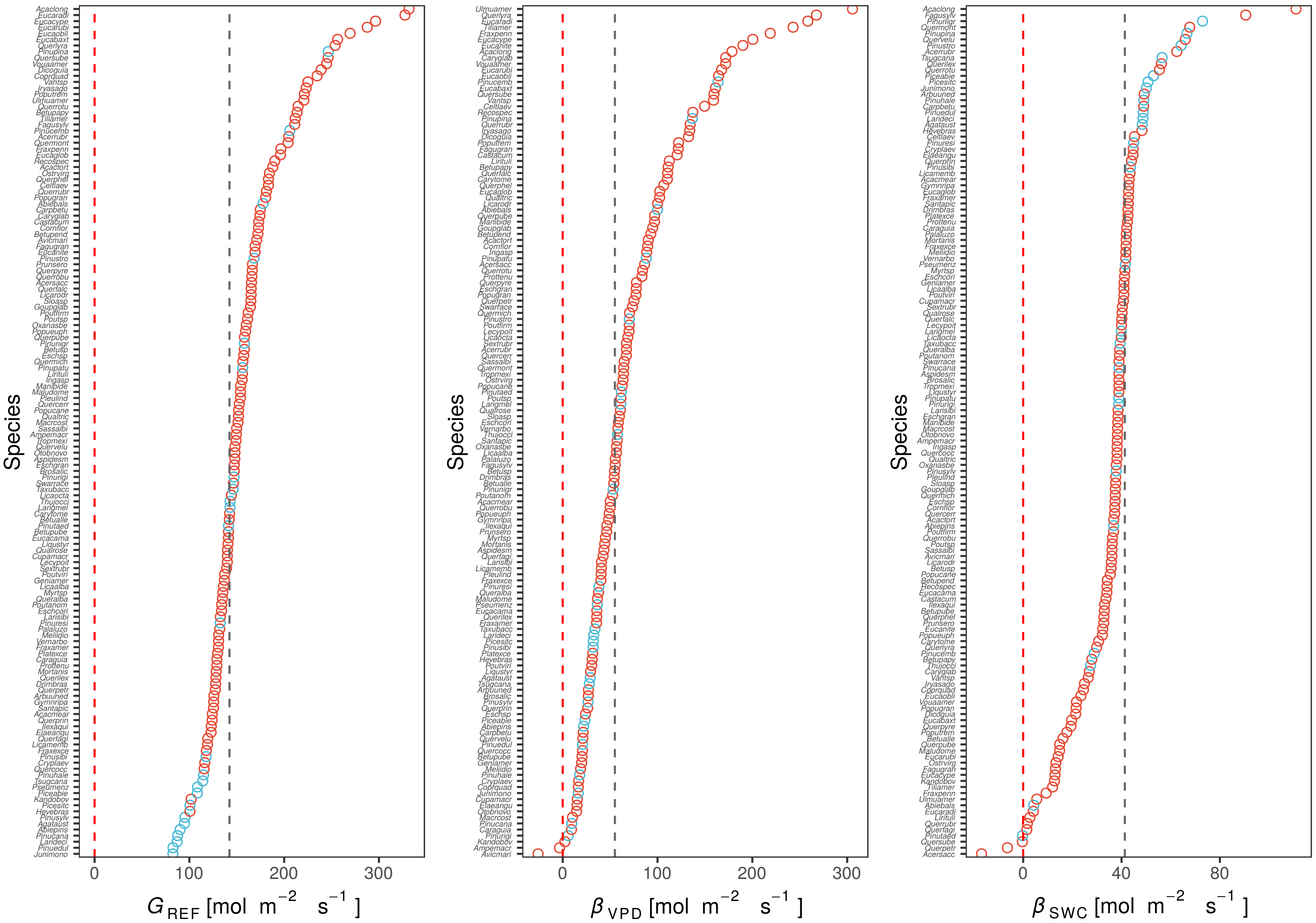
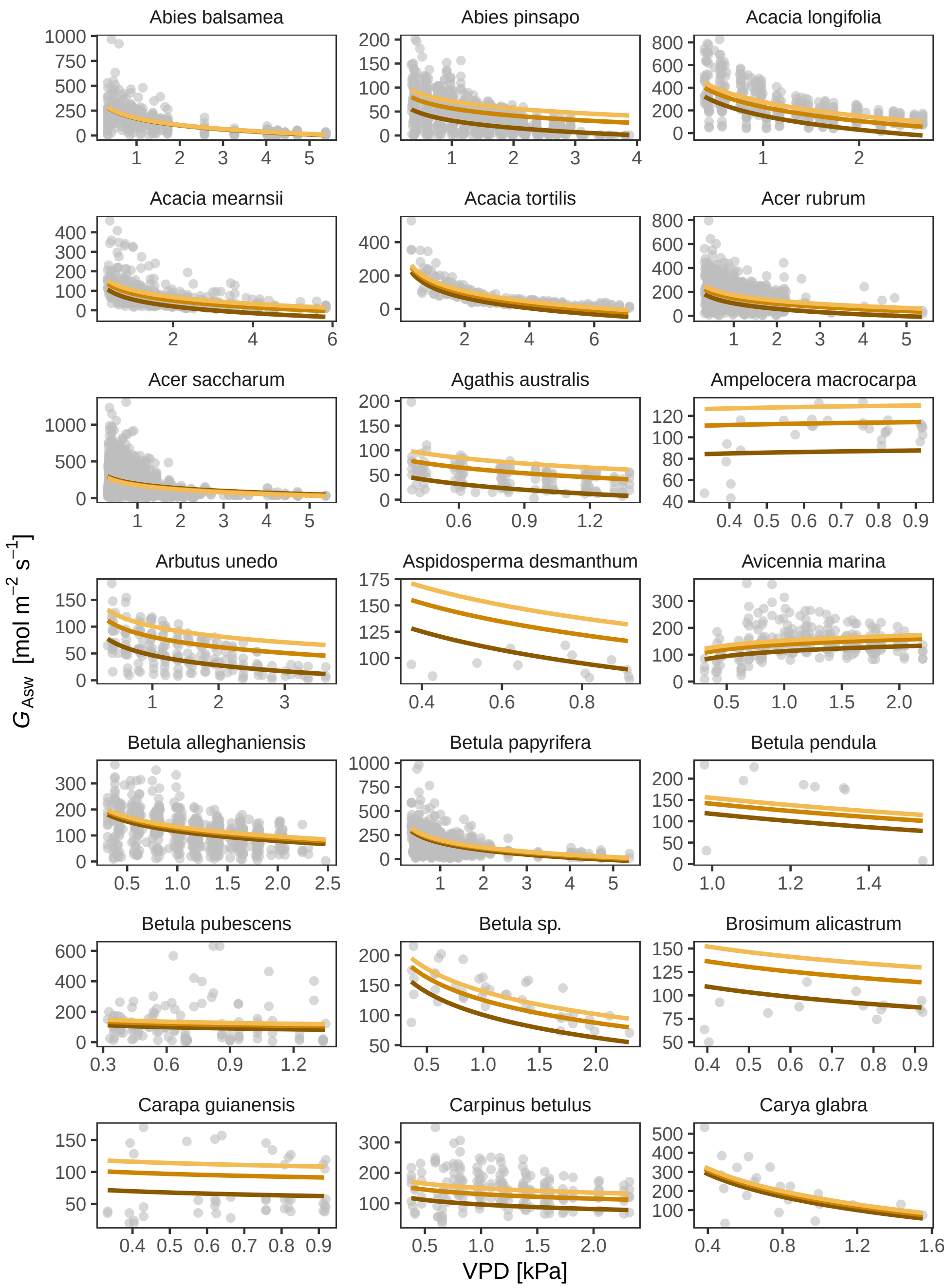
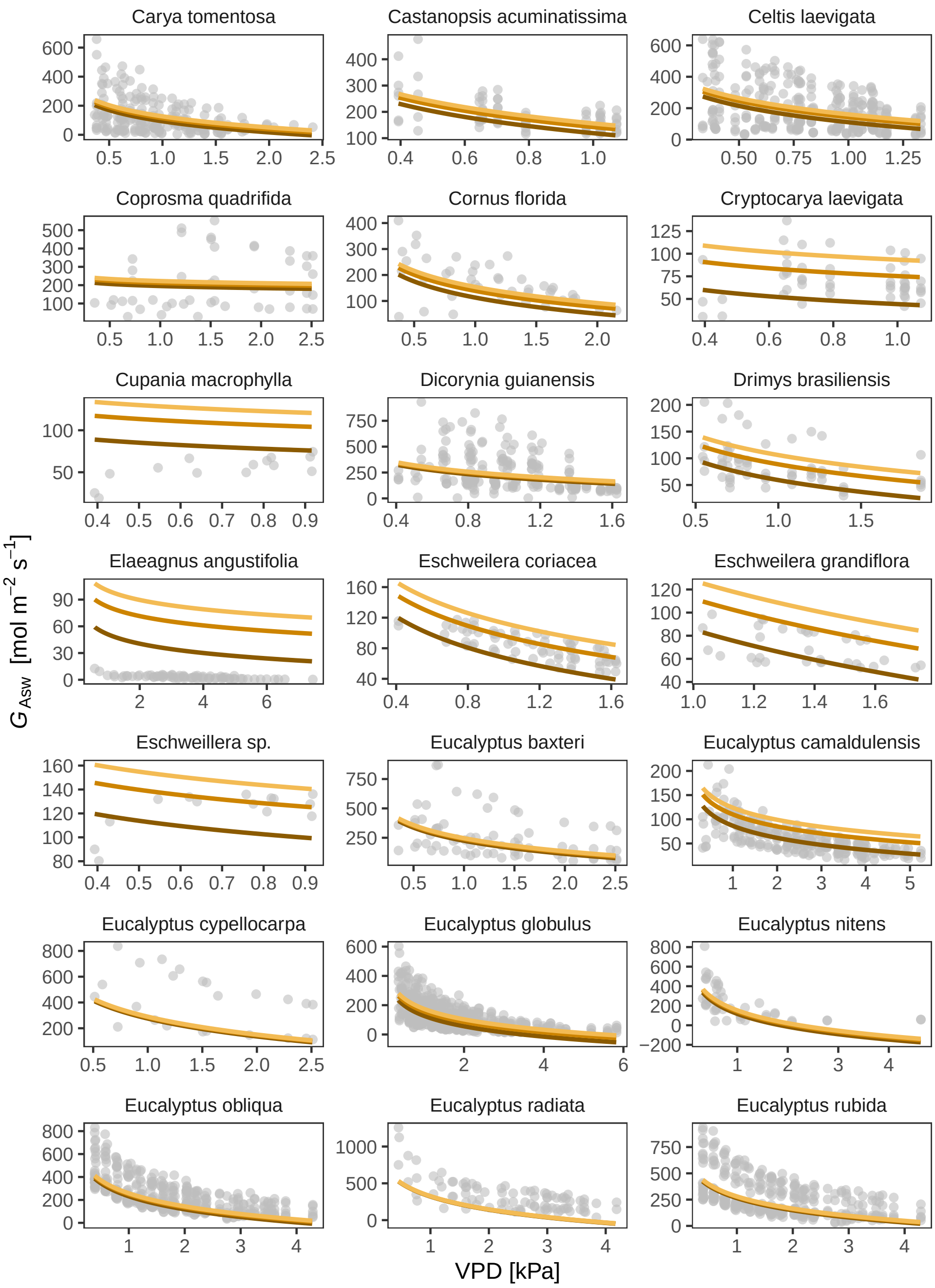
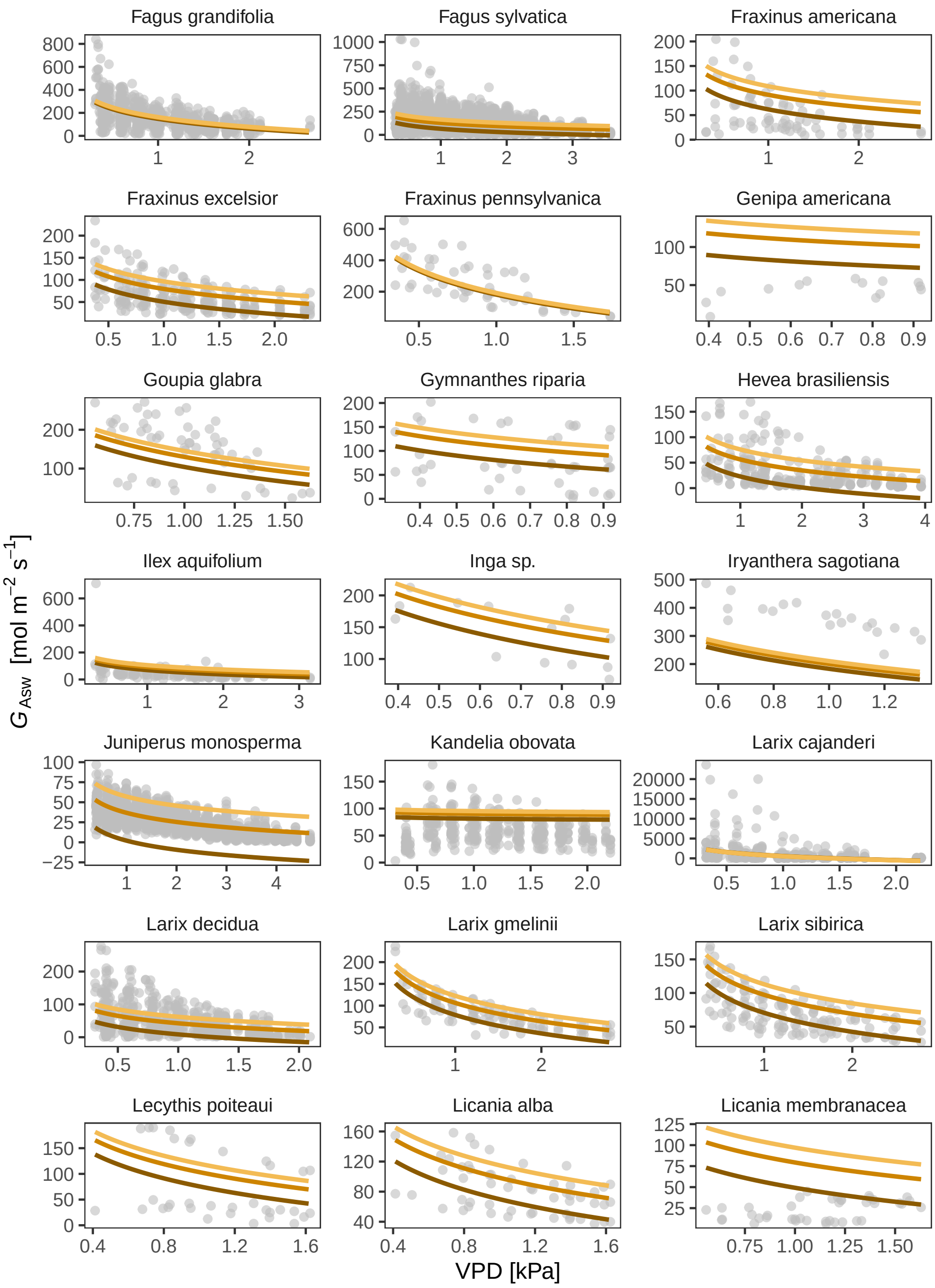
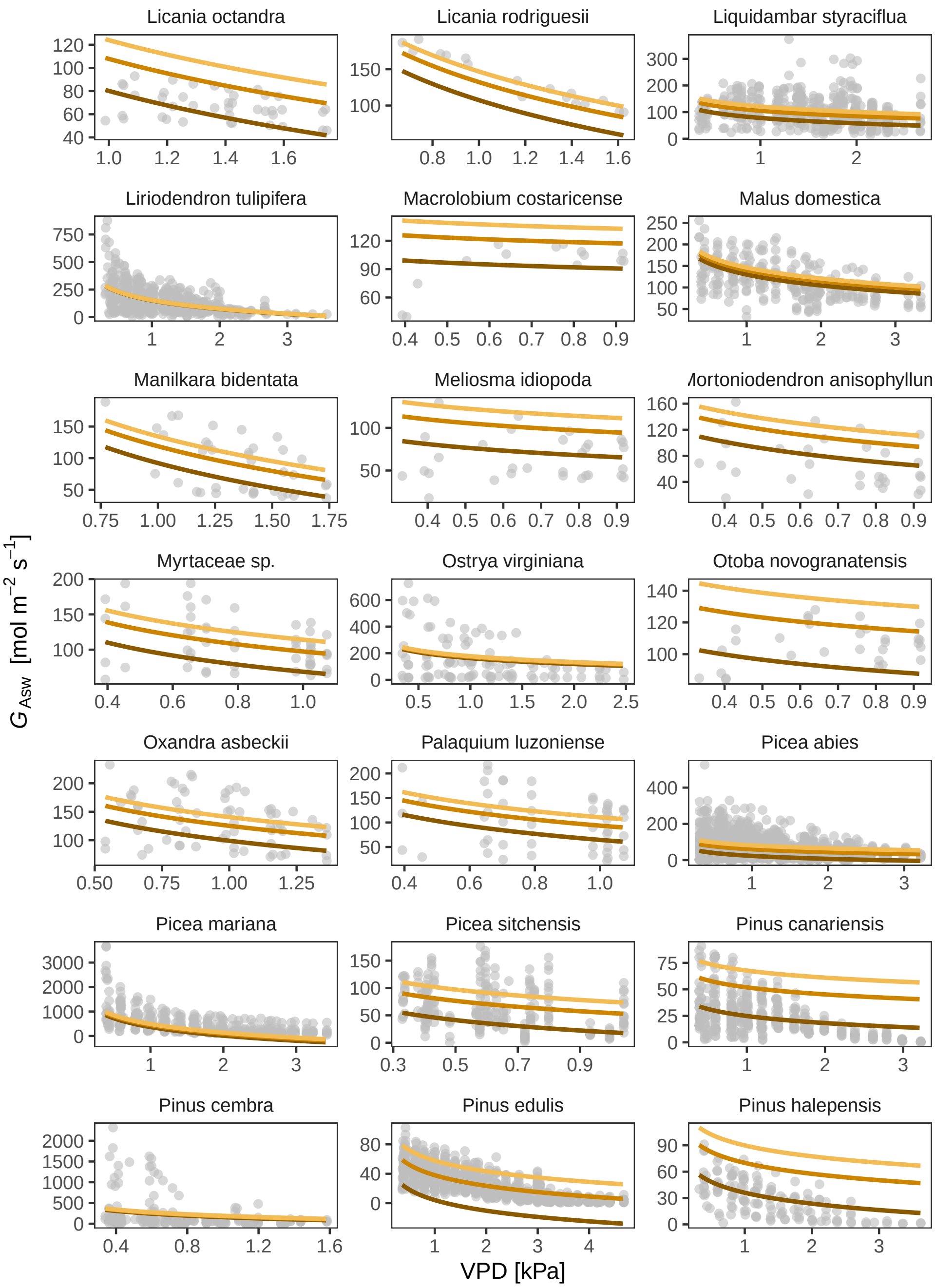


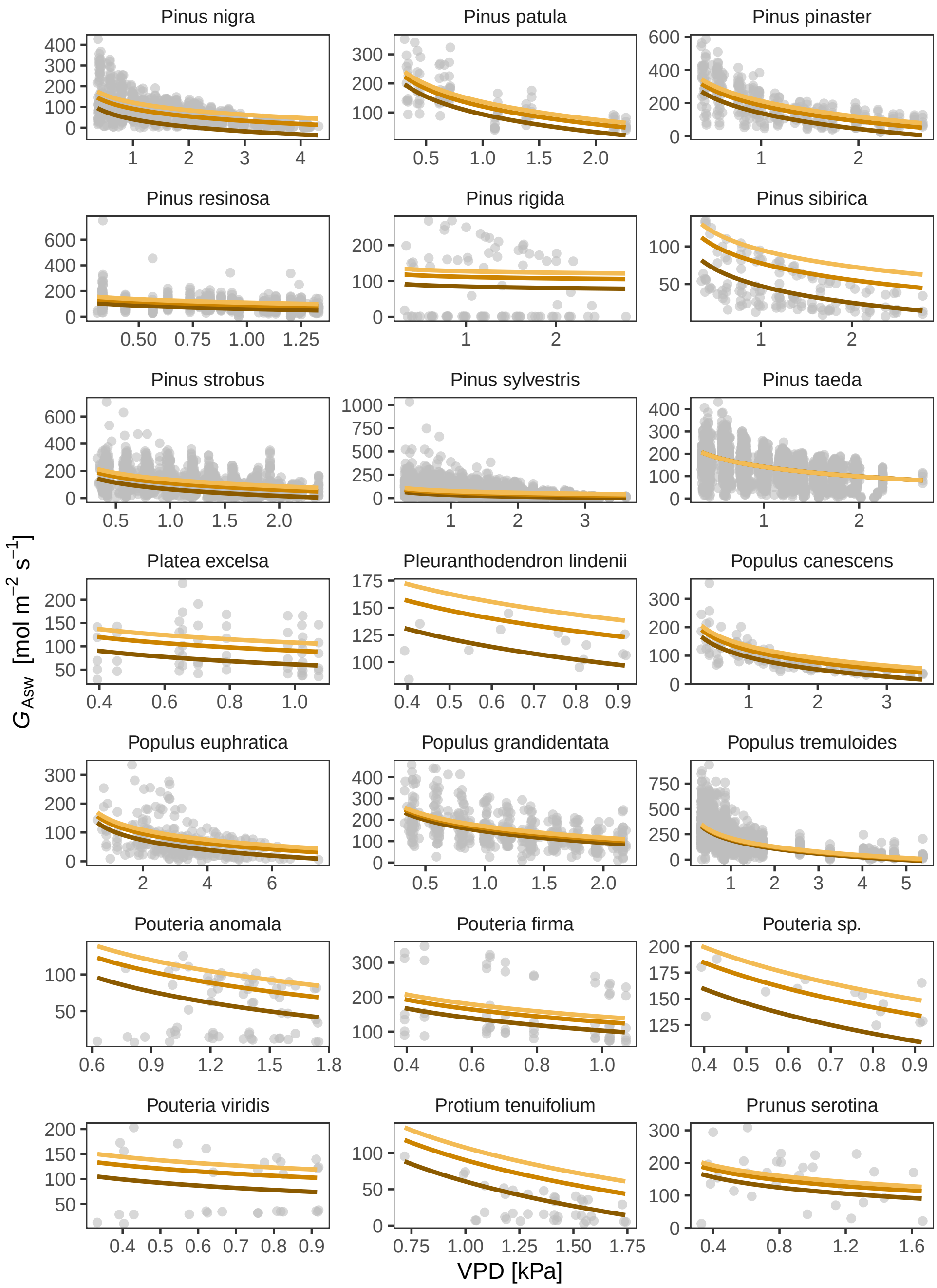
Figure C.2: Water use parameters at the species level. Grey dashed lines are the weighted mean of the parameters

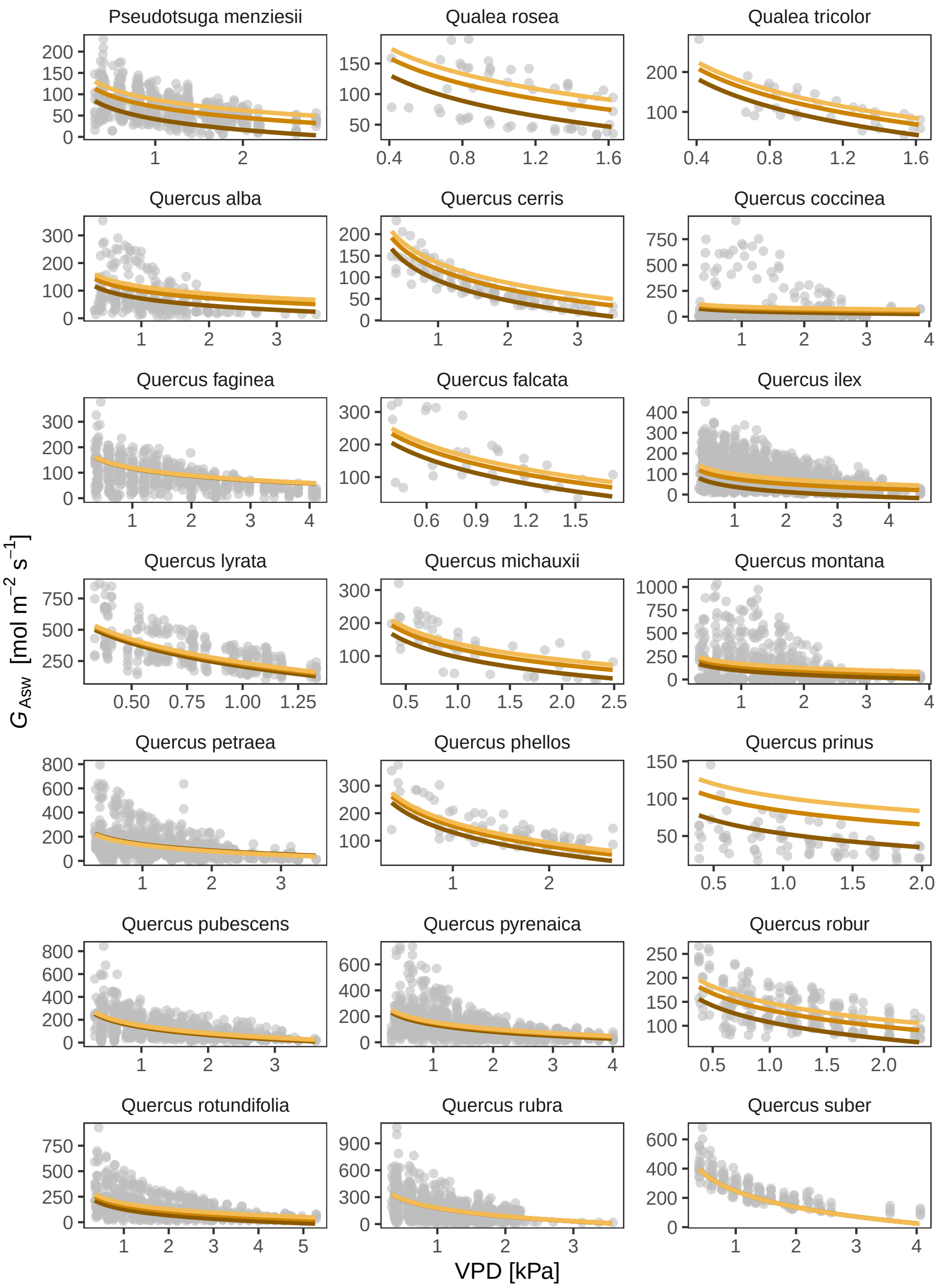

Abies balsamea
Abies pinsapo
Acacia longifolia
Acacia mearnsii
Acacia tortilis
Acer rubrum
Acer saccharum
Agathis australis
Ampelocera macrocarpa
Arbutus unedo
Aspidosperma desmanthum
Avicennia marina
Betula alleghaniensis
Betula papyrifera
Betula pendula
Betula pubescens
Betula sp.
Brosimum alicastrum
Carapa guianensis
Carpinus betulus
Carya glabra
G_{Asw} [mol m^{-2} s^{-1}]
VPD [kPa]


Carya tomentosa
Castanopsis acuminatissima
Celtis laevigata
Coprosma quadrifida
Cornus florida
Cryptocarya laevigata
Cupania macrophylla
Dicorynia guianensis
Drimys brasiliensis
Elaeagnus angustifolia
Eschweilera coriacea
Eschweilera grandiflora
Eschweillera sp.
Eucalyptus baxteri
Eucalyptus camaldulensis
Eucalyptus cypellocarpa
Eucalyptus globulus
Eucalyptus nitens
Eucalyptus obliqua
Eucalyptus radiata
Eucalyptus rubida
G_{Asw} [mol m^{-2} s^{-1}]
VPD [kPa]


Fagus grandifolia
Fagus sylvatica
Fraxinus americana
Fraxinus excelsior
Fraxinus pennsylvanica
Genipa americana
Goupia glabra
Gymnanthes riparia
Hevea brasiliensis
Ilex aquifolium
Inga sp.
Iryanthera sagotiana
Juniperus monosperma
Kandelia obovata
Larix cajanderi
Larix decidua
Larix gmelinii
Larix sibirica
Lecythis poiteaui
Licania alba
Licania membranacea
G_{Asw} [mol m^{-2} s^{-1}]
VPD [kPa]


Licania octandra
Licania rodriguesii
Liquidambar styraciflua
Liriodendron tulipifera
Macrolobium costaricense
Malus domestica
Manilkara bidentata
Meliosma idiopoda
Mortoniodendron anisophyllum
Myrtaceae sp.
Ostrya virginiana
Otoba novogranatensis
Oxandra asbeckii
Palaquium luzoniense
Picea abies
Picea mariana
Picea sitchensis
Pinus canariensis
Pinus cembra
Pinus edulis
Pinus halepensis
G_{Asw} [mol m^{-2} s^{-1}]
VPD [kPa]


Pinus nigra
Pinus patula
Pinus pinaster
Pinus resinosa
Pinus rigida
Pinus sibirica
Pinus strobus
Pinus sylvestris
Pinus taeda
Platea excelsa
Pleuranthodendron lindenii
Populus canescens
Populus euphratica
Populus grandidentata
Populus tremuloides
Pouteria anomala
Pouteria firma
Pouteria sp.
Pouteria viridis
Protium tenuifolium
Prunus serotina
G_{Asw} [mol m^{-2} s^{-1}]
VPD [kPa]


Pseudotsuga menziesii
Qualea rosea
Qualea tricolor
Quercus alba
Quercus cerris
Quercus coccinea
Quercus faginea
Quercus falcata
Quercus ilex
Quercus lyrata
Quercus michauxii
Quercus montana
Quercus petraea
Quercus phellos
Quercus prinus
Quercus pubescens
Quercus pyrenaica
Quercus robur
Quercus rotundifolia
Quercus rubra
Quercus suber
G_{Asw} [mol m^{-2} s^{-1}]
VPD [kPa]

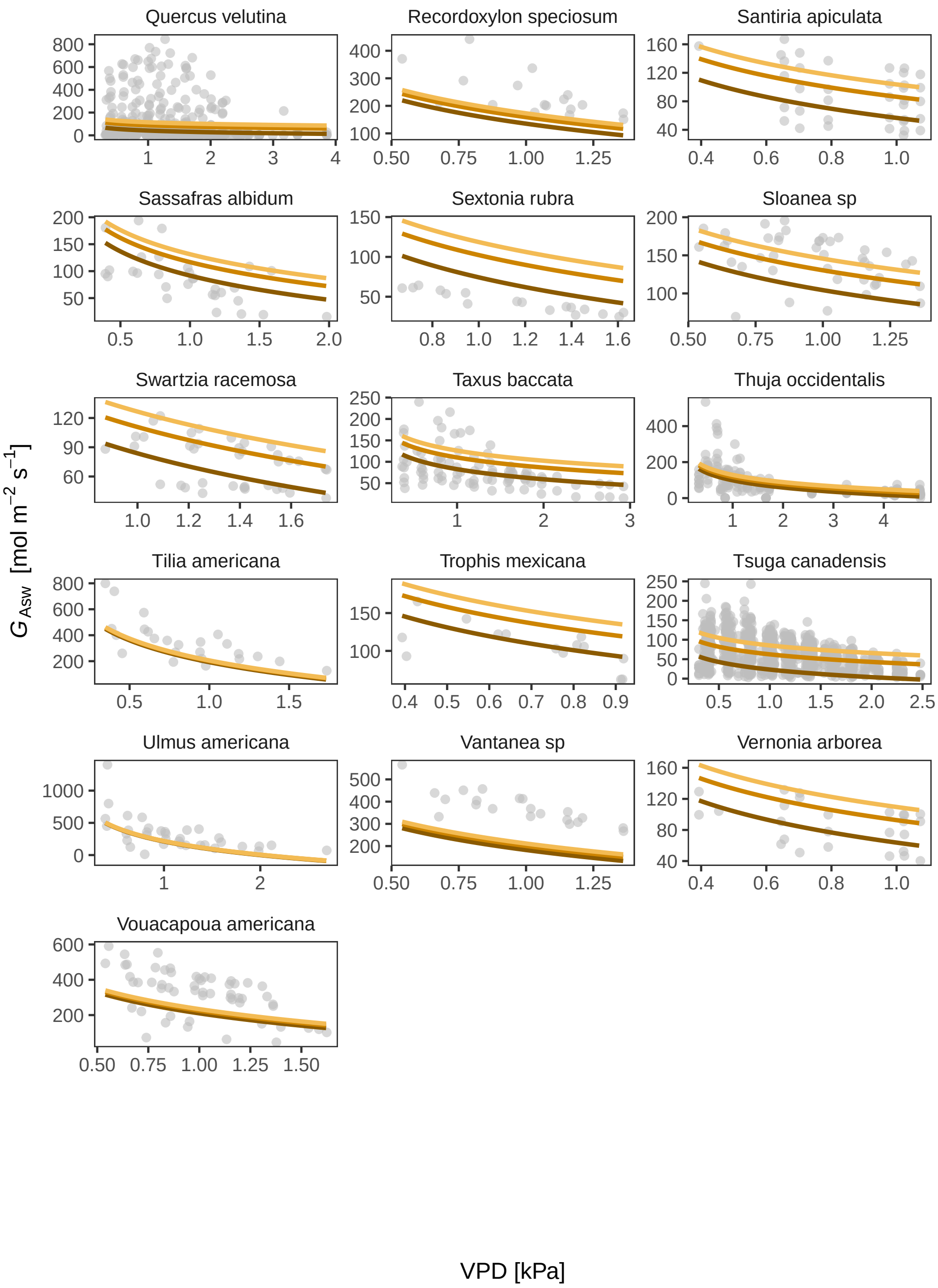
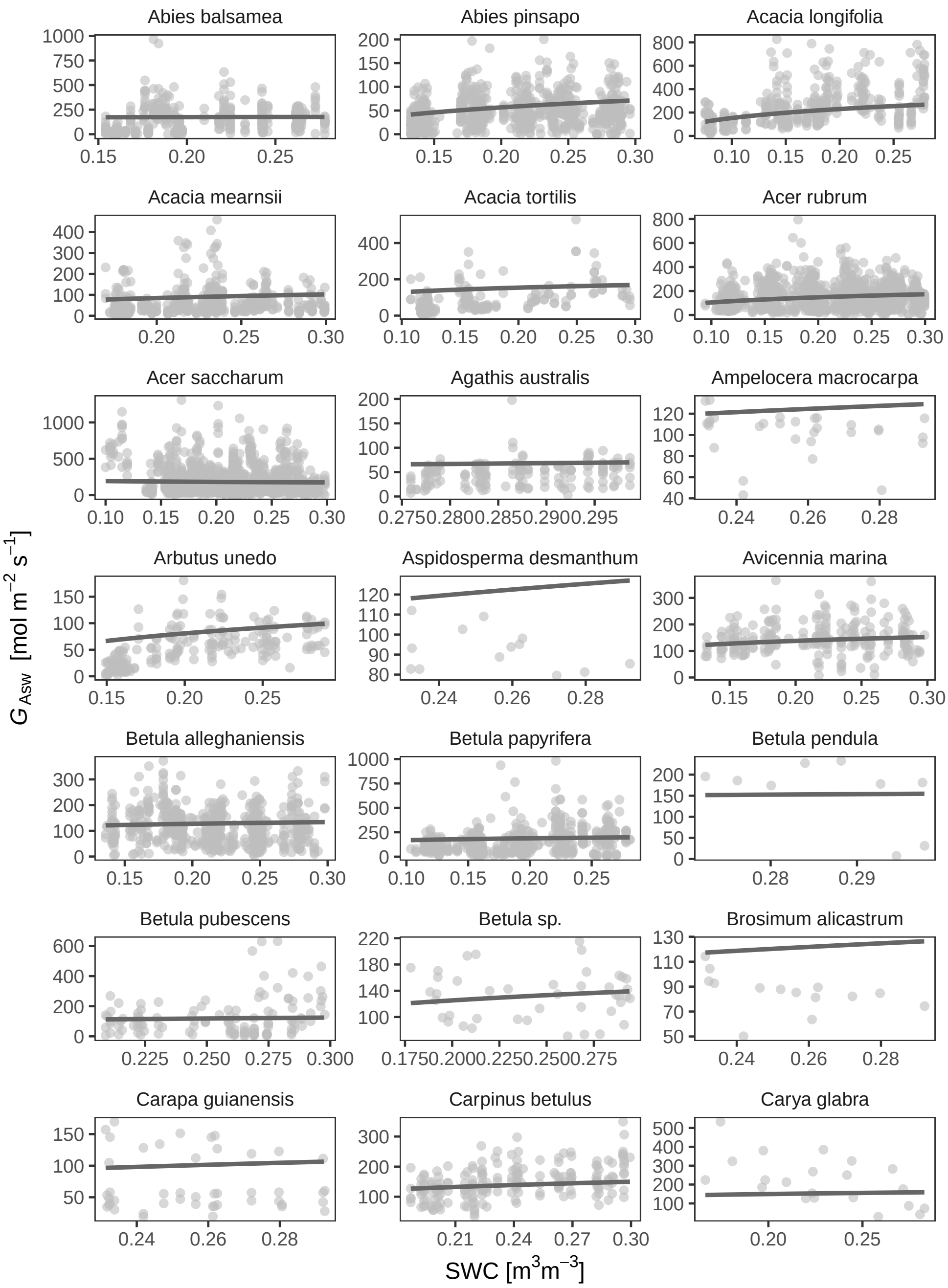
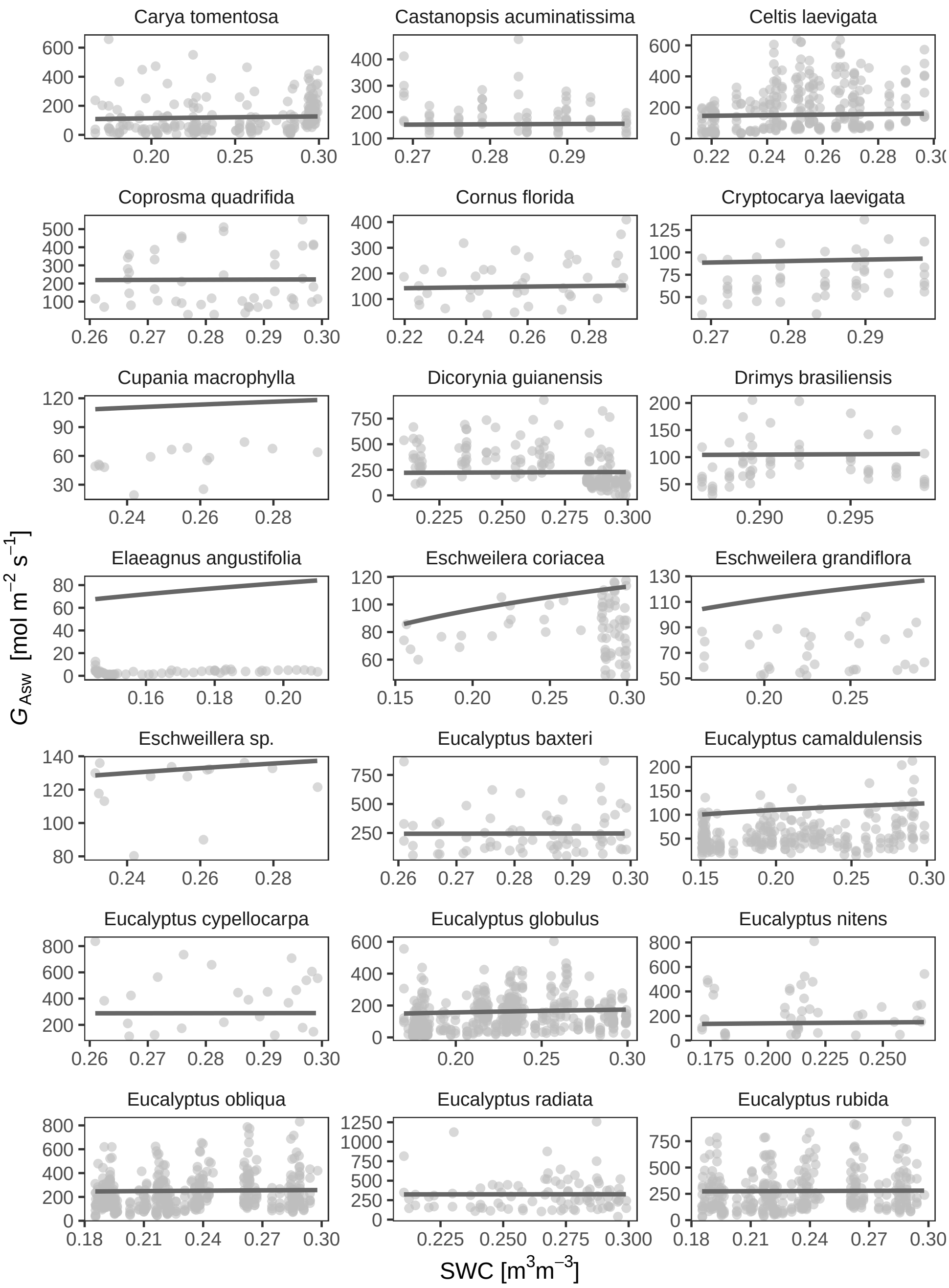
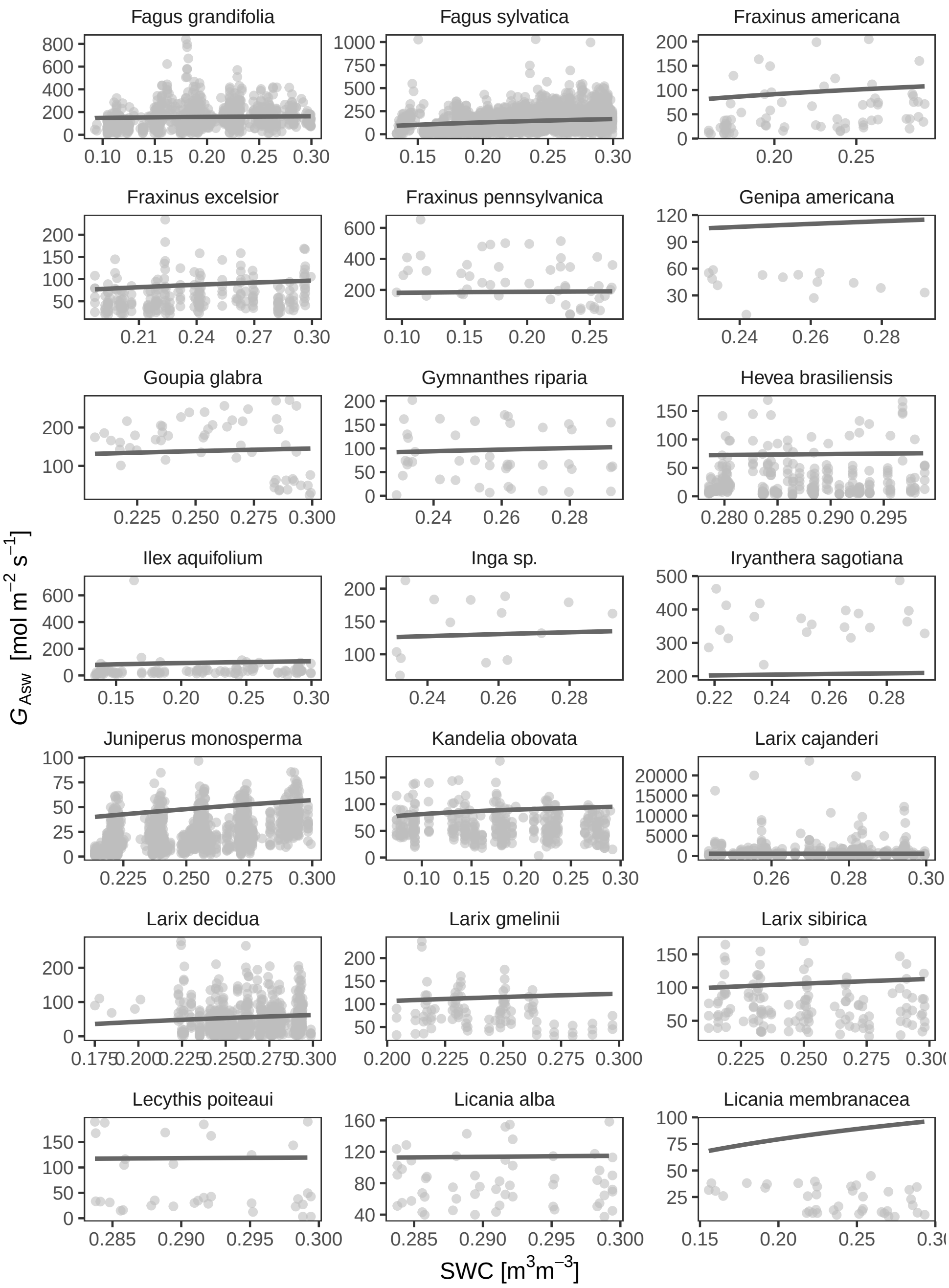
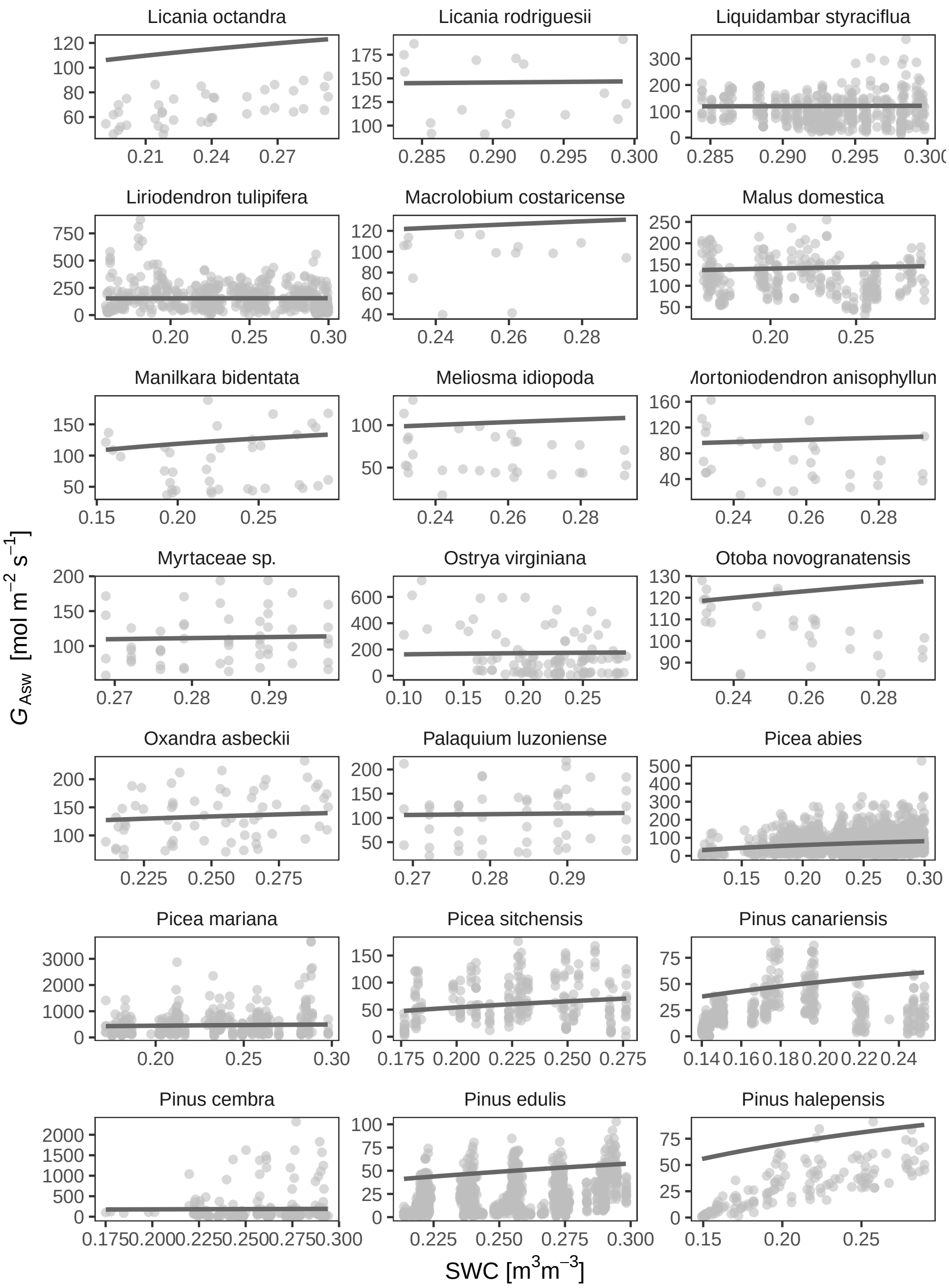


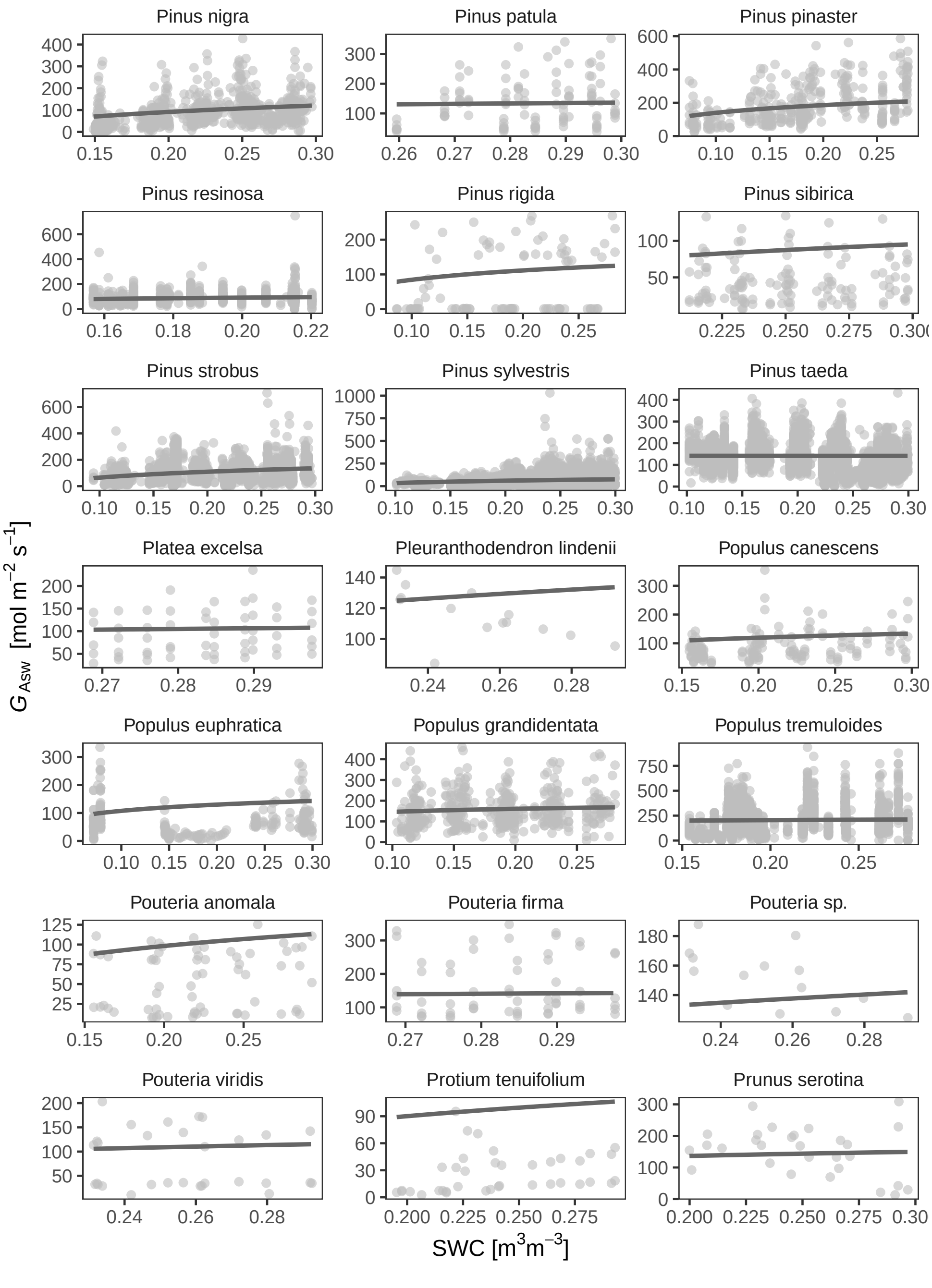
Figure C.3: Species G_{Asw} responses to VPD. Each species have different curves representing distinct levels of SWC (from dark to light, 0.1, 0.2, 0.3 $[m^3m^{-3}]$).

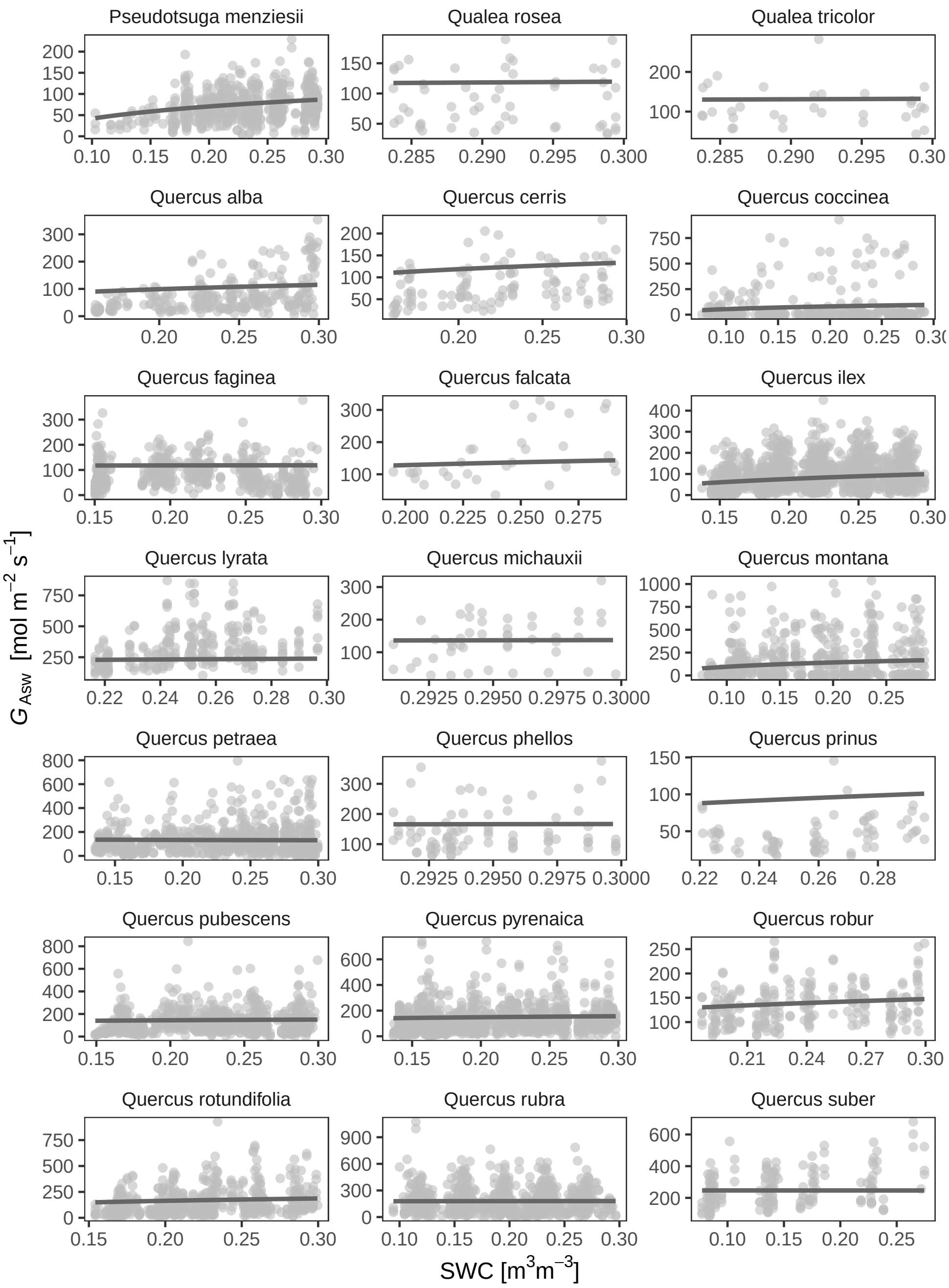

Abies balsamea
Abies pinsapo
Acacia longifolia
Acacia mearnsii
Acacia tortilis
Acer rubrum
Acer saccharum
Agathis australis
Ampelocera macrocarpa
Arbutus unedo
Aspidosperma desmanthum
Avicennia marina
Betula alleghaniensis
Betula papyrifera
Betula pendula
Betula pubescens
Betula sp.
Brosimum alicastrum
Carapa guianensis
Carpinus betulus
Carya glabra
G_{Asw} [mol m^{-2} s^{-1}]
SWC [m^{3}m^{-3}]


Carya tomentosa
Castanopsis acuminatissima
Celtis laevigata
Coprosma quadrifida
Cornus florida
Cryptocarya laevigata
Cupania macrophylla
Dicorynia guianensis
Drimys brasiliensis
Elaeagnus angustifolia
Eschweilera coriacea
Eschweilera grandiflora
Eschweillera sp.
Eucalyptus baxteri
Eucalyptus camaldulensis
Eucalyptus cypellocarpa
Eucalyptus globulus
Eucalyptus nitens
Eucalyptus obliqua
Eucalyptus radiata
Eucalyptus rubida
G_{Asw} [mol m^{-2} s^{-1}]
SWC [m^{3}m^{-3}]


Fagus grandifolia
Fagus sylvatica
Fraxinus americana
Fraxinus excelsior
Fraxinus pennsylvanica
Genipa americana
Goupia glabra
Gymnanthes riparia
Hevea brasiliensis
Ilex aquifolium
Inga sp.
Iryanthera sagotiana
Juniperus monosperma
Kandelia obovata
Larix cajanderi
Larix decidua
Larix gmelinii
Larix sibirica
Lecythis poiteaui
Licania alba
Licania membranacea
G_{Asw} [mol m^{-2} s^{-1}]
SWC [m^{3}m^{-3}]


Licania octandra
Licania rodriguesii
Liquidambar styraciflua
Liriodendron tulipifera
Macrolobium costaricense
Malus domestica
Manilkara bidentata
Meliosma idiopoda
Mortoniodendron anisophyllum
Myrtaceae sp.
Ostrya virginiana
Otoba novogranatensis
Oxandra asbeckii
Palaquium luzoniense
Picea abies
Picea mariana
Picea sitchensis
Pinus canariensis
Pinus cembra
Pinus edulis
Pinus halepensis
G_{Asw} [mol m^{-2} s^{-1}]
SWC [m^{3}m^{-3}]


Pinus nigra
Pinus patula
Pinus pinaster
Pinus resinosa
Pinus rigida
Pinus sibirica
Pinus strobus
Pinus sylvestris
Pinus taeda
Platea excelsa
Pleuranthodendron lindenii
Populus canescens
Populus euphratica
Populus grandidentata
Populus tremuloides
Pouteria anomala
Pouteria firma
Pouteria sp.
Pouteria viridis
Protium tenuifolium
Prunus serotina
G_{Asw} [mol m^{-2} s^{-1}]
SWC [m^{3}m^{-3}]


Pseudotsuga menziesii
Qualea rosea
Qualea tricolor
Quercus alba
Quercus cerris
Quercus coccinea
Quercus faginea
Quercus falcata
Quercus ilex
Quercus lyrata
Quercus michauxii
Quercus montana
Quercus petraea
Quercus phellos
Quercus prinus
Quercus pubescens
Quercus pyrenaica
Quercus robur
Quercus rotundifolia
Quercus rubra
Quercus suber
G_{Asw} [mol m^{-2} s^{-1}]
SWC [m^{3}m^{-3}]

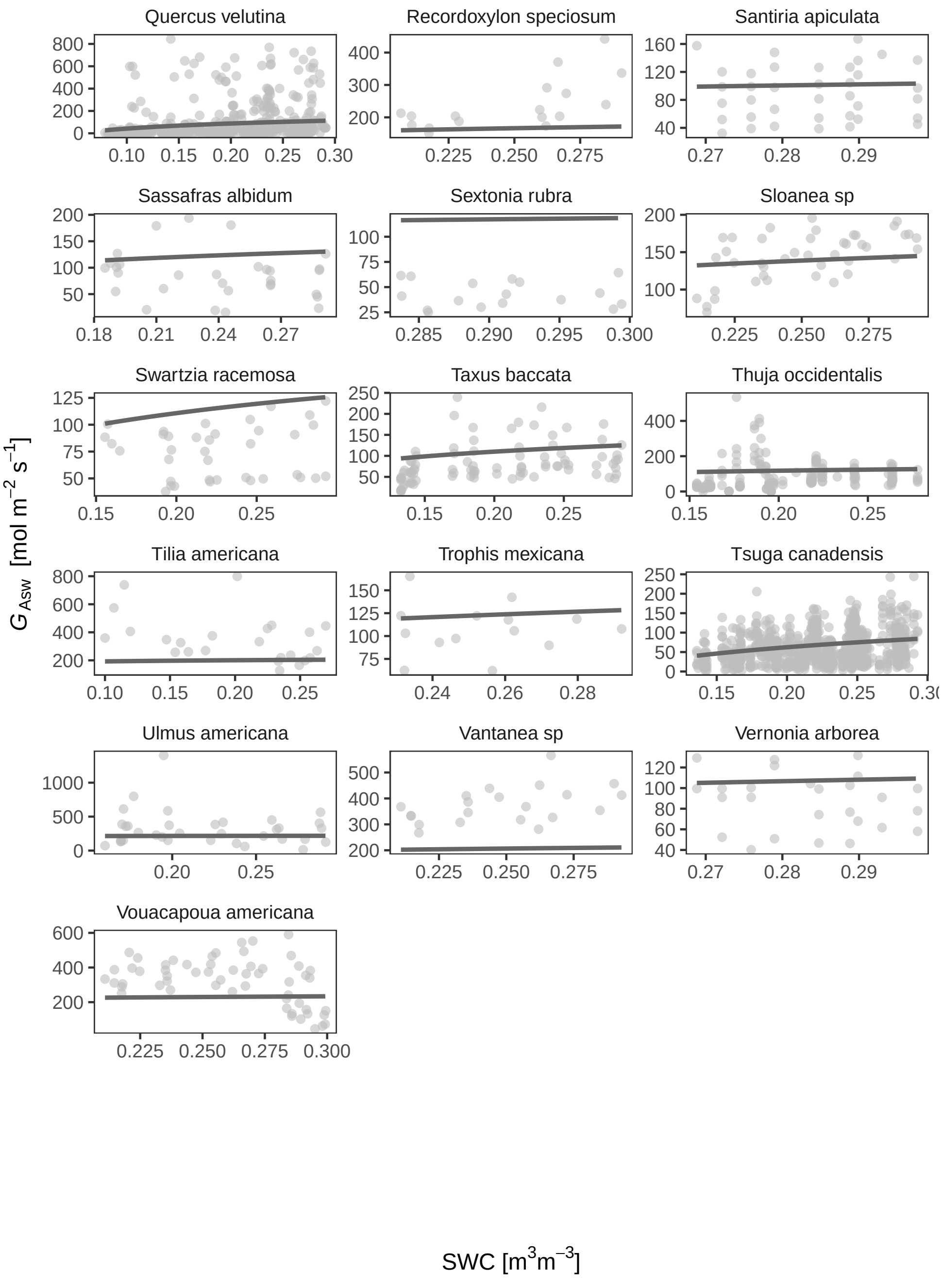


Figure C.4: Species G_{Asw} responses to SWC. Curves are fitted using a VPD reference level of 1 kPa.

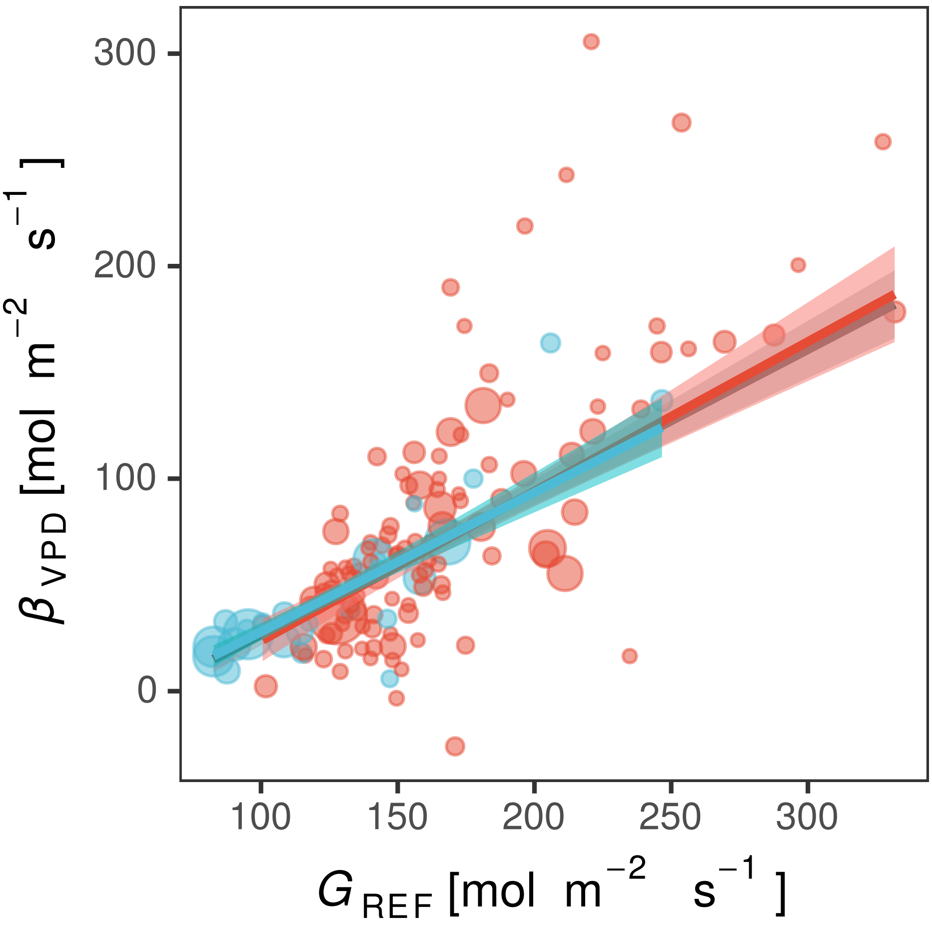


Figure C.5: Scatterplot between G_{REF} and β_{VPD} parameters. Grey line is global relationship. Blue and red lines are angiosperms and gymnosperms relationships, respectively. Shadow areas are 95% confidence interval.

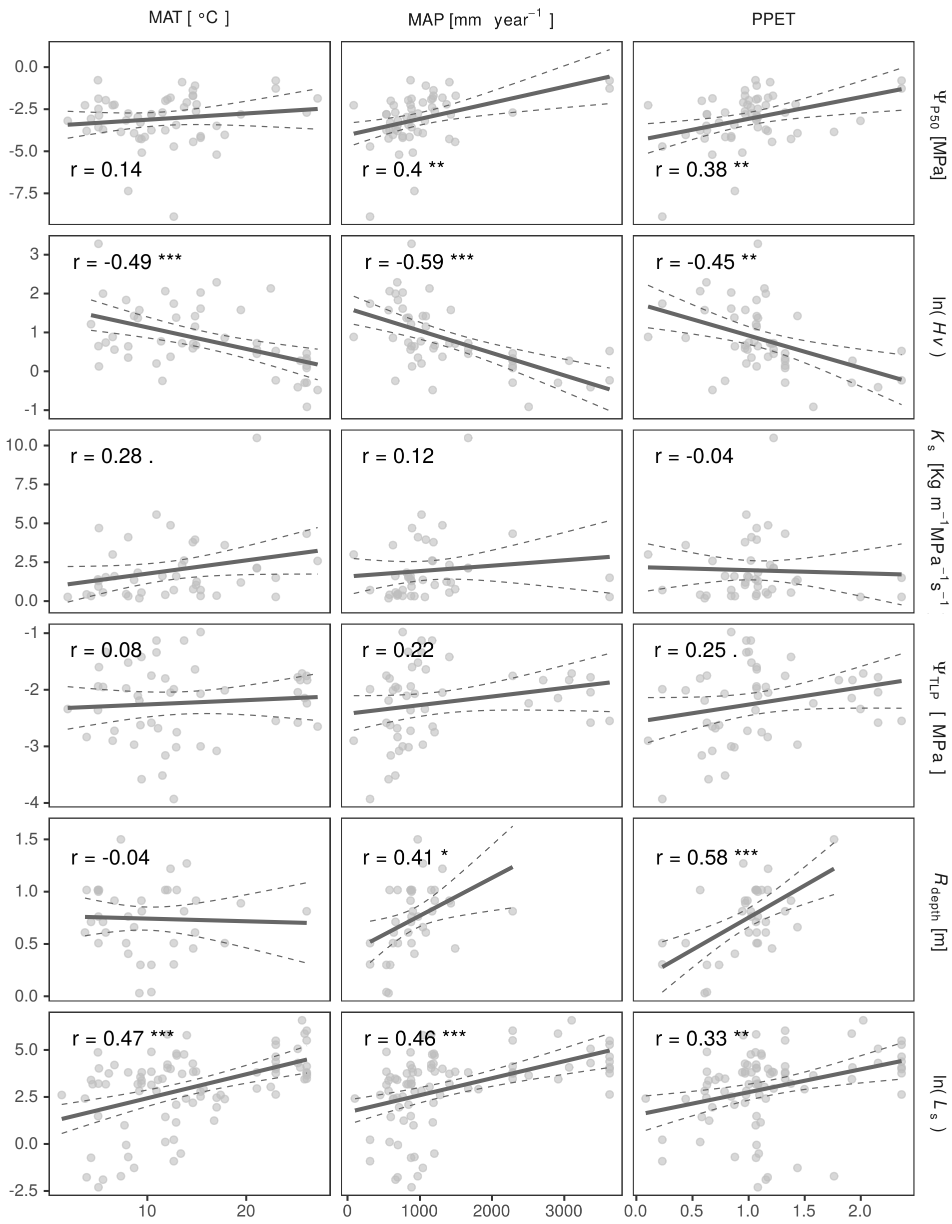


Figure C.6: Species' climatic variables and water relations traits relationships. MAP: mean annual precipitation, MAT: mean annual temperature, PPET: mean annual precipitation over potential evapotranspiration. All climatic variables were calculated as the weighted average of the characteristic plots of the trees of each species, using tree-days as weighting factor.

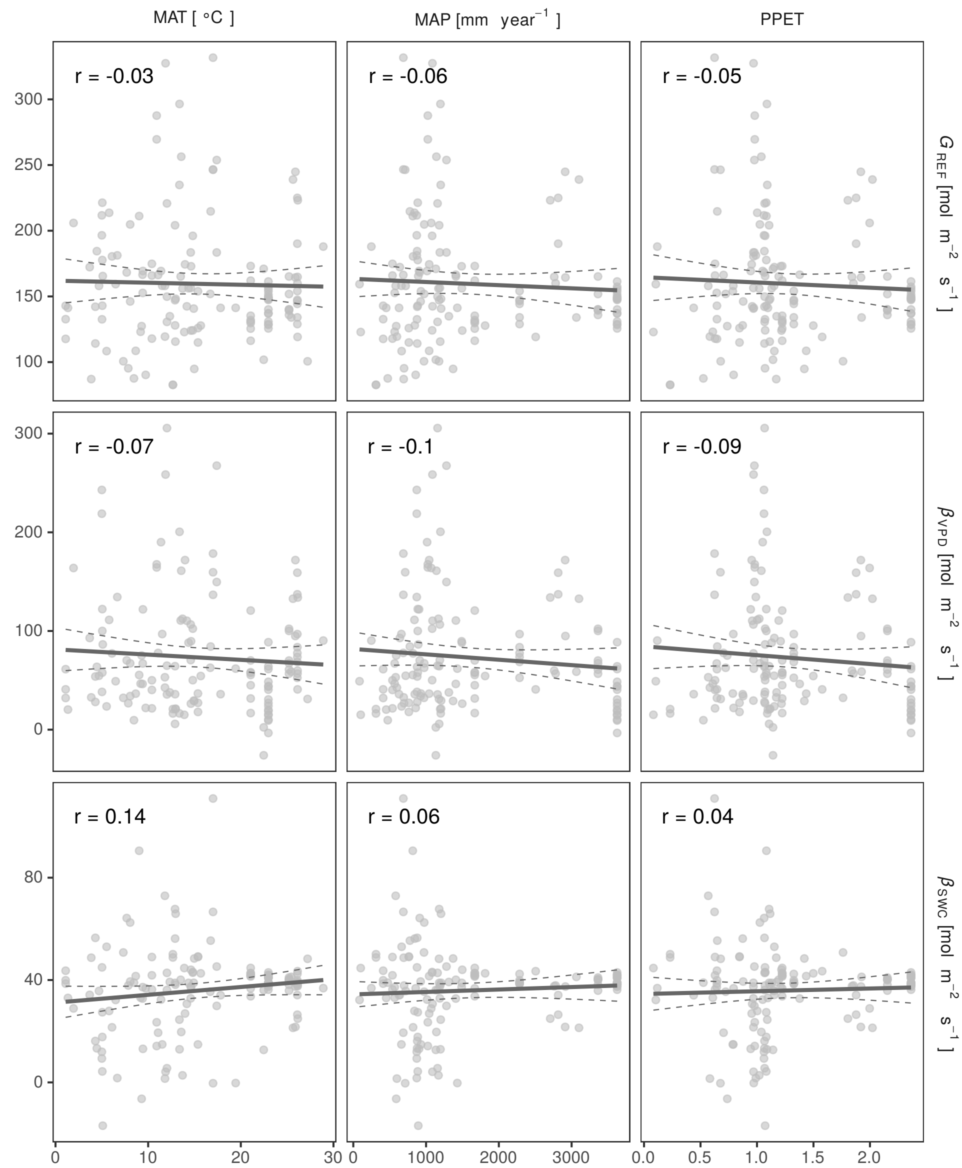


Figure C.7: Species' climatic variables and water use parameters relationships. MAP: mean annual precipitation, MAT: mean annual temperature, PPET: mean annual precipitation over potential evapotranspiration. All climatic variables were calculated as the weighted average of the characteristic plots of the trees of each species, using tree-days as weighting factor.

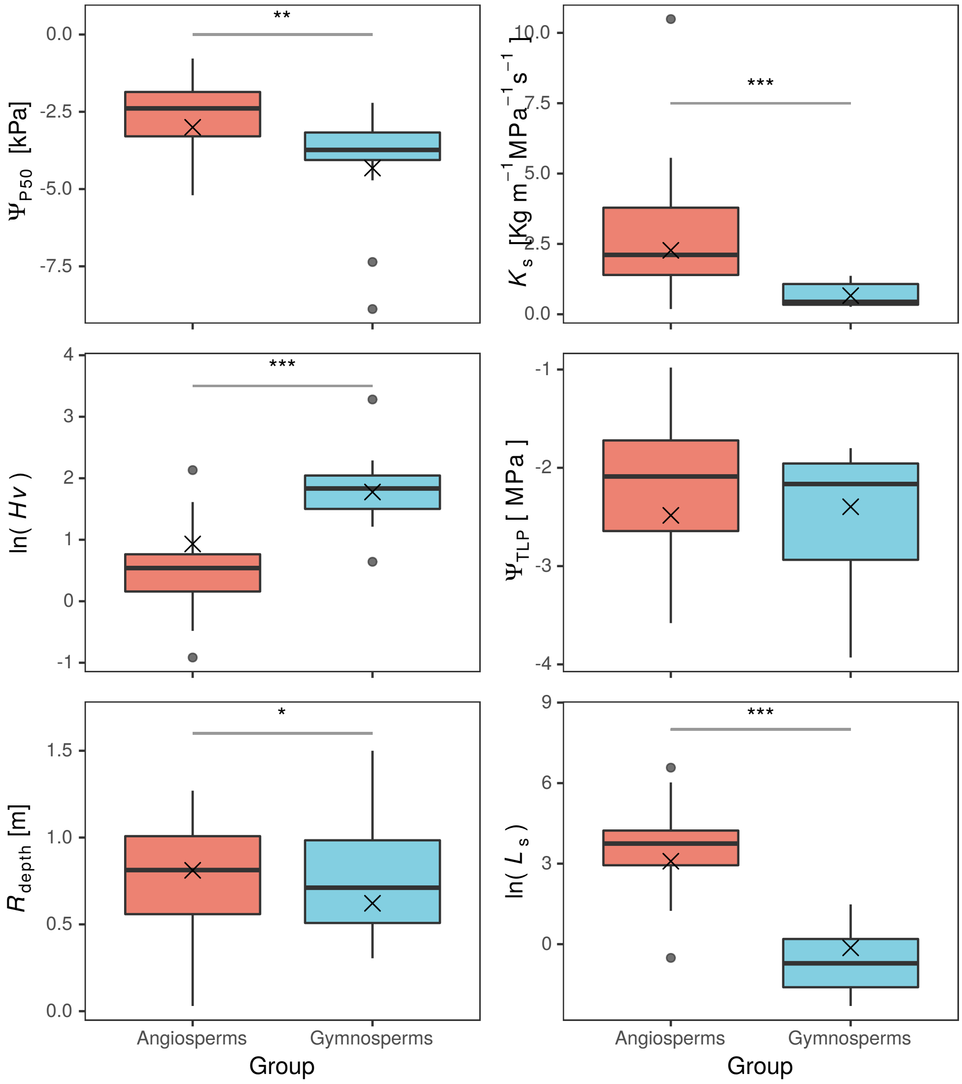


Figure C.8: Boxplots of water relations traits for angiosperms and gymnosperms. Statistical significance level is showed as symbols: ., P < 0.1; *, P < 0.05; **, P < 0.01; ***, P < 0.001. Crosses are weighted means of each trait by groups

C.3 Tables D

Table C.1: SAPFLUXNET plot treatments included in this study (Poyatos *etal*. 2020).

Plot treatment
None
Control
control
Ambient Control
Control - Unthinned
natural conditions
Reference
1Premortality
2premortality
distructive sampling
Girdling early successional
Pre-thinning
Before thinning
Before Thinning
non thinned
none (periodict thinning every 5-6 years 20 to 25% of basal area)
Radiation Level
AMBIENT CO2 FACE rings
fertilization at plantation
AcaciaMonoculture
MixtureEucalyptusAndAcacia
EucalyptusMonoculture
Pre Irrigation

Table C.2: Species resume table. CEP names are Cornell Ecology Programs species names. Ψ_{P50}: water potential at 50% water conductivity loss $[MPa]$; K_{s}: maximum sapwood water conductivity$[Kg\ m^{-1}\ MPa^{-1}\ s^{-1}]$; Hv: Huber value $[cm^2_{Asw}\ m^{-2}_{leaf\ area}]$; Ψ_{TLP}: water potential at turgor-loss point$[MPa]$; R_{depth}: rooting depth $[m]$; L_{s}: individual leaf area $[cm^2]$.

Species	CEP names	Group	# tree-days	# trees	# plots	Ψ_{P50}	K_{s}	Ψ_{TLP}	Hv	R_{depth}	L_{s}
Abies balsamea	Abiebals	Gymnosperms	855	19	1	-2.479	1.292		26.600	0.508	
Abies pinsapo	Abiepins	Gymnosperms	11822	22	3	-4.150					
Acacia longifolia	Acaclong	Angiosperms	2130	10	1						11.715
Acacia mearnsii	Acacmear	Angiosperms	4555	23	2				4.134		
Acacia tortilis	Acactort	Angiosperms	1740	3	1						
Acer rubrum	Acerrubr	Angiosperms	17230	49	9	-2.755	4.108	-1.520	1.422	0.762	44.983
Acer saccharum	Acersacc	Angiosperms	10928	156	8	-2.873	4.695	-1.600	1.134	1.016	55.675
Agathis australis	Agataust	Gymnosperms	1272	6	1	-2.210	1.250				
Ampelocera macrocarpa	Ampemacr	Angiosperms	100	2	1						103.560
Arbutus unedo	Arbuuned	Angiosperms	1900	4	1	-4.198	0.714	-0.980	5.017		12.470
Aspidosperma desmanthum	Aspidesm	Angiosperms	35	1	1						42.925
Avicennia marina	Avicmari	Angiosperms	828	6	1				8.435		20.800
Betula alleghaniensis	Betualle	Angiosperms	3750	16	2						29.938
Betula papyrifera	Betupapy	Angiosperms	3869	21	2	-1.966	1.538	-1.330	2.096	0.610	23.942
Betula pendula	Betupend	Angiosperms	9	1	1	-2.265				0.610	11.177
Betula pubescens	Betupube	Angiosperms	397	9	2						13.510
Betula sp.	Betusp	Angiosperms	204	2	1						
Brosimum alicastrum	Brosalic	Angiosperms	40	1	1				1.685		58.953
Carapa guianensis	Caraguia	Angiosperms	150	3	1	-0.800	0.270		0.793		
Carpinus betulus	Carpbetu	Angiosperms	530	5	1	-3.750					23.160
Carya glabra	Caryglab	Angiosperms	47	1	1	-2.100				1.270	324.425
Carya tomentosa	Carytome	Angiosperms	645	10	2						
Castanopsis acuminatissima	Castacum	Angiosperms	96	8	1		10.490		1.570		45.000
Celtis laevigata	Celtlaev	Angiosperms	745	13	2						13.580
Coprosma quadrifida	Coprquad	Angiosperms	57	4	2						0.600
Cornus florida	Cornflor	Angiosperms	126	1	1	-4.442	0.768		2.034	0.457	46.343
Cryptocarya laevigata	Cryplaev	Angiosperms	72	6	1		2.140		1.750		19.075
Cupania macrophylla	Cupamacr	Angiosperms	40	1	1						
Dicorynia guianensis	Dicoguia	Angiosperms	596	9	2			-1.712			717.500
Drimys brasiliensis	Drimbras	Angiosperms	90	5	1						18.420
Elaeagnus angustifolia	Elaeangu	Angiosperms	402	2	1						11.200
Eschweilera coriacea	Eschcori	Angiosperms	249	4	2			-1.828	1.312		58.654
Eschweilera grandiflora	Eschgran	Angiosperms	378	2	1			-1.754	0.746		62.085
Eschweillera sp.	Eschsp	Angiosperms	40	1	1						
Eucalyptus baxteri	Eucabaxt	Angiosperms	112	4	2						
Eucalyptus camaldulensis	Eucacama	Angiosperms	564	3	1	-4.025	3.600	-2.010	2.364	0.508	10.910
Eucalyptus cypellocarpa	Eucacype	Angiosperms	29	2	2						
Eucalyptus globulus	Eucaglob	Angiosperms	4555	23	2	-1.100	3.950	-1.640	3.155	0.610	
Eucalyptus nitens	Eucanite	Angiosperms	378	7	1				2.163		
Eucalyptus obliqua	Eucaobli	Angiosperms	2466	6	1			-1.340			16.790
Eucalyptus radiata	Eucaradi	Angiosperms	170	2	1						
Eucalyptus rubida	Eucarubi	Angiosperms	2055	5	1		5.560	-1.130	1.222		
Fagus grandifolia	Fagugran	Angiosperms	6815	32	3	-5.080				0.813	45.167
Fagus sylvatica	Fagusylv	Angiosperms	15075	93	12	-2.972	1.830	-2.107	3.934		24.030
Fraxinus americana	Fraxamer	Angiosperms	378	2	1	-1.920				1.016	339.552
Fraxinus excelsior	Fraxexce	Angiosperms	636	6	1	-2.805		-1.750		0.040	133.800
Fraxinus pennsylvanica	Fraxpenn	Angiosperms	178	2	1	-0.777	1.397	-2.360		1.016	
Genipa americana	Geniamer	Angiosperms	40	1	1	-1.270	1.500	-2.550			242.210
Goupia glabra	Goupglab	Angiosperms	172	3	3						31.288
Gymnanthes riparia	Gymnripa	Angiosperms	150	3	1						
Hevea brasiliensis	Hevebras	Angiosperms	1302	6	1	-1.859	2.582	-2.650	0.618		
Ilex aquifolium	Ilexaqui	Angiosperms	567	3	1	-4.241	0.186	-2.190	4.825	0.030	16.770
Inga sp.	Ingasp	Angiosperms	40	1	1						

Table C.2: Species resume table. CEP names are Cornell Ecology Programs species names. Ψ_{P50}: water potential at 50% water conductivity loss $[MPa]$; K_{s}: maximum sapwood water conductivity$[Kg\, m^{-1}\, MPa^{-1}\, s^{-1}]$; Hv: Huber value $[cm^2_{Asw}\, m^{-2}_{leaf\ area}]$; Ψ_{TLP}: water potential at turgor-loss point$[MPa]$; R_{depth}: rooting depth $[m]$; L_{s}: individual leaf area $[cm^2]$. *(continued)*

Species	CEP names	Group	# tree-days	# trees	# plots	Ψ_{P50}	K_{s}	Ψ_{TLP}	Hv	R_{depth}	L_{s}
Iryanthera sagotiana	Iryasago	Angiosperms	72	1	1			-1.830			
Juniperus monosperma	Junimono	Gymnosperms	23650	15	3	-8.882	0.710	-3.930	5.700	0.305	0.400
Kandelia obovata	Kandobov	Angiosperms	2584	8	1						
Larix decidua	Larideci	Gymnosperms	3127	23	5	-3.791	0.434	-2.835		1.016	0.170
Larix gmelinii	Larigmel	Gymnosperms	303	3	1						
Larix sibirica	Larisibi	Angiosperms	516	3	1						
Lecythis poiteaui	Lecypoit	Angiosperms	90	2	1			-2.581			
Licania alba	Licaalba	Angiosperms	141	3	1			-2.044	0.664		157.435
Licania membranacea	Licamemb	Angiosperms	217	2	2			-2.239	0.401		38.313
Licania octandra	Licaocta	Angiosperms	256	2	1				1.088		32.005
Licania rodriguesii	Licarodr	Angiosperms	34	1	1						
Liquidambar styraciflua	Liqustyr	Angiosperms	742	23	3	-2.622	1.042		1.949	0.914	47.104
Liriodendron tulipifera	Lirituli	Angiosperms	2246	27	7	-2.390	2.610	-1.130		0.813	116.933
Macrolobium costaricense	Macrcost	Angiosperms	40	1	1						79.840
Malus domestica	Maludome	Angiosperms	1175	5	2			-2.070			16.200
Manilkara bidentata	Manibide	Angiosperms	500	2	1	-2.700	4.333		1.309	0.813	45.229
Meliosma idiopoda	Meliidio	Angiosperms	100	2	1						
Mortoniodendron anisophyllum	Mortanis	Angiosperms	100	2	1						
Myrtaceae sp.	Myrtsp	Angiosperms	72	6	1						
Ostrya virginiana	Ostrvirg	Angiosperms	549	3	2						23.994
Otoba novogranatensis	Otobnovo	Angiosperms	100	2	1						196.140
Oxandra asbeckii	Oxanasbe	Angiosperms	263	3	2						
Palaquium luzoniense	Palaluzo	Angiosperms	72	6	1						
Picea abies	Piceabie	Gymnosperms	11873	109	11	-3.714	0.558	-1.950	7.375	0.711	0.150
Picea sitchensis	Picesitc	Gymnosperms	990	15	1	-3.850				1.500	0.180
Pinus canariensis	Pinucana	Gymnosperms	4890	10	1						
Pinus cembra	Pinucemb	Gymnosperms	1151	14	5	-3.192	0.267	-2.340			
Pinus edulis	Pinuedul	Gymnosperms	23715	15	3	-4.718		-1.990		0.508	1.250
Pinus halepensis	Pinuhale	Gymnosperms	1329	3	1	-4.105	0.335	-3.000	7.590		
Pinus nigra	Pinunigr	Gymnosperms	11246	15	3	-3.753	0.407	-1.800	7.860	1.016	1.110
Pinus patula	Pinupatu	Gymnosperms	152	8	1						
Pinus pinaster	Pinupina	Gymnosperms	2130	10	1	-3.489	0.352		9.870		
Pinus resinosa	Pinuresi	Gymnosperms	1176	42	1			-1.940		1.016	4.400
Pinus rigida	Pinurigi	Gymnosperms	489	2	2						3.150
Pinus sibirica	Pinusibi	Gymnosperms	516	3	1						
Pinus strobus	Pinustro	Gymnosperms	32538	60	4						2.700
Pinus sylvestris	Pinusylv	Gymnosperms	42463	215	21	-3.163	0.448	-1.975	6.257	0.508	0.947
Pinus taeda	Pinutaed	Gymnosperms	24380	97	4	-2.810	1.197		4.848	0.889	
Platea excelsa	Platexce	Angiosperms	72	6	1						
Pleuranthodendron lindenii	Pleulind	Angiosperms	40	1	1						53.633
Populus canescens	Popucane	Angiosperms	597	3	1						
Populus euphratica	Popueuph	Angiosperms	841	9	3	-2.264	2.998	-2.900	2.420		
Populus grandidentata	Popugran	Angiosperms	6888	12	1						42.608
Populus tremuloides	Poputrem	Angiosperms	4455	99	1	-1.876	0.934		1.910	1.000	24.690
Pouteria anomala	Poutanom	Angiosperms	912	3	1				1.392		42.295
Pouteria firma	Poutfirm	Angiosperms	72	6	1						
Pouteria sp.	Poutsp	Angiosperms	40	1	1						
Pouteria viridis	Poutviri	Angiosperms	100	2	1						
Protium tenuifolium	Prottenu	Angiosperms	242	2	1				1.587		413.810
Prunus serotina	Prunsero	Angiosperms	100	1	1	-4.270	0.550	-1.420		0.914	24.759
Pseudotsuga menziesii	Pseumenz	Gymnosperms	2985	18	3	-3.926	1.366	-2.970	4.153	0.660	0.280
Qualea rosea	Qualrose	Angiosperms	141	3	1			-1.779			

Table C.2: Species resume table. CEP names are Cornell Ecology Programs species names. Ψ_{P50}: water potential at 50% water conductivity loss $[MPa]$; K_{s}: maximum sapwood water conductivity$[Kg\, m^{-1}\, MPa^{-1}\, s^{-1}]$; Hv: Huber value $[cm^2_{Asw}\, m^{-2}_{leaf\ area}]$; Ψ_{TLP}: water potential at turgor-loss point$[MPa]$; R_{depth}: rooting depth $[m]$; L_{s}: individual leaf area $[cm^2]$. *(continued)*

Species	CEP names	Group	# tree-days	# trees	# plots	Ψ_{P50}	K_{s}	Ψ_{TLP}	Hv	R_{depth}	L_{s}
Qualea tricolor	Qualtric	Angiosperms	78	2	1						
Quercus alba	Queralba	Angiosperms	1094	9	5	-1.818	4.877	-2.050	1.454	1.219	54.302
Quercus cerris	Quercerr	Angiosperms	284	2	1			-3.580			29.190
Quercus coccinea	Quercocc	Angiosperms	5343	11	3						121.678
Quercus faginea	Querfagi	Angiosperms	6784	10	2	-2.002		-3.160			4.210
Quercus falcata	Querfalc	Angiosperms	134	1	1	-0.893	2.323		2.057		41.635
Quercus ilex	Querilex	Angiosperms	65295	62	6	-3.438	1.595	-3.015	3.980		8.078
Quercus lyrata	Querlyra	Angiosperms	745	13	2						
Quercus michauxii	Quermich	Angiosperms	132	4	1	-1.700					71.498
Quercus montana	Quermont	Angiosperms	5488	14	2						
Quercus petraea	Querpetr	Angiosperms	4617	29	5	-3.294		-2.624		0.300	35.000
Quercus phellos	Querphel	Angiosperms	185	5	1	-1.375	3.787		1.806		8.935
Quercus prinus	Querprin	Angiosperms	316	2	1	-1.700					
Quercus pubescens	Querpube	Angiosperms	6505	19	2	-2.696	1.612	-3.515	0.782		32.200
Quercus pyrenaica	Querpyre	Angiosperms	6680	32	2			-2.680			30.260
Quercus robur	Querrobu	Angiosperms	636	6	1	-2.802		-2.583		0.300	46.537
Quercus rotundifolia	Querrotu	Angiosperms	4796	10	2						3.460
Quercus rubra	Querrubr	Angiosperms	15185	32	6	-2.237	1.602	-2.725	1.746	0.914	66.641
Quercus suber	Quersube	Angiosperms	1816	4	1	-5.200		-3.080			7.030
Quercus velutina	Quervelu	Angiosperms	5132	16	3			-2.750		1.016	110.450
Recordoxylon speciosum	Recospec	Angiosperms	41	1	1						
Santiria apiculata	Santapic	Angiosperms	55	5	1						
Sassafras albidum	Sassalbi	Angiosperms	117	1	1						68.080
Sextonia rubra	Sextrubr	Angiosperms	34	1	1						74.000
Sloanea sp	Sloasp	Angiosperms	156	2	2						
Swartzia racemosa	Swarrace	Angiosperms	476	2	1				1.156		246.450
Taxus baccata	Taxubacc	Gymnosperms	922	2	1	-7.360	0.320		1.900	0.406	0.500
Thuja occidentalis	Thujocci	Gymnosperms	340	10	1	-3.570				0.762	0.100
Tilia americana	Tiliamer	Angiosperms	72	1	1						130.715
Trophis mexicana	Tropmexi	Angiosperms	40	1	1						13.880
Tsuga canadensis	Tsugcana	Gymnosperms	5739	24	2	-3.070	0.329		3.362	0.711	0.480
Ulmus americana	Ulmuamer	Angiosperms	133	1	1						56.993
Vantanea sp	Vantsp	Angiosperms	69	1	1						
Vernonia arborea	Vernarbo	Angiosperms	36	3	1		2.110		2.060		
Vouacapoua americana	Vouaamer	Angiosperms	178	3	3			-2.147	0.744		353.583

Table C.3: Results of the linear models relating water use parameters calculated using G'_{Asw} to water relations traits. Parameters are explained by individual traits using simple linear models with number of species-days as weighting factor.

Parameter	Trait	N Species	Intercept	Slope	R^2
G'_{REF}	$ln(\lvert\Psi_{\mathrm{P50}}\rvert)$	25	333.019 ***	-111.725 **	0.331
	$ln(K_{\mathrm{s}})$	19	196.081 ***	81.935 **	0.359
	$ln(Hv)$	20	297.029 ***	-71.225 *	0.188
	$\lvert\Psi_{\mathrm{TLP}}\rvert$	25	196.754 **	-4.398	0.000
	R_{depth}	13	-13.266	303.191 **	0.508
	$ln(L_{\mathrm{s}})$	26	151.531 ***	31.494 ***	0.497
β'_{VPD}	$ln(\lvert\Psi_{\mathrm{P50}}\rvert)$	25	235.774 ***	-95.494 *	0.215
	$ln(K_{\mathrm{s}})$	19	125.553 ***	95.013 **	0.448
	$ln(Hv)$	20	221.274 ***	-69.362 *	0.153
	$\lvert\Psi_{\mathrm{TLP}}\rvert$	25	62.062	17.932	0.000
	R_{depth}	13	-74.639 *	245.287 ***	0.681
	$ln(L_{\mathrm{s}})$	26	69.367 ***	31.574 ***	0.409
β'_{SWC}	$ln(\lvert\Psi_{\mathrm{P50}}\rvert)$	25	34.052 .	21.703	0.066
	$ln(K_{\mathrm{s}})$	19	57.145 ***	-19.246 .	0.111
	$ln(Hv)$	20	39.018 .	13.555	0.008
	$\lvert\Psi_{\mathrm{TLP}}\rvert$	25	86.217 ***	-9.086	0.011
	R_{depth}	13	94.44 ***	-29.023	0.038
	$ln(L_{\mathrm{s}})$	26	73.395 ***	-8.696 **	0.234

Statistical significant levels: ., P < 0.1; *, P < 0.05; **, P < 0.01; ***, P < 0.001.

Table C.4: Results of the linear models relating water use parameters to water relations traits using REW instead of SWC. Parameters are explained by individual traits using simple linear models with number of species-days as weighting factor.

Parameter	Trait	N Species	Intercept	Slope	R^2
G_{REF}	$ln(\|\Psi_{\mathrm{P50}}\|)$	55	198.741 ***	-70.836 ***	0.328
	$ln(K_{\mathrm{s}})$	43	112.403 ***	37.208 ***	0.375
	$ln(Hv)$	49	177.173 ***	-45.734 ***	0.389
	$\|\Psi_{\mathrm{TLP}}\|$	48	171.577 ***	-24.124 **	0.118
	R_{depth}	37	28.834	122.446 ***	0.373
	$ln(L_{\mathrm{s}})$	86	86.92 ***	17.171 ***	0.488
β_{VPD}	$ln(\|\Psi_{\mathrm{P50}}\|)$	55	109.036 ***	-48.046 ***	0.240
	$ln(K_{\mathrm{s}})$	43	49.473 ***	20.603 **	0.181
	$ln(Hv)$	49	96.583 ***	-34.355 ***	0.369
	$\|\Psi_{\mathrm{TLP}}\|$	48	79.314 ***	-12.005	0.037
	R_{depth}	37	-1.771	79.374 ***	0.252
	$ln(L_{\mathrm{s}})$	86	33.569 ***	11.392 ***	0.336
β_{REW}	$ln(\|\Psi_{\mathrm{P50}}\|)$	55	13.956 **	-3	0.000
	$ln(K_{\mathrm{s}})$	43	11.426 ***	1.256	0.000
	$ln(Hv)$	49	11.166 ***	0.339	0.000
	$\|\Psi_{\mathrm{TLP}}\|$	48	18.869 ***	-3.274 .	0.054
	R_{depth}	37	5.99	5.114	0.000
	$ln(L_{\mathrm{s}})$	86	15.63 ***	-0.373	0.000

Statistical significant levels: ., P < 0.1; *, P < 0.05; **, P < 0.01; ***, P < 0.001.

Table C.5: Results of the linear models relating water use parameters calculated using G'_{Asw}, water relations traits, climate and tree height. Water use parameters are explained by individual traits, MAP (mean annual precipitation) and H (tree height) using simple linear models using number of species-days as weighting factor. β values are the slopes for each explanatory variable. NI = not included variable after model selection.

Parameter	Trait	N Species	Intercept	β_{trait}	β_{MAP}	β_{H}	R^2
G'_{REF}	$ln(\lvert\Psi_{\mathrm{P50}}\rvert)$	25	328.177 ***	-106.498 **	NI	NI	0.262
	$ln(K_{\mathrm{s}})$	19	199.257 ***	74.161 **	NI	NI	0.317
	$ln(Hv)$	20	296.21 ***	-68.395 *	NI	NI	0.177
	$\lvert\Psi_{\mathrm{TLP}}\rvert$	25	72.695	NI	0.175 **	NI	0.240
	R_{depth}	13	0.75	280.314 **	NI	NI	0.468
	$ln(L_{\mathrm{s}})$	26	158.682 ***	28.552 ***	NI	NI	0.435
β'_{VPD}	$ln(\lvert\Psi_{\mathrm{P50}}\rvert)$	25	-10.852	NI	0.274 ***	-5.198 **	0.476
	$ln(K_{\mathrm{s}})$	19	71.809	60.751 *	0.153 .	-4.342 .	0.539
	$ln(Hv)$	20	149.585 .	-54.146 .	0.177 *	-6.093 *	0.432
	$\lvert\Psi_{\mathrm{TLP}}\rvert$	25	-17.511	NI	0.29 ***	-5.639 **	0.522
	R_{depth}	13	-63.756 .	226.165 ***	NI	NI	0.630
	$ln(L_{\mathrm{s}})$	26	23.708	23.07 **	0.182 **	-5.54 ***	0.615
β'_{SWC}	$ln(\lvert\Psi_{\mathrm{P50}}\rvert)$	25	95.16 ***	NI	-0.084 **	1.953 **	0.366
	$ln(K_{\mathrm{s}})$	19	84.858 ***	NI	-0.072 *	1.91 *	0.261
	$ln(Hv)$	20	78.013 **	NI	-0.06 *	1.809 .	0.191
	$\lvert\Psi_{\mathrm{TLP}}\rvert$	25	98.488 ***	NI	-0.089 ***	1.91 *	0.388
	R_{depth}	13	92.124 ***	NI	NI	-1.025 .	0.173
	$ln(L_{\mathrm{s}})$	26	90.501 ***	-5.107	-0.066 *	2.011 **	0.402

Statistical significant levels: ., P < 0.1; *, P < 0.05; **, P < 0.01; ***, P < 0.001.

References

Placeholder