Table 1. Summary of observed variation in thermally-relevant leaf traits with canopy height and/or between sun and shade leaves

trait	symbol	units	response	forest type(s)	reference(s)
Leaf anatomy and morphological traits					
leaf mass per area (or inverse of specific leaf area)	LMA (or $1/SLA$)	$g \cdot cm^{-2}$	↑ with height	TeB, TrB, BoN	Coble and Cavaleri 2014, Mau et al. 2018, Sack et al. 2006, Chin and Sillett 2019
			↑ with light	TeB, TrB, BoN	Coble and Cavaleri 2014, Mau et al. 2018, Sack et al. 2006, Wyka et al. 2012
leaf density		$g \cdot cm^{-3}$	↑ with height	TeB	Coble and Cavaleri 2014
			↑ with light	TeB, TrB	Coble and Cavaleri 2014, Marques et al. 2000
			≈ with light	BoN	Wyka et al. 2012
leaf area	LA	cm^2	↓ with height	TeB, TrB, BoN	Kusi and Karasi 2020, Cavaleri et al. 2010, Kenzo et al. 2016, Gebauer et al. 2015
			↓ with light	TrB, TeB, BoN	Kusi and Karasi, 2020, Sack et al. 2006, Gebauer et al. 2015
stomatal density	$D_{stomata}$	mm^{-2}	↑ with height	TrB, TeB, BoN	Marenco et al. 2017, Kafuti et al. 2020, Van Wittenberghe et al. 2012, Sack et al. 2006, Chin and Silette 2017
			↑ with light	TeB, TrB	Sack et al. 2006, Kafuti et al. 2020, Marenco et al. 2017
minor vein density	VLA_{min}	$mm \cdot mm^{-2}$	↑ with height	TeB	Zhang et al. 2019
			↑ with light	TeB	Zhang et al. 2019
leaf thickness		μm	↑ with height	TrB, TeB, BoN	Weerasinghe et al. 2014,Coble and Cavaleri 2014, Van Wittenberghe et al. 2012, Oldham et al. 2010, Marenco et al. 2017
			↑ with light	TeB, BoN, TrB	Coble and Cavaleri 2014, Wyka et al. 2012, Marenco et al. 2016, Weerasinghe et al. 2014
trichome density		mm^{-2}	↑ with height	TrB	Ichie et al. 2016
			↑ with light	TeB, TrB	Gregoriou et al. 2007, Ichie et al. 2016, Levizou et al. 2005, Liakoura 1997
blade inclination angle (vertical)	ϕB	∘	↑ with height	TeB, TrB	Niinemets et al. 1998, Ishida et al. 1998, Fauset et al. 2018
			↑ with light	TeB, TrB	Millen and Clendon 1979, Ishida et al. 1998, Niinemets et al. 1998, Fauset et al. 2018
pinnate lobation		cm^2	↑ with height	TeB	Sack et al. 2006
			↓ with height	TeB	Kusi and Karasi, 2020
			↑ with light	TeB	Kusi and Karasi 2020, Sack et al. 2006
drip tip length		cm	↓ with height	TrB	Panditharathna et al. 2008
			↓ with light	TrB	Panditharatna et al. 2008
upper cuticle thickness	CT	μm	↑ with height	TrB, BoN	Panditharathna et al. 2008, Chin and Sillett 2019

Table 1. Summary of observed variation in thermally-relevant leaf traits with canopy height and/or between sun and shade leaves *(continued)*

trait	symbol	units	response	forest type(s)	reference(s)
			↑ with light	TrB, TeB	Panditharathna et al. 2008, Marques et al. 2000, Baltzer and Thomas 2005
adaxial leaf wettability (as drop contact angle)	DCA_{ad}	∘	↑ with height	TeB	Van Wittenberghe et al. 2012
	$duration of surface wetness$	%	↓ with height	TrB	Dietz et al. 2007
	DCA	∘	↑ with light	TeB	Van Wittenberghe et al. 2012
			↑ with height	TrB, TeB, BoN	Kenzo et al. 2015, Coble et al. 2016, Scartazza et al. 2016, Duursma and Marshall, 2006, Harley et al. 1996
Leaf biochemical and physiological traits					
Nitrogen content	N_a	$g \cdot m^{-2}$	≈↑ with light	TrB, TeB, BoN	Weerasinghe et al. 2014, Hernandez et al. 2020, Scartazza et al. 2016, Coble et al. 2016, Harley et al. 1996, Duursma and Marshall, 2006.
			≈↓ with height	TrB, TeB, BoN	Weerasinghe et al. 2014, Kenzo et al. 2015, Coble et al. 2016, Scartazza et al. 2016, Harley et al. 1996, Turnbull et al. 2003
	N_m	$mg \cdot g^{-1}$	≈↓ with light	TrB, TeB, BoN	Chen et al. 2020, Kenzo et al. 2015, Coble et al. 2016, Scartazza et al. 2016, Harley et al. 1996, Wyka et al. 2012
			↑ with height	TrB, TeB, BoN	Weerasinghe et al. 2014,van de Weg et al. 2012, M.A Cavaleri et al. 2008, Mau et al. 2018
Phosphorous content	P_a	$g \cdot m^{-2}$	↑ with light	TrB, Te, BoN	Weerasinghe et al. 2014, Wyka et al. 2012
			≈↓ with height	TrB	Weerasinghe et al. 2014, Chen et al. 2020, Mau et al. 2018
	P_m	$mg \cdot g^{-1}$	≈ with light	TrB, TeB	Weerasinghe et al. 2014, Chen et al. 2020, Mau et al. 2018
			↑ with height	TrB, TeB	Koniger et al. 1995, Scartazza et al. 2016, Niinemets et al. 1998
xanthophyll cycle pigments	VAZ	μmolm^{-2}	↑ with light	TeB, TrB	Scartazza et al. 2016, Mastubara et al. 2009
			↓ with height	TrB, TeB	Harris and Medina 2013, Hansen et al. 2001
chlorophyll content	chl	$mg \cdot cm^{-2}$	↓ with light	TrB, TeB	Marques et al. 2000, Poorter et al. 1995, Hansen et al. 2001
			↑ with height	TeB, TrB	Scartazza et al. 2016, Poorter et al. 1995
b carotene and lutein		μmolm^{-2}	↑ with light	TeB, TrB	Scartazza et al. 2016, Koniger et al. 1995
			↑ with height	TeB, TrB	Scartazza et al. 2016, Poorter et al. 1995

Table 1. Summary of observed variation in thermally-relevant leaf traits with canopy height and/or between sun and shade leaves *(continued)*

trait	symbol	units	response	forest type(s)	reference(s)
chlorophyll a/b ratio	$chla/b$	$mol \cdot mol^{-1}$	↑ with light	TeB, TrB	Scartazza et al. 2016, Poorter et al. 1995, Matsubara et al. 2009, Niinemets et al. 1998
			↑ with height	BoN, TeB, TrB	Duursma and Marshall, 2006, Coble et al. 2017, Kenzo et al. 2015
carbon isotope composition	$\delta^{13}C$	$\%_\circ$	↑ with light	BoN, TeB, TrB	Duursma and Marshall, 2006, Coble et al. 2016, Kenzo et al. 2015
			↓ with height	TeB	Scartazza et al. 2016
intercellular CO_2 concentration	C_i	μmol $\cdot mol^{-1}$	↓ with light	TeB	Scartazza et al. 2016
			≈ with height	TrB	Poorter et al. 1995, 2000
PAR absorptance	ABS	% nm	≈↑ with light	TrB	Poorter et al. 1995, 2000
			↓ with height	TrB	Poorter et al. 1995, 2000
absorptance efficiency	ABS	$\% \cdot g^{-1}$	↓ with light	TrB	Poorter et al. 1995, 2000
			↓ with height	TrB	Poorter et al. 1995, 2000
PAR transmittance		%	↓ with light	TrB	Poorter et al. 1995, 2000
			≈ with height	TrB	Poorter et al. 1995, 2000
reflectance		%	≈ with light	TrB	Poorter et al. 1995, 2000

Table 2. Summary of observed variation in leaf metabolism and thermal responses across the vertical gradient and/or between sun and shade leaves

trait	symbol	units	response	forest type(s)	reference(s)
Stomatal conductance					
max stomatal conductance	g_{smax}	$molm^{-2}s^{-1}$	↑ with height	TrB, TeB, BoN	Kafuti et al. 2020, Van Wittenberghe et al. 2012, Roberts et al. 1990, Dang et al. 1997
			↓ with height	BoN, TrB	Ambrose et al. 2015, Marenco et al. 2017, Zeifel et al. 2001
			↑ with light	BoN, TrB, TeB	Zeifel et al. 2001, Slot et al. 2019, Hernandez et al. 2020, Urban et al. 2007
stomatal conductance limitation with temperature	g_s	$molm^{-2}s^{-1}$	↑ with height	TrB, BoN	Hernandez et al. 2020, Zeifel et al. 2001
			↑ with light	BoN, TrB	Zeifel et al. 2001, Hernandez et al. 2020
stomtatal conductance at optimal temperature	g_s at T_{opt}	$molm^{-2}s^{-1}$	≈↑ with height	TeB	Carter and Cavaleri 2018
			≈↑ with light	TrB	Slot et al. 2019
boundary-layer conductance	g_a	$mmol^{-2}s^{-1}$	↑ with height	TrB	Roberts et al. 1990
	g_{bV}	mms^{-1}	↑ with height	BoN	Martin et al. 1999
			↑ with light	TrB	Roberts et al. 1990
	g_{bV}	mms^{-1}	≈ with light	BoN	Martin et al. 1999
Photosynthesis					
maximum photosynthetic capacity (area-based)	$A_{max_{area}}$	μmol $\cdot m^{-2} \cdot s^{-1}$	↑ with height	TeB, TrB	Carter and Cavaleri 2018, Kosugi et al. 2012, Niinemets et al. 2015, Mau et al. 2018
			≈↓ with height	TeB (F.sylvatica)	Bachofen et al. 2020
			↑ with light	TeB, TrB, BoN	Hamerlynck and Knapp 1994, Kosugi et al. 2012, Coble et al. 2017, Mau et al. 2018, Urban et al. 2007, Wyka et al. 2012
maximum photosynthetic capacity (mass-based)	$A_{max_{mass}}$	$nmol \cdot g^{-1} \cdot s^{-1}$	≈ with height	TrB	Rijkerse et al. 2000, Ishida et al. 1999
			≈ with light	TeB, TrB, BoN	Wyka et al. 2013, Rijkerse et al. 2000, Ishida et al. 1999
maximum light-saturated net photosynthesis	A_{sat}	μmol $\cdot m^{-2} \cdot s^{-1}$	↑ with height	TeB, TrB	Scartazza et al. 2016, Weerasinghe et al. 2014
			↑ with light	TeB, TrB	Scartazza et al. 2016, Slot et al. 2019
A_{sat} at optimum temperature	A_{opt}	μmol $\cdot m^{-2} \cdot s^{-1}$	≈↑ with height	TeB, TrB	Carter and Cavaleri 2018, Mau et al. 2018
			↑ with light	TrB	Slot et al. 2019, Mau et al. 2018
optimum temperature for photosynthesis	T_{opt}	°C	≈ with height	TrB, TeB	Miller et al. 2021, Carter and Cavaleri 2018, Mau et al. 2018
			≈ with light	TrB, TeB	Hernandez et al. 2020, Slot et al. 2019, Carter and Cavaleri 2018
photosynthetic light compensation point	LCP	μ mol m^{-2}	↑ with height	TeB, BoN, TrB	Bachofen et al. 2020, Harris and Medina 2013
			↑ with light	TrB, TeB, BoN	Slot et al. 2019, Hamerlynck and Knapp, 1994, Bachofen et al. 2020

Table 2. Summary of observed variation in leaf metabolism and thermal responses across the vertical gradient and/or between sun and shade leaves *(continued)*

trait	symbol	units	response	forest type(s)	reference(s)
maximal carboxylation rate(area-based)	$V_{cmax_{area}}$	$\mu mol \cdot m^{-2} s^{-1}$	↑ with height	TeB, TrB	Scartazza et al. 2016, Kosugi et al. 2012, van de Weg et al. 2012
			↑ with light	TeB,TrB, BoN	Scartazza et al. 2016, Kosugi et al. 2012, Hernandez et al. 2020, Urban et al. 2007
maximal carboxylation rate(mass-based)	$V_{cmax_{mass}}$	$nmol \cdot g^{-1} \cdot s^{-1}$	≈ with height	TrB, TeB	van de Weg et al. 2012, Scartazza et al. 2016
			≈ with light	TrB, TeB	van de Weg et al. 2012, Scartazza et al. 2016
		nmol $C_{O_2} g^{-1} s^{-1}$	≈↓ with light	TeB	Legner et al. 2014
V_{cmax} at optimum temperatue	$V_{cmax}(T_{opt})$	$\mu mol \cdot m^{-2} s^{-1}$	≈↑ with height	TeB	Carter and Cavaleri 2018
			≈ with light	TrB	Hernandez et al. 2020
electron transport rate(area-based)	$J_{max_{area}}$	$\mu mol \cdot m^{-2} s^{-1}$	↑ with height	TeB, TrB	Scartazza et al. 2016, Kosugi et al. 2012 van de Weg et al. 2012
			↑ with light	TeB,TrB	Scartazza et al. 2016, Kitao et al. 2012, Kosugi et al. 2012, Hernandez et al. 2020
electron transport rate(mass-based)	$J_{max_{mass}}$	$nmol \cdot g^{-1} \cdot s^{-1}$	≈ with height	TrB, TeB	van de Weg et al. 2012, Scartazza et al. 2016
			≈ with light	TrB, TeB	van de Weg et al. 2012, Scartazza et al. 2016
		$nmol \cdot e^{-1} g^{-1} s^{-1}$	≈↓ with light	TeB	Legner et al. 2014
J_{max} at optimal temperature	$J_{max}(T_{opt})$	$\mu mol \cdot m^{-2} s^{-1}$	≈ with light	TrB	Hernandez et al. 2020
leaf temperature	T_L	°C	↑ with height	TrB, TeB	Fauset et al. 2018, Mau et al. 2018, Ishida et al. 1999, Rey-Sanchez et al. 2016, Hamerlynck and Knapp, 1994
			↓ with height	BoN	Muller et al. 2021, Martin et al. 1999
			↑ with light	TrB, TeB	Fauset et al. 2018, Ishida et al. 1999, Rey-Sanchez et al. 2016, Miller et al. 2021, Hamerlynck and Knapp, 1994
			≈ with light	BoN	Muller et al. 2021
thermal time constant (in relation to increasing gs)	t	s	↓ with height	TrB, TrS	Fauset et al. 2018, Curtis et al. 2019
			↓ with light	TrB	Fauset et al. 2018
photosynthetic heat tolerance	T_{50}	°C	↑ with height*	TrS	Curtis et. al, 2018
			≈↑ with light	TrB, TeB	Slot et al. 2019, Hamerlynck and Knapp, 1994
critical temperature beyond which Fv/Fm declines	T_{crit}	°C			
			≈↑ with light	TrB, TeB	Slot et al. 2019
high-temperature CO_2 compensation point	T_{max}	°C	≈ with height	TrB	Weerasinghe et al. 2014
			≈ with light	TrB	Slot et al. 2019
Respiration					
respiration rate at 25°C	R	$\mu molCO_2 m^{-2} s^{-1}$	↑ with height	TeB, BoN, TrB	Turnbull et al. 2003, Araki et al. 2017, Mier et al. 2001
		$\mu molCO_2 kg^{-1} s^{-1}$	≈ with height	TeB, BoN, TrB	Turnbull et al. 2003, Mier et al. 2001

Table 2. Summary of observed variation in leaf metabolism and thermal responses across the vertical gradient and/or between sun and shade leaves *(continued)*

trait	symbol	units	response	forest type(s)	reference(s)
			↑ with light	BoN, TrB	Araki et al. 2017, Mier et al. 2001
dark respiration (area-based)	R_{dark_a}	$\mu molm^{-2}s^{-1}$	↑ with height	TrB, TeB	Weerasinghe et al. 2014, Kosugi et al. 2012, Bolstad et al. 1999, Scartazza et al. 2019
			↑ with light	TrB, TeB, BoN	Weerasinghe et al. 2014, Kosugi et al. 2012, Scartazza et al. 2019, Hamerlynck and Knapp, 1994, Urban et al. 2007
dark respiration (mass-based)	R_{dark_m}	$nmol \cdot g^{-1} \cdot s^{-1}$	$\approx uparrow$ with height	TrB	van de Weg et al. 2012, Kenzo et al. 2015
			≈ with light	TrB	van de Weg et al. 2012, Kenzo et al. 2015
dark respiration at reference T	$R_{dark}(T_{ref})$	$\mu mol \cdot m^{-2}s^{-1}$	↑ with height	TrB, TeB, BoN	Weerasinghe et al. 2014, Kosugi et al. 2012, Bolstad et al. 1999, Turnbull et al. 2003
		$\mu mol(kgleaf)^{-1}s^{-1}$	↑ with height	TrB, TeB, BoN	Weerasinghe et al. 2014, Kosugi et al. 2012, Bolstad et al. 1999, Turnbull et al. 2003
		μ mol (kg N) $^{-1}s^{-1}$	↑ with height	TeB, BoN	Bolstad et al. 1999, Turnbull et al. 2003
		$\mu mol \cdot m^{-2}s^{-1}$	↑ with light	TeB, TrB	Bolstad et al. 1999, Weerasinghe et al. 2014, Slot et al. 2019
temperature sensitivity of R_{dark}	Q_{10}	$^{\circ}C^{-1}$	≈ with height	TrB, TeB, BoN	Weerasinghe et al. 2014, Bolstad et al. 1999, Araki et al. 2017*
		$^{\circ}C^{-1}$	≈↑ with height	TeB, BoN	Harley et al. 1996, Turnbull et al. 2003
			≈↓ with light	TrB, TeB, BoN	Weerasinghe et al. 2014, Bolstad et al. 1999, Araki et al. 2017*
			↑ with light	TeB	Harley et al. 1996
light respiration	R_L	$\mu mol \cdot m^{-2}s^{-1}$	↑ with height	TrB	Weerasinghe et al. 2014
			↑ with light	TrB	Weerasinghe et al. 2014
activation energy of respiration	E_0	$kJ \cdot mol^{-1}K^{-1}$	≈ with height	TrB, TeB, BoN	Weerasinghe et al. 2014, Turnbull et al. 2003, Xu and Griffin 2006
			≈ with light	TrB	Weerasinghe et sl. 2014, Slot et al. 2019
VOC production					
isoprene emission rate (in emitting species)	I	nmol $m^{-2}s^{-1}$	↑ with height	TeB	Harley et al. 1996, Harley et al. 1997
			↑ with light	TeB	Niinemets and Sun, 2014, Harley et al. 1996, Sharkey and Monson, 2014
monoterpenoid emissions	MT	$\mu gm^{-2}s^{-1}$	↓ with height	TeB	(FIX SPECIAL CHARACTER!) Maimpraga et al. 2013
			↓ with light	TeB	(FIX SPECIAL CHARACTER!) Maimpraga et al. 2013

*composite climatic stress variable from canopy temperature, vapour pressure deficit, and relative humidity is higher in lower canopy