

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)
<b>Leaf anatomy and morphological traits</b>					
leaf mass per area (or inverse of specific leaf area)	$LMA$ (or $1/SLA$ )	$g \cdot cm^{-2}$	↑ with height ↑ with light	temperate, tropical global	Mau et al. 2018, Coble et al. 2017 Hernandez et al. 2019, Mastubara et al. 2009, Martin et. al 2020, Coble et al. 2017, Slot et al. 2019
leaf area	$LA$	$mm^2$	↓ with height	temperate, tropical	Beaumont and Burns 2009, Kafuti et al. 2020
stomatal density	$D_{stomata}$	$mm^{-2}$	↓ with light ↑ with height	tropical	Slot et al. 2019, Sack et al. 2006
leaf thickness	$LeaThi$	$\mu m$	↑ with light ↑ with height	global, temperate	Valladares and Niinemets, 2008 Poorter et al. 2019, Van Wittenberghe et al. 2012
trichome density	$trichome$	$mm^{-2}$	↑ with light ↑ with height	global tropical	Poorter et al. 2019 Ichie et al. 2016, Perez-Estrada et al. 2000
blade inclination angle (vertical)	$\phi B$	o	↑ with height	sutropical, temperate, tropical temperate	Gregoriou et al. 2007, Levizou et al. 2005, Liakoura 1997 Niinemets et al. 1998
lobation	$lobation$	$cm^2$	↑ with light ↑ with height	temperate temperate Quercus sp.	Niinemets et al. 1998 Sack et al. 2006, Baranski, 1975
cuticle thickness	$CT$	$\mu m$	↑ with light ↑ with height ↑ with light ↑ with height	temperate Quercus sp. tropical, temperate tropical, temperate tropical, temperate	Kusi and Karasi 2020, Sack et al. 2006 Panditharathna et al. 2008, Baltzer and Thomas 2005 Panditharathna et al. 2008, Baltzer and Thomas 2005 Coble and Cavaleri 2014, Scartazza et al. 2016, Hernandez et al. 2019
<b>Leaf biochemical and physiological traits</b>					
Nitrogen per leaf area	$N_a$	$g \cdot m^{-2}$	↑ with light	tropical, global	Martin et al. 2020, Hernandez et al. 2020, Poorter et al. 2019, Harley et al. 1996
Nitrogen per leaf mass	$N_m$	$mg \cdot g^{-1}$	≈ with ??? ≈ with light ↑ with height	tropical, temperate temperate broadleaf tropical	Hernandez et al. 2020, Scartazza et al. 2016 Harley et al. 1996, Bolstad et al. 1999 M.A Cavaleri et al. 2008, J.Lloyd et al. 2009
Phosphorous per leaf area	$P_a$	$g \cdot m^{-2}$	↑ with light ↑ with height	tropical temperate	Martin et al. 2020 Scartazza et al. 2016, Niinemets et al. 1998
xanthophyll cycle pigments	$VAZ$	$\mu mol m^{-2}$	↑ with light ↑ with height	tropical, global conifer, temperatre	Mastubara et al. 2009, Valladares and Niinemets, 2008 Duursma and Marshall, 2006, Coble et al. 2017
carbon isotope composition	$\delta^{13}C$	‰	↑ with light ↑ with height	conifer tropical	Duursma and Marshall, 2006 Poorter et al. 1995
chlorophyll a/b ratio	$chla/b$	$mol mol^{-1}$	↑ with light	tropical, global	Matsubara et al. 2009, Niinemets et al. 1998, Valladares and Niinemets, 2008
PAR absorptance	$ABS$	% nm	≈ with height ≈ with light ↓ with height	tropical tropical tropical	Poorter et al. 1995, Lee and Graham, 1986 Poorter et al. 1995, Lee and Graham, 1986 Poorter et al. 1995, Lee and Graham, 1986
absorptance efficiency	$ABS$	% $\cdot g^{-1}$	↓ with light	tropical	Poorter et al. 1995, Lee and Graham, 1986

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)
<b>Stomatal conductance</b>					
max stomatal conductance	$g_{s_{max}}$	$mmol^{-2}s^{-1}$	↑ with height	tropical, temperate	Kafuti et al. 2020, Van Wittenberghe et al. 2012, Roberts et al. 1990
			↓ with height	temperate	Coble and Cavaleri 2015; Ishii et al. 2008
			↑ with light	global, tropical	Valladares and Niinemets, 2008, Hernandez et al. 2019
stomatal conductance	$g_s$		↑ with light	tropical	Slot et al. 2019
optimum temperature of $g_s$	$T_{opt}$ of $g_s$	°C	≈ with light	tropical	Slot et al. 2019
frequency of stomatal closure			↑ with height	tropical	Roberts et al. 1990
<b>Photosynthesis</b>					
photosynthetic capacity	$A_A$	$\mu mol \cdot m^{-2} \cdot s^{-1}$	↑ with height	temperate, tropical	Niinemets et al. 2015, Mau et al. 2018
			↑ with light	temperate	Coble et al. 2017, Hikosaka and Terashima 1995, Evans 1989
light-saturated net photosynthesis	$A_{sat}$		↑ with light	tropical	Slot et al. 2019
optimum temperature of $A_{sat}$	$T_{opt}$ of $A_{sat}$	°C	≈↑ with light	tropical	Slot et al. 2019
light compensation point	$LCP$		↑ with light	tropical	Slot et al. 2019
maximal carboxylation rate	$V_{cmax}$	$\mu mol \cdot m^{-2}s^{-1}$	↑ with height	temperate	Scartazza et al. 2016
			↑ with light	global	Valladares and Niinemets, 2008
$V_{cmax}$ at optimal temperature	$V_{cmax}(T_{opt})$	$\mu mol \cdot m^{-2}s^{-1}$	≈ with light	tropical	Hernandez et al. 2020
electron transport rate	$J_{max}$	$\mu mol \cdot m^{-2}s^{-1}$	↑ with height	temperate	Scartazza et al. 2016
			↑ with light	global	Valladares and Niinemets, 2008
$J_{max}$ at optimal temperature	$J_{max}(T_{opt})$	$\mu mol \cdot m^{-2}s^{-1}$	≈ with light	tropical	Hernandez et al. 2020
thermal damage threshold	$T_{50}$	°C	≈↑ with light	tropical	Slot et al. 2019
			↓ with height*	savanna	Curtis et. al, 2018
<b>Respiration</b>					
dark respiration at reference T	$R_{dark}(T_{ref})$	$\mu mol \cdot m^{-2}s^{-1}$	↑ with height	temperate	Scartazza et al. 2016
			↑ with light	tropical	Bolstad et al. 1999, Slot et al. 2019
		$\mu mol (kg \text{ leaf})^{-1}s^{-1}$	↑ with light	temperate	Bolstad et al. 1999
		$\mu mol (kg \text{ N})^{-1}s^{-1}$	↑ with light	temperate	Bolstad et al. 1999
temperature sensitivity of $R_{dark}$	$Q_{10}$	°C <sup>-1</sup>	≈↓ with light	temperate	Bolstad et al. 1999
<b>VOC production</b>					
isoprene emission rate (in emitting species)	$I$	$nmol \text{ m}^{-2}s^{-1}$	↑ with height	temperate	Harley et al. 1996, Harley et al. 1997
			↑ with light	temperate	Niinemets and Sun, 2014, Harley et al. 1996, Sharkey and Monson, 2014

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