Appendix I & II are reproduced from Zhu X-G, Portis Jr. AR, Long SP (2004). *Plant Cell Environ* 27**:** 155-165

Appendix I. Equations used to simulate leaf and canopy net photosynthetic carbon uptake.

$$\Gamma^* = \frac{0.5O_i}{\tau} \quad (1)$$

$$A = (1 - \frac{\Gamma^*}{C_i})\min(W_c, W_j) - R_d \quad (2)$$

$$W_c = \frac{V_{cmax}C_i}{C_i + K^c{}_m(1 + O_i/K^o{}_m)} \quad (3)$$

$$W_j = \frac{JC_i}{4.5C_i + 10.5\Gamma^*} \quad (4)$$

$$g_s = g_0 + \frac{g_1 AH_{ra}}{C_a} \quad (5)$$

$O_i = O_a$ (At 25°C) (6)

$J = \{I_2 + J_{max} - [(I_2 + J_{max})^2 - 4\Theta I_2 J_{max}]^{0.5}\}/2\Theta$ (7)

$I_2 = I_0(1-s)(1-r)/2$ (8)

$A_c = f[I_{sun}, T_a, C_i, O_i].F_{sun} + f[I_{shade}, T_a, C_i, O_i].F_{shade}$ (9)

Where f indicates a function as described in equations 1~7.

$F_{sun} = [1 - e^{(-kF/\cos\theta)}]\cos\theta/k$ (10)

$F_{shade} = F - F_{sun}$ (11)

$$k=\frac{(x^2+\tan^2\theta)^{0.5}\cos\theta}{x+1.744(x+1.882)^{-0.733}} \quad (12)$$

$$\cos\theta = \sin\Omega\ \sin\delta + \cos\Omega\ \cos\delta\ \cos(15[t-t_{sn}]) \quad (13)$$

$$\delta = -23.5\cos[360(D_j+10)/365] \quad (14)$$

$$I_{dir} = I_s\cdot\alpha^{[(P/Po)/\cos\theta]} \quad (15)$$

$$I_{diff} = 0.5I_s(1-\alpha^{[(P/Po)/\cos\theta]})\cos\theta \quad (16)$$

$$I_{shade} = I_{diff}.e^{(-0.5F^{0.7})} + I_{scat} \quad (17)$$

$$I_{scat} = 0.07I_{dir}(1.1-0.1F)e^{-\cos\theta} \quad (18)$$

$$I_{sun} = I_{dir}\cos\lambda/\cos\theta + I_{shade} \quad (19)$$

$$\lambda = \cos^{-1}k \quad (20)$$

Appendix II

Definition of symbols. Values in parenthesis are those used in simulations, unless stated otherwise

Term	Units	Definition
A	μmol m^{-2} s^{-1}	Photosynthetic CO_2 uptake rate
A_c	μmol m^{-2} s^{-1}	Canopy carbon uptake per meter square ground area per second
A_{sat}	μmol m^{-2} s^{-1}	Light saturated rate of leaf photosynthetic rate
A_c'	mmol m^{-2} d^{-1}	A_c integrated over the course of one day
C_a	μmol mol^{-1}	Atmospheric CO_2 concentration
C_i	μmol mol^{-1}	Intercellular CO_2 concentration
D_j	day of year	The i^{th} Day in a year (200)
F	m^2 m^{-2}	Total leaf area index, *i.e.*, the ratio of leaf area per unit ground area (3)
F_{shade}	m^2 m^{-2}	F that is shaded at any point in time
F_{sun}	m^2 m^{-2}	F that is sunlit at any point in time
g_0	mmol m^{-2} s^{-1}	Stomatal conductance coefficient g_0 (81.1)
g_1	mmol mol^{-1}	Stomatal conductance coefficient g_1 (9580)
g_s	mmol m^{-2} s^{-1}	Stomatal conductance
H_{ra}	dimensionless	Relative humidity of the atmosphere surrounding the leaf
I	μmol m^{-2} s^{-1}	Photon flux density

I_o	μmol m^{-2} s^{-1}	Incident photon flux density of diffuse radiation
I_{dir}	μmol m^{-2} s^{-1}	Photon flux density of direct radiation
I_s	μmol m^{-2} s^{-1}	Solar constant, *i.e.*, the photon flux density in a plane perpendicular to the solar beam above the atmosphere (2600)
I_{scat}	μmol $m^{-2}s^{-1}$	Photon flux density of scattered radiation within the canopy
I_{shade}	μmol $m^{-2}s^{-1}$	Mean I for shaded leaves within a canopy
I_{sun}	μmol $m^{-2}s^{-1}$	Mean I for sunlit leaves within a canopy
I_2	μmol $m^{-2}s^{-1}$	Photon flux density absorbed by PSII
J	μmol $m^{-2}s^{-1}$	Potential rate of whole chain electron transport through PSII for a given I_2
J_{max}	μmol $m^{-2}s^{-1}$	Light saturated J (180)
k	Dimensionless	Foliar absorption coefficient
$K^c{}_m$	μmol mol^{-1}	Rubisco Michaelis-Menten constant for CO_2 (460 for the control)
$K^o{}_m$	mmol mol^{-1}	Rubisco Michaelis-Menten constant for O_2 (330 for the control)
O_a	mmol mol^{-1}	Atmospheric O_2 concentration (210)
O_i	mmol mol^{-1}	Intercellular O_2 concentration (210)
P	kPa	Atmospheric pressure
P_o	kPa	Standard atmospheric pressure at sea level (101.324)
r	Dimensionless	Percent of light that is reflected and transmitted (23%)
R_d	μmol $m^{-2}s^{-1}$	Dark respiration rate (0)
s	dimensionless	Spectral imbalance (0.25), indicating the percentage of light

		energy that can not be used in photochemistry
t	hour	Time of day
t_{sn}	hour	Time of solar noon (12)
T_a	^oC	Air temperature (25)
V_{cmax}	$\mu mol\ m^{-2}s^{-1}$	Maximum rate of carboxylation at RuBP and CO_2 saturation (70)
W_c	$\mu mol\ m^{-2}s^{-1}$	Rubisco-limited rate of carboxylation
W_j	$\mu mol\ m^{-2}s^{-1}$	RubP-limited rate of carboxylation
x	dimensionless	The ratio of horizontal:vertical projected area of a canopy (1)
Γ^*	$\mu mol\ mol^{-1}$	CO_2 compensation point in the absence of dark respiration
τ	dimensionless	The specificity of Rubisco for CO_2 relative to O_2 (92.5)
α	dimensionless	Atmospheric transmittance (0.85)
Θ	dimensionless	Convexity factor for the non-rectangular hyperbolic response of electron transport through photosystem II to photon flux (0.7)
δ	Degree	Solar declination
Ω	º	Latitude (52)
θ	º	Solar zenith angle
λ	º	Angle between leaf surface and the direct beam solar radiation