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Appendix A. Tables presenting (A1) equations for the multiple element limitation (MEL) model and (A2) the process and parameter definitions, values, and sources for the MEL model.

TABLE A1. Equations for the Multiple Element Limitation (MEL) model. Symbol definitions and initial values for all state variables are listed in Table 1 of the main text. Annual integrated values for the fluxes are also listed in Table 1. Symbol definitions for all processes and symbol definitions and values for all parameters are listed in Table A2 below. Snow pack dynamics were solved with a discrete daily time step as described in Brubaker et al. (1996). Snowmelt and rainfall were added to the soil water on a discrete daily time step. All other differential equations were solved with a 4th/5th order Runge-Kutta numerical integrator with a variable time step to assure accuracy (Press et al. 1986). Equations are arranged in general categories; the same categories are used in the list of processes and parameters in Table A2.

	Mass balance Equations:		
	Carbon		
(A.1)	$\frac{dB_C}{dt} = U_C - R_a - R_g - R_u - L_C - L_{CWC}$	(A.2)	$\frac{dD_{Cc}}{dt} = L_{CWC} - T_{CWC}$
(A.3)	$\frac{dD_{C1}}{dt} = L_C + T_{CWC} + U_{DOMm} - R_{Cm1} - P_{DOM} - T_{DC12}$	(A.4)	$\frac{dD_{C2}}{dt} = T_{DC12} - R_{Cm2}$
(A.5)	$\frac{dE_{DOM}}{dt} = I_{DOM} + P_{DOM} - U_{DOMm} - L_{DOM}$		
	Nitrogen		
(A.6)	$\frac{dB_N}{dt} = U_{NH4} + U_{NO3} - L_N - L_{CWN}$	(A.7)	$\frac{dD_{Nc}}{dt} = L_{CWN} - T_{CWN}$
(A.8)	$\frac{dD_{N1}}{dt} = L_N + T_{CWN} + U_{NH4m} + U_{NO3m} + U_{DONm} - R_{Nm1} - P_{DON} - T_{DN12}$	(A.9)	$\frac{dD_{N2}}{dt} = T_{DN12} - R_{Nm2}$

(A.10)	$\frac{dE_{NH4}}{dt} = I_{NH4} + R_{Nm1} + R_{Nm2} - U_{NH4}$ $- U_{NH4m} - T_{Ntr} - L_{NH4}$	(A.11)	$\frac{dE_{NO3}}{dt} = I_{NO3} + T_{Ntr} - U_{NO3} - U_{NO3m}$ $- L_{NO3} - T_{DNtr}$
	Phosphorus		
(A.12)	$\frac{dB_P}{dt} = U_{PO4} - L_P - L_{CWP}$	(A.13)	$\frac{dD_{Pc}}{dt} = L_{CWP} - T_{CWP}$
(A.14)	$\frac{dD_{P1}}{dt} = L_P + T_{CWP} + U_{PO4m} - R_{Pm1} - T_{DP12}$	(A.15)	$\frac{dD_{P2}}{dt} = T_{DP12} - R_{Pm2}$
(A.16)	$\frac{dE_{PO4}}{dt} = I_{PO4} + R_{Pm1} + R_{Pm2} + T_{PAw} + T_{P2w}$ $- U_{PO4} - U_{PO4m} - L_{PO4} - T_{PO4s}$	(A.17)	$\frac{dP_A}{dt} = I_{PA} - T_{PAw}$
(A.18)	$\frac{dP_{2nd}}{dt} = T_{PO4s} - T_{P2w}$		
	Water		
(A.19)	$\frac{dW}{dt} = I_{rain} + T_{SM} - U_W - R_O$	(A.20)	$\frac{dW_{snow}}{dt} = I_{snow} - T_{SM}$
	Environment (equations for E_{NH4}, E_{PO4}, and E_{DOM} must be inverted to calculate aqueous concentrations)**:**		
(A.21)	$T_a = \frac{T_{max} + T_{min}}{2}$	(A.22)	$\theta = \frac{W}{1000\,z}$
(A.23)	$E_{NH4} = \frac{z\,D_{Bs}\,S_{NH4}\;N_{aqNH4}}{\varepsilon_{NH4} + N_{aqNH4}}$ $+ 14\times10^{-6}\,W\;N_{aqNH4}$	(A.24)	$E_{NO3} = 12\times10^{-6}\;W\,N_{aqNO3}$
(A.25)	$E_{DOM} = \frac{z\,D_{Bs}\,S_{DOM}\;C_{aqDOM}}{\varepsilon_{DOM} + C_{aqDOM}}$ $+ 12\times10^{-6}\,W\;C_{aqDOM}$	(A.26)	$E_{PO4} = \frac{z\,D_{Bs}\,S_{PO4}\;P_{aqPO4}}{\varepsilon_{PO4} + P_{aqPO4}}$ $+ 31\times10^{-6}\,W\;P_{aqPO4}$

(A.27)	$\Delta_e = \dfrac{e^{\frac{17.269 T_{max}}{237.3+T_{max}}} - e^{\frac{17.269 T_{min}}{237.3+T_{min}}}}{1637.25}$	(A.28)	$\theta_i = 0.92\ \rho_s$
(A.29)	$b = -\dfrac{\ln(\psi_f/\psi_w)}{\ln(\theta_f/\theta_w)}$	(A.30)	$m = \dfrac{11.5-b}{0.0736}\psi_f\left(\dfrac{\theta_i}{\theta_f}\right)^{-b}$
(A.31)	$n = 0.84 - \dfrac{0.08b}{11.5-b}$	(A.32)	$\psi_s = \psi_f(\theta/\theta_f)^{-b}$; if $\theta < \theta_i$ $= -m\left(\dfrac{\theta}{\rho_s - n}\right)\left(\dfrac{\theta}{\rho_s - 1}\right)$; if $\theta \geq \theta_i$
	Allometry (equations for B_{T*} and B_A must be solved simultaneously)**:**		
(A.33)	$B_T = \dfrac{B_C}{q_C}$	(A.34)	$B_{T*} = B_T + B_A V_L (1 - f_c)$
(A.35)	$B_A = \dfrac{B_{Amax}\gamma_B B_{T*}}{B_{Amax} + \gamma_B B_{T*}}$	(A.36)	$B_W = B_{T*} - B_A$
(A.37)	$B_L = f_c V_L B_A$	(A.38)	$B_R = V_R B_A$
(A.39)	$L = a_{sla} B_L$	(A.40)	$R_L = a_{srl} B_R$
(A.41)	$V_L = V_C + V_I$	(A.42)	$V_R = V_W + V_{NH4} + V_{NO3} + V_{PO4}$
(A.43)	$q_N = \dfrac{q_{LN}B_L + q_{WN}B_W + q_{RN}B_R}{B_T}$	(A.44)	$q_P = \dfrac{q_{LP}B_L + q_{WP}B_W + q_{RP}B_R}{B_T}$
	Canopy Phenology:		

(A.45)	$\begin{aligned} f_c &= f_{cmin} && ;\text{if } D_{day} < D_{bud} \\ &= f_{cmin} + 2\left(1 - f_{cmin}\right)\left(\frac{D_{day} - D_{bud}}{D_{full} - D_{bud}}\right)^2 && ;\text{if } D_{bud} < D_{day} < \frac{D_{bud} + D_{full}}{2} \\ &= 1 - 2\left(1 - f_{cmin}\right)\left(\frac{D_{full} - D_{day}}{D_{full} - D_{bud}}\right)^2 && ;\text{if } \frac{D_{bud} + D_{full}}{2} < D_{day} < D_{full} \\ &= 1 && ;\text{if } D_{full} < D_{day} \text{ and } J_{day} < J_{start} \\ &= 1 - 2\left(1 - f_{cmin}\right)\left(\frac{J_{day} - J_{start}}{J_{end} - J_{start}}\right)^2 && ;\text{if } J_{start} < J_{day} < \frac{J_{start} + J_{end}}{2} \\ &= f_{cmin} + 2\left(1 - f_{cmin}\right)\left(\frac{J_{end} - J_{day}}{J_{end} - J_{start}}\right)^2 && ;\text{if } \frac{J_{start} + J_{end}}{2} < J_{day} < J_{end} \\ &= f_{cmin} && ;\text{if } J_{end} < J_{day} \end{aligned}$		
	Photosynthesis/Transpiration (two equations for P_{sC} must be solves simultaneously)**:**		
(A.46)	$f_{PT} = e^{a_L\left(T_a - T_{OL}\right)}\left(\frac{T_{maxL} - T_a}{T_{maxL} - T_{OL}}\right)^{a_L\left(T_{maxL} - T_{OL}\right)}$	(A.47)	$P_{Imax} = g_I \frac{V_I - V_{\min}}{V_L}$
(A.48)	$U_{CI} = 1.6\, D_L\, f_{PT}\left(\frac{C_a - 60}{C_a + 120}\right)\frac{P_{Imax}}{k_I}\ln\left(\frac{P_{Imax} + E_0\, I/D_L}{P_{Imax} + E_0\, I\, e^{-k_I L}/D_L}\right)$		
(A.49)	$P_{Cmax} = g_C\, L\, e^{a_C\left(T_a - T_{OC}\right)}\left(\frac{T_{maxC} - T_a}{T_{maxC} - T_{OC}}\right)^{a_C\left(T_{maxC} - T_{OC}\right)} \frac{V_C - V_{\min}}{V_L}$		
(A.50)	$c_{cmax} = L\, c_{smax}$	(A.51)	$U_{Wp} = 7.775\, D_L\, c_{cmax}\, \Delta_e$
(A.52)	$U_{Ws} = g_W\, U_{Wp}\left(1 - e^{-k_E R_L \frac{\left(V_W - V_{min}\right)}{V_R}}\right)\left(\psi_s - \psi_w\right)$		
(A.53)	$c_{cs} = c_{cmax}\frac{U_{Ws}}{U_{Wp}}$	(A.54)	$\begin{aligned} P_{sC} &= D_L \frac{P_{Cmax}\, C_{i*}}{k_C + C_{i*}} \\ &= 0.000335 D_L\, c_{cs}\left(C_a - C_{i*}\right) \end{aligned}$

(A.55)	$U_C = \min\{U_{CI}, P_{sC}\}$	(A.56)	$C_i = \frac{k_C U_C}{D_L\, P_{Cmax} - U_C}$
(A.57)	$c_c = \frac{U_C}{0.000335\ D_L\left(C_a - C_i\right)}$	(A.58)	$U_W = 7.775\ D_L\, c_c\, \Delta_e$
(A.59)	$U_{CC} = P_{sC} + 0.001\left(\frac{dP_{sC}}{dV_W} - \frac{dP_{sC}}{dV_C}\right)$	(A.60)	$U_{CW} = P_{sC} - 0.001\left(\frac{dP_{sC}}{dV_W} - \frac{dP_{sC}}{dV_C}\right)$
	Plant Respiration:		
(A.61)	$R_a = r_m\left(q_{LN} B_L + q_{RN} B_R + q_{WN} B_W\right) Q_{10v}^{T_a/10}$	(A.62)	$R_u = \phi U_{NO3}$
(A.63)	$R_g = \frac{r_g}{1 + r_g}\left(U_C - R_m - R_u\right)$		
	Plant Nutrient Uptake (paired equations must be solved simultaneously)**:**		
(A.64)	$r_D = \sqrt{\frac{z}{\pi\, R_L}}$	(A.65)	$\beta_{NRD} = \frac{1}{4\pi} + \frac{r_D^4 - r_r^4 - 4\, r_D^4 \ln\left(r_D / r_r\right)}{8\pi\left[r_D^2 - r_r^2\right]^2}$
(A.66)	$U_{NH4} = g_{NH4}\left(\frac{V_{NH4} - V_{min}}{V_R}\right) R_L\, Q_{10v}^{T_a/10}\left(\frac{N_{aqNH4s}}{k_{NH4} + N_{aqNH4s}}\right)$ $= \frac{D_{NH4} R_L 14 \times 10^{-3}}{\beta_{NRD}}\left(N_{aqNH4s} - N_{aqNH4}\right)$		
(A.67)	$U_{NO3} = g_{NO3}\left(\frac{V_{NO3} - V_{min}}{V_R}\right) R_L\, Q_{10v}^{T_a/10}\left(\frac{N_{aqNO3s}}{k_{NO3} + N_{aqNO3s}}\right)$ $= \frac{D_{NO3} R_L 14 \times 10^{-3}}{\beta_{NRD}}\left(N_{aqNO3s} - N_{aqNO3}\right)$		

(A.68)	$U_{PO4} = g_{PO4}\left(\frac{V_{PO4} - V_{min}}{V_R}\right) R_L\, Q_{10v}^{T_a/10}\left(\frac{P_{aqPO4s}}{k_{PO4} + P_{aqPO4s}}\right)$ $= \frac{D_{PO4} R_L\, 31 \times 10^{-3}}{\beta_{NRD}}\left(P_{aqPO4s} - P_{aqPO4}\right)$		
	Litter Losses:		
(A.69)	$L_{Cdc} = 0$; if $J_{day} < J_{start}$ or $J_{end} < J_{day}$ $= -\left(1 - f_{c\min}\right) V_L\, B_A \frac{df_C}{dt}$; otherwise		
(A.70)	$L_C = \frac{B_C}{B_T}\left\{m_W B_W + m_{AR} B_R + m_{AL} V_L B_A f_{cmin} + L_{Cdc}\right\}$		
(A.71)	$L_N = \frac{B_N}{q_N B_T}\left\{m_W q_{WNl} B_W + m_{AR} q_{RNl} B_R + m_{AL} q_{LNl} V_L B_A f_{cmin} + q_{LNl} L_{Cdc}\right\}$		
(A.72)	$L_P = \frac{B_P}{q_P B_T}\left\{m_W q_{WPl} B_W + m_{AR} q_{RPl} B_R + m_{AL} q_{LPl} V_L B_A f_{cmin} + q_{LPl} L_{Cdc}\right\}$		
(A.73)	$L_{CWC} = \frac{B_C}{B_T}\left(m_{CW} + m_{CWX}\, e^{-k_{WL}\left(B_W - B_{Wc}\right)^2}\right) B_W$		
(A.74)	$L_{CWN} = \frac{q_{WNwl}}{q_C} L_{CWC}$	(A.75)	$L_{CWP} = \frac{q_{WPwl}}{q_C} L_{CWC}$
	Plant acclimation (Equations A.88-A.95 must be solved simultaneously)**:**		
(A.76)	$R_C = R_a + R_u + C_{gain}\left(L_C + L_{CWC}\right)\left(1 + r_g\right)\left(\frac{B_N B_P}{q_N q_P B_T^2}\right)^{0.25}$		
(A.77)	$R_N = N_{gain}\left(L_N + L_{CWN}\right)\left(\frac{q_N B_T}{B_N}\right)^{0.5}$	(A.78)	$R_{PO4} = P_{gain}\left(L_P + L_{CWP}\right)\left(\frac{q_P B_T}{B_P}\right)^{0.5}$

(A.79)	$\frac{d\overline{R}_k}{dt} = \tau\left(R_k - \overline{R}_k\right)$; for *k = C, N,* or *PO4*	(A.80)	$\frac{d\overline{U}_h}{dt} = \tau\left(U_h - \overline{U}_h\right)$ *;* for *h = CC, CW, CI, NH4, NO3,* or *PO4*
(A.81)	$\Theta_C = \max\left\{\frac{dU_C}{dV_C}, \frac{dU_C}{dV_W}, \frac{dU_C}{dV_I}\right\}$	(A.82)	$y_{NH4} = \frac{dU_{NH4}}{dV_{NH4}}$
(A.83)	$y_{NO3} = \frac{\frac{dU_{NO3}}{dV_{NO3}}}{1 + \frac{dU_{NO3}}{dV_{NO3}} \frac{\phi}{\Theta_C}}$	(A.84)	$\frac{d\overline{y}_j}{dt} = \tau\left(y_j - \overline{y}_j\right)$; for *j = NH4* or *NO3*
(A.85)	$y_{max} = \max\left\{\overline{y}_{NH4}, \overline{y}_{NO3}\right\}$		
(A.86)	$\chi_j = 0$; if $\frac{\overline{y}_j}{y_{\max}} < 1 - \sigma_y$ $= \left(\frac{\overline{y}_j}{y_{\max}} - 1 + \sigma_y\right)^2 \left(2 + \sigma_y - \frac{2\overline{y}_j}{y_{\max}}\right) \frac{1}{\sigma_y^3}$; otherwise ; for *j = NH4* or *NO3*		
(A.87)	$\overline{R}_j = \overline{R}_N \frac{\chi_j}{\chi_{NH4} + \chi_{NO3}}$; for *j = NH4* or *NO3*		
(A.88)	$\Omega_C = \frac{10\overline{R}_C + \overline{U}_{CC} + 0.0001q_C}{\overline{R}_C + 10\overline{U}_{CC} + 0.0001q_C\Phi}$	(A.89)	$\Omega_I = \frac{10\overline{R}_C + \overline{U}_{CI} + 0.0001q_C}{\overline{R}_C + 10\overline{U}_{CI} + 0.0001q_C\Phi}$
(A.90)	$\Omega_W = \frac{10\overline{R}_C + \overline{U}_{CW} + 0.0001q_C}{\overline{R}_C + 10\overline{U}_{CW} + 0.0001q_C\Phi}$	(A.91)	$\Omega_{NH4} = \frac{10\overline{R}_{NH4} + \overline{U}_{NH4} + 0.0001q_N}{\overline{R}_{NH4} + 10\overline{U}_{NH4} + 0.0001q_N\Phi}$
(A.92)	$\Omega_{NO3} = \frac{10\overline{R}_{NO3} + \overline{U}_{NO3} + 0.0001q_N}{\overline{R}_{NO3} + 10\overline{U}_{NO3} + 0.0001q_N\Phi}$	(A.93)	$\Omega_{PO4} = \frac{10\overline{R}_{PO4} + \overline{U}_{PO4} + 0.0001q_P}{\overline{R}_{PO4} + 10\overline{U}_{PO4} + 0.0001q_P\Phi}$
(A.94)	$\frac{dV_i}{dt} = a\ln\left(\Phi\Omega_i\right)V_i$; for *i = C, W, I, NH4, NO3,* or *PO4*	(A.95)	$\Phi = \prod \Omega_i^{-V_i}$; for *i = C, W, I, NH4, NO3,* or *PO4*

	Soil processes:		
(A.96)	$R_m = \left\{ 1 - \frac{\left(\frac{\omega_o - \theta/\rho_s}{\omega_o - \omega_{\min}} \right)^2}{1 + J_m \frac{\theta/\rho_s - \omega_{\min}}{\omega_o - \omega_{\min}}} \right\} Q_{10m}^{T_a/10}$	(A.97)	$T_{CWC} = r_{CW}\, R_m\, D_{Cc}$
(A.98)	$T_{CWN} = r_{CW}\, R_m\, D_{Nc}$	(A.99)	$T_{CWP} = r_{CW}\, R_m\, D_{Pc}$
(A.100)	$U_{DOMm} = R_m \alpha_{DOM} D_{C1} \left(\frac{C_{aqDOM}}{k_{DOMm} + C_{aqDOM}} \right)$	(A.101)	$U_{DONm} = U_{DOMm} / q_{DOM}$
(A.102)	$U_{NH4m} = R_m \alpha_{NH4} D_{C1} \frac{\varepsilon_C D_{C1}}{\phi_N D_{N1}} \left(\frac{N_{aqNH4}}{k_{NH4m} + N_{aqNH4}} \right)$		
(A.103)	$U_{NO3m} = R_m \alpha_{NO3} D_{C1} \frac{\varepsilon_C D_{C1}}{\phi_N D_{N1}} \left(\frac{N_{aqNO3}}{k_{NO3m} + N_{aqNO3}} \right)$		
(A.104)	$U_{PO4m} = R_m \alpha_{PO4} D_{C1} \frac{\varepsilon_C D_{C1}}{\phi_P D_{P1}} \left(\frac{N_{aqPO4}}{k_{PO4m} + N_{aqPO4}} \right)$		
(A.105)	$M_C = R_m \psi_m D_{C1} + U_{DOMm}$	(A.106)	$M_N = R_m \psi_{Nm} D_{N1} + U_{DONm} + U_{NH4m} + U_{NO3m}$
(A.107)	$M_P = R_m \psi_{Pm} D_{P1} + U_{PO4m}$	(A.108)	$D_m = \phi_P M_C M_P + \phi_N M_C M_N + \phi_N \phi_P M_N M_P / \varepsilon_C$
(A.109)	$\Lambda_C = \phi_N \phi_P M_N M_P / D_m$	(A.110)	$\Lambda_N = \phi_P M_C M_P / D_m$
(A.111)	$\Lambda_P = \phi_N M_C M_N / D_m$	(A.112)	$R_{Cm1} = M_C (1 - \Lambda_C)$
(A.113)	$R_{Nm1} = M_N (1 - \Lambda_N)$	(A.114)	$R_{Pm1} = M_P (1 - \Lambda_P)$
(A.115)	$P_{DOM} = R_m r_{DOM} D_{C1} D_{N1}$	(A.116)	$P_{DON} = P_{DOM} / q_{DOM}$

(A.117)	$T_{DC12} = R_m \, \xi_{12} \, D_{C1}$	(A.118)	$T_{DN12} = T_{DC12} / \phi_N$
(A.119)	$T_{DP12} = T_{DC12} / \phi_P$	(A.120)	$R_{Cm2} = R_m \, \rho_{m2} \, D_{C2}$
(A.121)	$R_{Nm2} = R_m \, \rho_{m2} \, D_{N2}$	(A.122)	$R_{Pm2} = R_m \, \rho_{m2} \, D_{P2}$
(A.123)	$T_{Ntr} = R_m \dfrac{r_{Ntr} \, N_{aqNH4}}{k_{Ntr} + N_{aqNH4}}$		
(A.124)	$T_{DNtr} = \dfrac{r_{DNtr} \, N_{aqNO3}}{k_{DNtr} + N_{aqNO3}} \left(\theta - \theta_0\right) Q_{10m}^{T_a/10}$; if $\theta_0 < \theta$ $= 0$; otherwise		
	Soil P transformations:		
(A.125)	$T_{PAw} = r_{PAw} \, P_A$	(A.126)	$T_{PO4s} = r_{PO4s} P_{aqPO4}$
(A.127)	$T_{P2w} = r_{P2w} \, P_{2nd}$		
	Hydrology and material loss:		
(A.128)	$R_O = D_W \left(W - 1000 z \, \theta_f\right)$	(A.129)	$L_{NH4} = R_O \; \eta_{NH4} \, 14 \times 10^{-6} N_{aqNH4}$
(A.130)	$L_{NO3} = R_O \; \eta_{NO3} \, 14 \times 10^{-6} N_{aqNO3}$	(A.131)	$L_{PO4} = R_O \; \eta_{PO4} \, 31 \times 10^{-6} N_{aqPO4}$
(A.132)	$L_{DOM} = R_O \; \eta_{DOM} \, 12 \times 10^{-6} N_{aqDOM}$	(A.133)	$I_{nt} = \min\left\{I_{ppt}, \; v_{\mathrm{int}}\left(\beta_{\mathrm{int}} B_W^{\eta_{br}} + L\right)\right\}$
(A.134)	$I_{rain} = I_{ppt} - I_{nt}$; if $T_a \geq T_{crt}$ $= 0$; otherwise	(A.135)	$I_{snow} = I_{ppt} - I_{nt}$; if $T_a < T_{crt}$ $= 0$; otherwise
(A.136)	$T_s = \max\{0, T_a - 2.5\}$		

(A.137)	$\begin{aligned} T_{SM} &= \frac{1}{c_{NR}}\left(c_{SW} I e^{-k_I L} + \sigma\left[c_{LW}\left(1-e^{-k_I L}\right)\left(T_a + 273.15\right)^4 - \left(T_s + 273.15\right)^4\right]\right) + c_C\, T_a \text{ ; if } \mathrm{T_a} > T_{crt} \\ &= 0 \qquad \text{; otherwise} \end{aligned}$

Table A2. Process and parameter definitions, values, and sources for the Multiple Element Limitation (MEL) model. The processes and parameters are arranged in the same categories use in Table A1and are listed roughly in the order of first appearance in the equations in Table A1.

Description	Symbol	values	Units	Comments
Driving Variables:				Year 2000 climate record for Hubbard Brook (www.hubbardbrook.org)
Daily minimum temperature	T_{min}	variable	^{o}C	
Daily maximum temperature	T_{max}	variable	^{o}C	
Daily total short-wave radiation	I	variable	MJ m^{-2} day^{-1}	
Precipitation	I_{ppt}	variable	mm day^{-1}	
Atmospheric CO_2	C_a	360	μmol mol^{-1}	assumed constant at 360 μmol mol^{-1}
NH_4 input	I_{NH4}	6.99e-4	g N m^{-2} day^{-1}	see Table 1 in main text
NO_3 input	I_{NO3}	1.89e-3	g N m^{-2} day^{-1}	
PO_4 input	I_{PO4}	1.10e-5	g P m^{-2} day^{-1}	
DOM input	I_{DOM}	5.56e-3	g C m^{-2} day^{-1}	
Day length	D_L	variable	hours day^{-1}	calculated from Julian day and latitude (44^{o} north)

Environment:				
Daily average temperature	T_a	----	^{o}C	calculated internally (Eq 21)
Volumetric water content	θ	----	mm mm^{-1} soil	calculated internally (Eq 22)
Soil water dissolved NH_4	N_{aqNH4}	----	µmol N L^{-1}	calculated internally (Eq 23)
Soil water dissolved NO_3	N_{aqNO3}	----	µmol N L^{-1}	calculated internally (Eq 24)
Soil water dissolved DOM	C_{aqDOM}	----	µmol C L^{-1}	calculated internally (Eq 25)
Soil water dissolved PO_4	P_{aqPO4}	----	µmol P L^{-1}	calculated internally (Eq 26)
Atmosphere dryness index	Δ_e	----	MPa	calculated internally (Eq 27)
Air entry water content	θ_i	----	mm mm^{-1} soil	calculated internally (Eq 28)
Soil water potential	ψ_s	----	MPa	calculated internally (Eq 32)
Variables used internally	b, m, n	----	----	calculated internally (Eqs 29, 30, 31)
Soil depth	z	0.479	m	based on Huntington et al. (1988) assuming 54 cm mineral soil - 24% stones + 6.9 cm organic soil, and a mineral density of 2.7 Likens et al. (2002 P 257)
Soil porosity	ρ_s	0.71	mm mm^{-1}	
Bulk density	D_{Bs}	0.783	Mg m^{-3}	
NH_4 sorption capacity	S_{NH4}	402	g NH_4-N Mg^{-1} dry soil	Fit to data in Mikolajkow (2003 Fig. 3)
NH_4 affinity constant	ε_{NH4}	786	umol NH_4 L^{-1}	
DOM sorption capacity	S_{DOM}	805	g DOM-C Mg^{-1}	Fit to Vandenbruwane et al. (2007 Fig. 1)

			dry soil	
DOM affinity constant	ε_{DOM}	2130	umol DOM L^{-1}	
PO4 sorption capacity	S_{PO4}	62	g PO_4-P Mg^{-1} dry soil	Fit to Vincent (2006 Fig 2.2)
PO4 affinity constant	ε_{PO4}	150	umol PO_4 L^{-1}	
field capacity	θ_f	0.15	mm mm^{-1}	Dunne and Leopold (1978 Fig 6-9) sandy loam
Wilting point	θ_w	0.05	mm mm^{-1}	Dunne and Leopold (1978 Fig 6-9) sandy loam
Field potential	ψ_f	-0.01	MPa	Dunne and Leoplod (1978 p 176)
Wilting potential	ψ_w	-2.5	MPa	Williams et al (1996 TBL1)
Allometry:				
Total biomass	B_T	----	g DW m^{-2}	calculated internally (Eq 33)
Total biomass with full canopy	B_{T*}	----	g DW m^{-2}	calculated internally (Eq 34)
Active biomass (leaves + fine roots)	B_A	----	g DW m^{-2}	calculated internally (Eq 35)
Woody biomass	B_W	----	g DW m^{-2}	calculated internally (Eq 36)
Leaf biomass	B_L	----	g DW m^{-2}	calculated internally (Eq 37)
Fine-root biomass	B_R	----	g DW m^{-2}	calculated internally (Eq 38)

Leaf area	L	----	m^2 m^{-2}	calculated internally (Eq 39)
Fine-root length	R_L	----	m m^{-2}	calculated internally (Eq 40)
Canopy effort	V_L	----	effort	calculated internally (Eq 41)
Root effort	V_R	----	effort	calculated internally (Eq 42)
Biomass optimum N content	q_N	----	g N g^{-1} DW	calculated internally (Eq 43)
Biomass optimum P content	q_P	----	g P g^{-1} DW	calculated internally (Eq 44)
C:dry weight ratio	q_C	0.45	g C g^{-1} DW	assumed value
Maximum B_A	B_{Amax}	1110	gDW m^{-2}	Fit to Arp et al. (1987 Fig. 3), Vadeboncoeur et al. (2007), and scaled to be consistent with Fahey et al. (2005 TBL 1)
B_A:B_T at low B_T	γ_B	0.5	none	
Specific leaf area	a_{sla}	0.0141	m^2 g^{-1} DW	Fahey et al (2005 TBL 1 and LAI from p 112)
Specific root length	a_{srl}	26.1	m g^{-1} DW	Fahey and Hughes (1994 p 537)
Leaf N fraction	q_{LN}	0.0221	g N g^{-1} DW	Whittaker et al. (1979 TBL 3)
Wood N fraction	q_{WN}	0.00227	g N g^{-1} DW	Whittaker et al. (1979 TBL 3)
Root N fraction	q_{RN}	0.02	g N g^{-1} DW	Fahey et al. (1988 TBL3)
Leaf P fraction	q_{LP}	1.73E-3	g P g^{-1} DW	Whittaker et al. (1979 TBL 3)
Wood P fraction	q_{WP}	2.26E-4	g P g^{-1} DW	Whittaker et al. (1979 TBL 3)
Root P fraction	q_{RP}	0.002	g P g^{-1} DW	Fahey et al. (1988 TBL3)
Canopy Phenology:				

Fraction canopy fullness	f_c	----	fraction	calculated internally (Eq 45)
Minimum canopy fraction	f_{cmin}	0.187	fraction	Fahey et al. (2005 TBL2) 171 g Cm-2 yr-1 leaf liter, (TBL 1) 201 g leaf C m^{-2}, and 5-yr turnover for evergreen leaves
Start degree day summation	J_{D1}	10	Julian Day	Calibrated to observed phenology (www.hubbardbrook.org)
Degree day buds open	D_{bud}	80	^{o}C day	
Degree day full canopy	D_{full}	640	^{o}C day	
Day fall starts	J_{start}	250	Julian day	
Day fall ends	J_{end}	305	Julian day	
Photosynthesis/Transpiration:				
Temperature modifier on U_{CI}	f_{PT}	----	none	calculated internally (Eq 46)
Maximum light photosynthesis	P_{Imax}	----	g C m^{-2} leaf hour^{-1}	calculated internally (Eq 47)
Canopy light photosynthesis	U_{CI}	-----	g C m^{-2} ground day^{-1}	calculated internally (Eq 48)
Maximum canopy carboxylation	P_{Cmax}	----	g C m^{-2} ground hour^{-1}	calculated internally (Eq 49)
Maximum canopy conductance	c_{cmax}	----	m hour^{-1}	calculated internally (Eq 50)

Potential transpiration	U_{Wp}	----	mm day^{-1}	calculated internally (Eq 51)
Soil-limited water uptake	U_{Ws}	----	mm day^{-1}	calculated internally (Eq 52)
Soil-limited canopy conductance	c_{cs}	----	m hour^{-1}	calculated internally (Eq 53)
Carboxylation/CO$_2$ diffusion	P_{sC}	----	g C m^{-2} day^{-1}	calculated internally (Eq 54)
Full-light internal CO$_2$	C_{i*}	----	µmol mol^{-1}	calculated internally (Eq 54)
Canopy C assimilation	U_C	----	g C m^{-2} day^{-1}	calculated internally (Eq 55)
Actual internal CO$_2$	C_i	----	µmol mol^{-1}	calculated internally (Eq 56)
Actual canopy conductance	c_c	----	m hour^{-1}	calculated internally (Eq 57)
Water uptake	U_W	----	mm day^{-1}	calculated internally (Eq 58)
C-limited photosynthesis	U_{CC}	----	g C m^{-2} day^{-1}	calculated internally (Eq 59)
H$_2$O-limited photosynthesis	U_{CW}	----	g C m^{-2} day^{-1}	calculated internally (Eq 60)
Temperature response parameters for light capture	T_{maxL}	60	^{o}C	Fit to Medlyn et al (2002 Fig 2)
	T_{OL}	33	^{o}C	
	a_L	0.25	^{o}C^{-1}	
Ps light constant	g_I	2.29	g C m^{-2} leaf hour^{-1}	Calibrated to U_C
Minimum effort	V_{min}	0.001	effort	set small enough to have little effect on effort budget but large enough for

				uptake to turn on in timely manner
Light extinct	k_I	0.5	$m^2\ m^{-2}$	Beer's coefficient Waring and Schlesinger (1985 Fig. 2.5)
Quantum yield	E_0	1.66	gC MJ^{-1}	equivalent to 0.06 mol C/mol quanta; McMurtrie et al (1992); Jarvis and Leverenz (1983)
Ps CO_2 rate constant	g_C	4.96	g C m^{-2} leaf $hour^{-1}$	Calibrated to U_C
Temperature response parameters for carboxylation	T_{maxC}	50	^oC	Fit to Medlyn et al (2002 Fig 2)
	T_{OC}	35	^oC	
	a_C	0.3	$^oC^{-1}$	
Maximum leaf conductance	c_{smax}	20	m hr-1	Williams et al. (1996 Fig. 9)
H_2O uptake constant	g_W	0.167	MPa^{-1}	Calibrated to U_W
Water uptake factor	k_E	1e-4	$m^2\ m^{-1}$	assumed small enough to not saturate curve at R_L
CO_2 1/2 saturation constant	k_C	350	µmol mol^{-1}	Rastetter et al. (2001)
Plant Respiration:				
Plant maintenance respiration	R_a	----	g C m^{-2} day^{-1}	calculated internally (Eq 61)
NO_3 uptake respiration	R_u	----	g C m^{-2} day^{-1}	calculated internally (Eq 62)
Growth respiration	R_g	----	g C m^{-2} day^{-1}	calculated internally (Eq 63)
Respiration constant	r_m	9.73E-3	gC g^{-1} N day^{-1}	Calibrated to NPP

Vegetation Q_{10}	Q_{10v}	2	none	Kozlowski, Kramer & Pallardy (1991 p54)
NO_3 C cost	ϕ	4.6	gC g^{-1} N	Gutschick (1981 p 617) 1/4 to 1/2 N fixation cost
Growth respiration	r_g	0.28	fraction	Waring and Schlesinger (1985 TBL 2.3)
Plant nutrient uptake:				
Average between-root distance	r_D	----	m	calculated internally (Eq 64)
Near-root depletion factor	β_{NRD}	----	none	calculated internally (Eq 65)
Plant NH_4 uptake	U_{NH4}	----	g N m^{-2} day^{-1}	calculated internally (Eq 66)
Dissolved NH_4 at root surface	N_{aqNH4s}	----	μmol N L^{-1}	calculated internally (Eq 66)
Plant NO_3 uptake	U_{NO3}	----	g N m^{-2} day^{-1}	calculated internally (Eq 67)
Dissolved NO_3 at root surface	N_{aqNO3s}	----	μmol N L^{-1}	calculated internally (Eq 67)
Plant PO_4 uptake	U_{PO4}	----	g P m^{-2} day^{-1}	calculated internally (Eq 68)
Dissolved PO_4 at root surface	P_{aqPO4s}	----	μmol P L^{-1}	calculated internally (Eq 68)
Root radius	r_r	5E-4	m	Fahey et al. (2005) definition of fine root
NH_4 uptake constant	g_{NH4}	2.31E-5	g N m^{-1} root day^{-1}	Calibrated to U_{NH4}
Plant NH_4 1/2 saturation constant	k_{NH4}	15	umol L-1	Williams and Yanai (1996 TBL 2)

NO_3 uptake const	g_{NO3}	3.35E-5	g N m^{-1} root day^{-1}	Calibrated to U_{NO3}
Plant NO_3 1/2 saturation constant	k_{NO3}	120	umol L^{-1}	Raynaud et al. (2006 TBL 6)
PO_4 uptake constant	g_{PO4}	1.69E-6	g P m^{-1} root day^{-1}	Calibrated to U_{PO4}
Plant PO_4 1/2 saturation constant	k_{PO4}	2	umol L^{-1}	Williams and Yanai (1996 TBL 2) and Comas et al. (2002 Fig 2)
Diffusion constant NH_4	D_{NH4}	8.64E-5	m^2 d^{-1}	Raynaud and Leadley (2004 TBL3) mean values
Diffusion constant NO_3	D_{NO3}	4.03E-5	m^2 d^{-1}	
Diffusion constant PO_4	D_{PO4}	2.39E-5	m^2 d^{-1}	
Litter losses:				
Deciduous leaf litter	L_{Cdc}	----	g C m^{-2} day^{-1}	calculated internally (Eq 69)
Total fine litter C	L_C	----	g C m^{-2} day^{-1}	calculated internally (Eq 70)
Total fine litter N	L_N	----	g N m^{-2} day^{-1}	calculated internally (Eq 71)
Total fine litter P	L_P	----	g P m^{-2} day^{-1}	calculated internally (Eq 72)
Coarse woody litter C	L_{CWC}	----	g C m^{-2} day^{-1}	calculated internally (Eq 73)
Coarse woody litter N	L_{CWN}	----	g N m^{-2} day^{-1}	calculated internally (Eq 74)

Coarse woody litter P	L_{CWP}	----	g P m^{-2} day^{-1}	calculated internally (Eq 75)
Evergreen leaf turnover	m_{AL}	7.76E-4	day^{-1}	calibrated to L_C; maintaining the same relative contributions among tissues as in Whittaker et al. (1979 TBL 5)
Wood turnover	m_W	3.02E-5	day^{-1}	
Root turnover	m_{AR}	1.35E-3	day^{-1}	
Leaf litter N fraction	q_{LNl}	0.0119	g N g^{-1} DW	calibrated to L_N; maintaining the same relative concentrations among tissues as in Whittaker et al (1979 TBL 5)
Wood litter N fraction	q_{WNl}	5.72E-3	g N g^{-1} DW	
Root litter N fraction	q_{RNl}	0.0212	g N g^{-1} DW	
Leaf litter P fraction	q_{LPl}	6.62E-4	g P g^{-1} DW	calibrated to L_P; maintaining the same relative concentrations among tissues as in Whittaker et al (1979 TBL 5)
Wood litter P fraction	q_{WPl}	4.12E-4	g P g^{-1} DW	
Root litter P fraction	q_{RPl}	9.04E-4	g P g^{-1} DW	
Coarse woody turnover	m_{CW}	3.09E-5	day^{-1}	calibrated to L_{CWC}
Canopy closure woody litter parameters	m_{CWX}	1.50E-4	day^{-1}	calibrated to Fig 2
	B_{Wc}	8000	g C m^{-2}	
	k_{WL}	1E-7	m^4 g^{-2} C	
Coarse litter N fraction	q_{WNwl}	1.99E-3	gN g^{-1} DW	= $q_c D_{Nc}/D_{Cc}$; see Table 1
Coarse litter P fraction	q_{WPwl}	1.74E-4	gP g^{-1} DW	=$q_c D_{Pc}/D_{Cc}$; see Table 1
Plant acclimation:				
Plant C requirement	R_C	----	g C m^{-2} day^{-1}	calculated internally (Eq 76)

Plant N requirement	R_N	----	g N m^{-2} day^{-1}	calculated internally (Eq 77)
Plant PO$_4$ requirement	R_{PO4}	----	g P m^{-2} day^{-1}	calculated internally (Eq 78)
Integrated requirement for *k*	$\overline{R_k}$	----	g m^{-2} day^{-1}	calculated internally (Eq 79)
Integrated uptake of *h*	$\overline{U_h}$	----	g m^{-2} day^{-1}	calculated internally (Eq 80)
Maximum C marginal yield	Θ_C	----	g C effort^{-1} m^{-2} day^{-1}	calculated internally (Eq 81)
Marginal yield for NH$_4$	y_{NH4}	----	g N effort^{-1} m^{-2} day^{-1}	calculated internally (Eq 82)
Marginal yield for NO$_3$	y_{NO3}	----	g N effort^{-1} m^{-2} day^{-1}	calculated internally (Eq 83)
Integrated marginal yield for *j*	$\overline{y_j}$	----	g N effort^{-1} m^{-2} day^{-1}	calculated internally (Eq 84)
Maximum N marginal yield	y_{max}	----	g N effort^{-1} m^{-2} day^{-1}	calculated internally (Eq 85)
Relative yield for *j*	χ_j	----	none	calculated internally (Eq 86)
Integrated requirement of *j*	$\overline{R_j}$	----	g N m^{-2} day^{-1}	calculated internally (Eq 87)
Requirment:uptake ratio for *i*	Ω_i	----	none	calculated internally (Eqs 88-93)

Weighted geometric mean Ω	Φ	----	none	calculated internally (Eq 95)
Gain C	C_{gain}	0.247	none	Calibrated to steady state allocation of effort
Gain N	N_{gain}	0.612	none	
Gain P	P_{gain}	0.582	none	
Requirement turnover	τ	0.003	day^{-1}	assumed ~ 1 yr
N-yield range	σ_y	0.05	none	assumed yield must be within 5% before alternate N source used
Acclimation rate	a	0.003	day^{-1}	assumed ~ 1 yr
Soil processes:				
Temperature/moisture response	R_m	----	none	calculated internally (Eq 96)
Coarse woody C turnover	T_{CWC}	----	g C m^{-2} day^{-1}	calculated internally (Eq 97)
Coarse woody N turnover	T_{CWN}	----	g N m^{-2} day^{-1}	calculated internally (Eq 98)
Coarse woody P turnover	T_{CWP}	----	g P m^{-2} day^{-1}	calculated internally (Eq 99)
Microbial DOM uptake	U_{DOMm}	----	g C m^{-2} day^{-1}	calculated internally (Eq 100)
Microbial DON uptake	U_{DONm}	----	g N m^{-2} day^{-1}	calculated internally (Eq 101)
Microbial NH$_4$ uptake	U_{NH4m}	----	g N m^{-2} day^{-1}	calculated internally (Eq 102)
Microbial NO$_3$ uptake	U_{NO3m}	----	g N m^{-2} day^{-1}	calculated internally (Eq 103)
Microbial PO$_4$ uptake	U_{PO4m}	----	g P m^{-2} day^{-1}	calculated internally (Eq 104)

Total microbial C use	M_C	----	g C m^{-2} day^{-1}	calculated internally (Eq 105)
Total microbial N use	M_N	----	g N m^{-2} day^{-1}	calculated internally (Eq 106)
Total microbial P use	M_P	----	g P m^{-2} day^{-1}	calculated internally (Eq 107)
Efficiency divisor	D_m	----	g^{2} C m^{-4} day^{-2}	calculated internally (Eq 108)
Microbial C efficiency	Λ_C	----	none	calculated internally (Eq 109)
Microbial N efficiency	Λ_N	----	none	calculated internally (Eq 110)
Microbial P efficiency	Λ_P	----	none	calculated internally (Eq 111)
Phase I C mineralization	R_{Cm1}	----	g C m^{-2} day^{-1}	calculated internally (Eq 112)
Phase I N mineralization	R_{Nm1}	----	g N m^{-2} day^{-1}	calculated internally (Eq 113)
Phase I P mineralization	R_{Pm1}	----	g P m^{-2} day^{-1}	calculated internally (Eq 114)
DOM production	P_{DOM}	----	g C m^{-2} day^{-1}	calculated internally (Eq 115)
DON production	P_{DON}	----	g N m^{-2} day^{-1}	calculated internally (Eq 116)
Phase I to Phase II C transfer	T_{DC12}	----	g C m^{-2} day^{-1}	calculated internally (Eq 117)
Phase I to Phase II N transfer	T_{DN12}	----	g N m^{-2} day^{-1}	calculated internally (Eq 118)
Phase I to Phase II P transfer	T_{DP12}	----	g P m^{-2} day^{-1}	calculated internally (Eq 119)
Phase II C mineralization	R_{Cm2}	----	g C m^{-2} day^{-1}	calculated internally (Eq 120)
Phase II N mineralization	R_{Nm2}	----	g N m^{-2} day^{-1}	calculated internally (Eq 121)
Phase II P mineralization	R_{Pm2}	----	g P m^{-2} day^{-1}	calculated internally (Eq 122)

Nitrification	T_{Ntr}	----	g N m^{-2} day^{-1}	calculated internally (Eq 123)
Denitrification	T_{DNtr}	----	g N m^{-2} day^{-1}	calculated internally (Eq 124)
Microbial moisture response parameters	ω_o	0.45	pore fraction	fit to Waring and Schesinger (1985 Fig 8.7)
	J_m	1	none	
	ω_{min}	0.01	pore fraction	
Microbial Q_{10}	Q_{10m}	2	none	assumes Q_{10} of ~4 (Davidson et al 1998) divided by 2 to account for relative ranges of air versus soil temperature
Coarse Woody turnover	r_{CW}	2.15E-4	day^{-1}	calibrated to T_{CWC}
Microbial DOM uptake rate	α_{DOM}	9.80E-4	day^{-1}	calibrated to U_{DOMm}
Microbial DOM 1/2 saturation constant	k_{DOMm}	2240	umol N L^{-1}	assumed NH_4 value*q_{DOM}
C:N DOM	q_{DOM}	26.72	g C g^{-1} N	Dittman et al. (2007 TBL 1) Average of hardwood corrected to mass ratio.
Microbial NH_4 uptake rate constant	α_{NH4}	1.68E-4	g N g^{-1} C day^{-1}	Calibrated to U_{NH4m}
Maximum microbial C efficiency	ε_C	0.6	none	Hunt et al. (1991 TBL 2)
Phase II soil C:N	ϕ_N	17.6	g C g^{-1} N	Whittaker et al. (1979 TBL 3) C:N Humus layer
Microbial NH_4 1/2 saturation	k_{NH4m}	10	umol N L^{-1}	Raynaud et al. (2006 TBL 2) assumes soil water at field capacity

constant				
Microbial NO_3 uptake rate constant	α_{NO3}	2.35E-5	g N g^{-1} C day^{-1}	Calibrated to U_{NO3m}
Microbial NO_3 1/2 saturation constant	k_{NO3m}	80	umol N L^{-1}	Raynaud et al. (2006 TBL 2) assumes soil water at field capacity
Microbial PO_4 uptake rate constant	α_{PO4}	2.10E-5	g P g^{-1} C day^{-1}	calibrated to U_{PO4m}
Phase II soil C:P	ϕ_P	267	g C g^{-1} P	Whittaker et al (1979 TBL 3) Humus C:P
Microbial PO_4 1/2 saturation constant	k_{PO4m}	1.33	umol P L^{-1}	assumes same microbe:plant ratio as for NH_4
C mineralization constant	ψ_m	2.18E-4	day^{-1}	Calibrated to steady state for Phase I soil organic matter
N mineralization constant	ψ_{Nm}	1.16E-4	day^{-1}	
P mineralization constant	ψ_{Pm}	5.27E-4	day^{-1}	
DOM production rate constant	r_{DOM}	2.57E-6	m^2 g^{-1} N day^{-1}	Calibrated to P_{DOM}
Phase I to phase II transition rate	ξ_{12}	8.31E-5	day^{-1}	Calibrated to T_{DC12}
Phase II mineralize rate	ρ_{m2}	1.90E-5	day^{-1}	Calibrated to R_{Cm2}

Nitrification constant	r_{Ntr}	0.060	g N m^{-2} day^{-1}	calibrated to T_{Ntr}
Nitrification 1/2 saturation constant	k_{Ntr}	10	umol N L^{-1}	Raynaud et al. (2006 TBL 2) assumes soil water at field capacity
Denitrification constant	r_{DNtr}	1.63	g N m^{-2} day^{-1}	calibrated to T_{DNtr}
Denitrification 1/2 saturation constant	k_{DNtr}	80	umol NO$_3$ L^{-1}	Tian et al. (2010 TBL 5) assumes soil water at field capacity
Denitrification minimum soil moisture	θ_0	0.15	mm mm^{-1} soil	assumed = field capacity
Soil P transformations:				
^{o}1 mineral weathering	T_{PAW}	----	g P m^{-2} day^{-1}	internally calculated (Eq 125)
^{o}2 mineral formation	T_{PO4s}	----	g P m^{-2} day^{-1}	internally calculated (Eq 126)
^{o}2 mineral weathering	T_{P2W}	----	g P m^{-2} day^{-1}	internally calculated (Eq 127)
^{o}1 weathering constant	r_{PAw}	1.39E-7	day^{-1}	Calibrated to T_{PAW}
^{o}2 formation constant	r_{PO4s}	3.94E-5	day^{-1}	Calibrated to T_{PO4s}
^{o}2 weathering constant	r_{P2w}	1.39E-7	day^{-1}	Calibrated to T_{P2w}
Hydrology and material loss:				
Run off and deep percolation	R_O	----	mm day^{-1}	calculated internally (Eq 128)

NH_4 loss	L_{NH4}	----	g N m^{-2} day^{-1}	calculated internally (Eq 129)
NO_3 loss	L_{NO3}	----	g N m^{-2} day^{-1}	calculated internally (Eq 130)
PO_4 loss	L_{PO4}	----	g P m^{-2} day^{-1}	calculated internally (Eq 131)
DOM loss	L_{DOM}	----	g C m^{-2} day^{-1}	calculated internally (Eq 132)
Intercepted water	I_{nt}	----	mm day^{-1}	calculated internally (Eq 133)
Rainfall	I_{rain}	----	mm day^{-1}	calculated internally (Eq 134)
Snow fall	I_{snow}	----	mm day^{-1}	calculated internally (Eq 135)
Snow pack temperature	T_s	----	^{o}C	calculated internally (Eq 136)
Snow melt	T_{SM}	----	mm day^{-1}	calculated internally (Eq 137)
soil drain rate	D_w	1	day^{-1}	sandy loam, Heath (1983)
Loss fraction NH_4	η_{NH4}	0.042	none	Calibrated to L_{NH4}
Loss fraction NO_3	η_{NO3}	0.005	none	Calibrated to L_{NO3}
Loss fraction PO_4	η_{PO4}	0.130	none	Calibrated to L_{PO4}
Loss fraction DOM	η_{DOM}	0.786	none	Calibrated to L_{DOM}
Interception volume	ν_{int}	0.158	L m^{-2} leaf day^{-1}	Calibrated to I_{nt}
Non-leaf surface constant	β_{int}	0.0184	m^2 leaf $m^{\eta br\ -2}$ ground $g^{-\eta br}{}_{DW}$	Fit to Whittaker et al. (1974 TBL 2) Stem and branch surface
Branch exponent	η_{br}	0.558	none	

Snow critical temp	T_{crt}	0.75	^{o}C	Brubaker et al. (1996)
Latent heat of fusion H_2O	C_{NR}	0.334	MJ L^{-1}	Physical constant
Short wave absorption	C_{SW}	0.1	none	Dunne and Leopold (1978 Fig 13.5)
Long wave absorption	C_{LW}	2.1	none	Calibrated to snow water equivalents for 1999-2001 (Campbell et al. 2010)
Convective coefficient	C_C	2	mm $^{o}C^{-1}$ day^{-1}	Brubaker et al. (1996)
Stefan-Boltzmann constant	σ	4.9E-9	MJ m^{-2} day^{-1} $^{o}K^{-4}$	Monteith (1973)

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