Model 4C tree species parameter

Table 1 Species-specific parameters, which are used in 4C

Variable name	Unit	Beech	Spruce	Pine	Oak	Douglas fir	Description of parameter	References
							Competition and mortality	
		Fagus sylvatica	Picea abies	Pinus sylvestris	Quercus robur	Pseudotsuga menziesii		
a_{max}	y	430	930	760	1060	930	maximal tree age of individual trees in absence of major disturbances	Expert assessment and BUGMANN (1994)
a_{rec}	y	3	3	3	3	3	stress recovery time	Expert assessment
p_{st}	-	5	4	1	2	4	shade tolerance, high = 5, low = 1	ELLENBERG (1996)
k	-	0.4	0.6	0.6	0.5	0.3	Light extinction coefficient	
							Physiological parameters	
σ_n	y^{-1}	0.032	0.05	0.03	0.03	0.025	specific nitrogen uptake capacity of fine roots	Expert assessment, TREEDYN3 (BOSSEL (1994), SONNTAG (1998))
Y	-	0.5	0.52	0.52	0.5	0.5	respiration coefficient : fraction of gross production which is respired by the whole plant	Modified from LANDSBERG and WARING (1997)

Variable name	Unit	Beech	Spruce	Pine	Oak	Douglas fir	Description of parameter	References
s_f	y^{-1}	1	0.181	0.31	1	0.2	senescence rate of leaves (= 1/life span)	Various sources BARTELINK (1998), BOSSEL (1994), MÄKELÄ (1997), LEEMANS and PRENTICE (1989)
s_s	y^{-1}	0.026	0.05	0.04	0.05	0.05	senescence rate of sap wood	
s_r	y^{-1}	0.65	0.5	0.5	0.5	0.75	senescence rate of fine roots	
p_{cn}	gN (g C)$^{-1}$	0.008	0.0052	0.0079	0.008	0.00955	average plant nitrogen-carbon ratio for biomass	Various sources used in FORSANA (GROTE (1998); GROTE and SUCKOW (1998)) and TREEDYN3 (BOSSEL (1994))
N_{fol}	mg g^{-1}	26.01	13.36	13.46	25	15.22	N concentration of foliage	JACOBSEN et al. (2003)
N_{frt}	mg g^{-1}	7.15	10.77	7.44	8.94	3.67	N concentration of fine roots	
N_{crt}	mg g^{-1}	3.03	4.14	1.77	3.71	1.62	N concentration of coarse roots	
N_{tbc}	mg g^{-1}	4.27	5.24	3.61	6.19	3.62	N concentration of twigs and branches	
N_{stem}	mg g^{-1}	1.54	1.22	1.09	2.1	1.035	N concentration of stemwood	
$r_{allofol}$	-	0.1	0.1	0.1	0.1	0.1	reallocation parameter of foliage	Expert assessment

Variable name	Unit	Beech	Spruce	Pine	Oak	Douglas fir	Description of parameter	References
$r_{allofrt}$	-	0.1	0.1	0.1	0.1	0.1	reallocation parameter of fine root	Expert assessment
α_c	-	0.48	0.5	0.46	0.56	0.54	average growth increment of branches, twigs and gross roots relative to the sap wood increment	Expert assessment
cr_{frac}	-	0.5	0.6	0.6	0.55	0.54	fraction of twigs, branches, roots that is coarse roots	Modified from CANNELL (1982)
ρ_s	kg cm^{-3}	0.00065	0.00042	0.000403	0.00056	0.000405	density of sap wood, often be approximated by wood density	Various sources: BURGER (1950), MÄKELÄ (1997), HOFFMANN (1995), ELLENBERG (1996)
η_s	kg cm^{-2}	0.03	0.096	0.05	0.02	0.093	leaf mass to sap wood area	BARTELINK (1998), BERNINGER and NIKINMAA (1994), MÄKELÄ et al. (1995), MENCUCCINI and GRACE (1995), KAIPIAINEN and HARI (1985)
							isometric and allometric relationships	
α_h	cm kg^{-1}	125	40	190	100	40	height growth rate	Expert assessment

Variable name	Unit	Beech	Spruce	Pine	Oak	Douglas fir	Description of parameter	References
α_{vh1}	-	1089.3	284.8	206	946.7	750	parameter for non-linear height-foliage relationship	Derived from data fits for the relationship
α_{vh2}	-	0.1351	-0.0151	0.03177	0.299	-0.015	parameter for non-linear height-foliage relationship	
α_{vh3}	-	0.504	0.5039	0.877	0.948	0.35	parameter for non-linear height-foliage relationship	
c_a	m cm^{-1}	0.09571	0.06383	0.05213	0.095	0.081287	parameter for crown coverage – DBH relation	Data fits from e.g.: LÄSSIG (1991), VANSELOW (1951)
c_b	m	0.57732	0.33567	0.48139	0.5	0.355485	parameter for crown radius - DBH relation	
c_c	m	15	12	10	15	5	parameter for crown radius - DBH relation	
$S_{min,c}$	m^2 kg^{-1}	12	3.78	4	14	2.82	minimum specific one-sided leaf area	Expert assessment (Bugmann, Bossel, Mäkelä and other)
$S_{a,c}$	-	12	2.4	1	4.7	4.87	light depending. specific one-sided leaf area	Modified from LYR et al. (1964)

Variable name	Unit	Beech	Spruce	Pine	Oak	Douglas fir	Description of parameter	References
							Photosynthesis parameters all photosynthesis parameters are currently non species specific,	
ϕ_c		1	0.8	0.9	1	0.8	efficiency parameter, different for evergreen and deciduous trees	Modified from BUGMANN (1994)
K_{mc}	Pa	30	30	30	30	30	Michaelis constant for CO_2 at 25 °C	HAXELTINE and PRENTICE (1996)
K_{mo}	kPa	30	30	60	30	30	Inhibition constant for O_2 at 25 °C	
τ	-	3400	2600	3400	3400	2600	CO_2/O_2 specificity value at 25 °C	
Q_{10c}	-	2.1	2.1	2.1	2.1	2.1	Q_{10} of temperature dependency of Michaelis constant for CO_2	
Q_{10o}	-	1.2	1.2	1.2	1.2	1.2	Q_{10} of temperature dependency of Inhibition constant for O_2	
$Q_{10\tau}$	-	0.57	0.57	0.57	0.57	0.57	Q_{10} of temperature dependency of specificity CO_2/O_2 ratio	
b	-	0.01	0.015	0.01	0.01	0.015	mitochondrial respiration rate (Rd) / maximal carboxylation rate (Vm)	
							phenology related parameters	

Variable name	Unit	Beech	Spruce	Pine	Oak	Douglas fir	Description of parameter	References
BB_{end}	d	282	366	366	287	366	average day of leaf drop	
$T_{I,min}$	°C	-10.34	-	-	-23.05	-	prohibitor-inhibitor model (PIM): Inhibitor minimum temperature	SCHABER (2002)
$T_{I,opt}$	°C	-0.89	-	-	-0.3	-	PIM: Inhibitor optimum temperature	
$T_{I,max}$	°C	18.11	-	-	16.91	-	PIM: Inhibitor maximum temperature	
a_2	-	0.058326	-	-	0.055149	-	PIM: Inhibitor scaling factor	
T_{IPmin}	°C	-10.03	-	-	3.46	-	PIM: Promotor minimum temperature	
$T_{P,opt}$	°C	28.61	-	-	34.55	-	PIM: Promotor optimum temperature.	
T_{IPmax}	°C	44.49	-	-	34.55	-	PIM: Promotor maximum temperature	
a_3	-	0.109494	-	-	0.331253	-	PIM: Promotor scaling factor	
a_1, a_4	-	0.039178	-	-	0.010379	-	PIM: Promotor scaling factor -	
							Interception	

Variable name	Unit	Beech	Spruce	Pine	Oak	Douglas fir	Description of parameter	References
C_{pots}	mm m^{-2}	0.6	0.8	0.9	0.5	0.8	potential interception storage capacity	Modified from JANSSON et al. (1991) and monitoring data
							decomposition parameters	
k_{pom}^{f}	d^{-1}	0.02	0.06	0.02	0.015	0.08	mineralization constant of foliage litter	Modified from BAUHUS (1994) , BERG (1986), BERG and STAAF (1980), BERGMANN (1998), EDMONDS (1979), GOSZ et al. (1973), JOHANSSON (1994), MACKENSEN and BAUHUS (1999), PARDO et al. (1997), PESCHKE and MOLLENHAUER (1993)
k_{syn}^{f}	-	0.3	0.2	0.5	0.4	0.2	synthesis coefficient of humus from foliage litter	
k_{pom}^{fr}	d^{-1}	0.02	0.05	0.035	0.01	0.05	mineralization constant of fine root litter	
k_{syn}^{fr}	-	0.4	0.1	0.5	0.3	0.3	synthesis coefficient of humus from fine root litter	
k_{pom}^{fr}	d^{-1}	0.02	0.05	0.035	0.01	0.05	mineralization constant of fine root litter	
k_{syn}^{c}	-	0.1	0.1	0	0.1	0.1	synthesis coefficient of humus from coarse roots litter	
k_{pom}^{tb}	d^{-1}	0.006	0.006	0.006	0.006	0.006	mineralization constant of twigs, branches litter	

Variable name	Unit	Beech	Spruce	Pine	Oak	Douglas fir	Description of parameter	References
k_{syn}^{tb}	-	0.5	0.8	0.5	0.5	0.8	synthesis coefficient of humus from twigs, branches litter	
k_{pom}^{st}	d^{-1}	0.0025	0.0005	0.0005	0.0005	0.0005	mineralization constant of stem litter	
k_{syn}^{st}	-	0.1	0.1	0	0.1	0.1	synthesis coefficient of humus from stem litter	

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