



# Forest-CEW User Guide (Draft)

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May 2018

## 1 Data preparation

Forest-CEW requires these measurements above canopy: air temperature ( $^{\circ}\text{C}$ ), vapor pressure deficit (kPa), wind speed ( $\text{m s}^{-1}$ ), global solar radiation ( $\text{W m}^{-2} \text{s}^{-1}$ ), downward long wave radiation ( $\text{W m}^{-2} \text{s}^{-1}$ ), precipitation ( $\text{mm hr}^{-1}$ ), air pressure (kPa), and air  $\text{CO}_2$  concentration ( $\mu\text{mol mol}^{-1}$ ). You must prepare those data and save them in a text file. Items in a line of data should be separated by one or more space characters, or by a comma. Any lines starting with # are treated as comments.

Users may include one more column in the file containing the net ecosystem exchange (NEE) with positive values indicating gross productions larger than respirations. A value larger than 999.9 or smaller than -999.9 may be used to indicate missing values. If the NEE is available, the model will show the correlation coefficient between the model output and the measurements at the end of a simulation.

## 2 Execute Program

The package at <http://united-csfe.com/fcew/> includes two model programs. The one named “fcew.exe” is for advanced users and the one named “Forect-CEW.exe” is for those who are not familiar with using commands in Windows.

Suppose you are an advanced user and “fcew.exe” is in the current directory of your DOS windows, it will try to read your input data from the file “io/input.txt”, start modeling, and save results in the “io” directory. The program takes two optional arguments. You may pass a different data file through the first argument and a different output directory through the second. The first time you execute the program, it will generate files containing default parameter values in the output directory. You may use a text editor to modify them.

If you use “Forect-CEW.exe” (just double click it), the first thing you need to do is opening a data file through the file menu. Once succeeded, the program will use the path of the data file as the output path, If the path is accessed the first time, the program will generate a few files which contain default parameters values, which can be modified through the parameter menu. Note that the user interface program will copy the results and parameter values of a simulation to a new directory named according simulation time.

## 3 Optimization Approach

Obtaining a good agreement between modeled and observed net ecosystem exchange (NEE) is an important goal of using the model. The default parameter values produce NEE values that most likely are not as good as anticipated. As LAI is the most important factor that determines the gross primary production (GPP), it is critical to obtain a reliable LAI for the full-leaf season and simulate that period as a start.

Users should examine the regression of the modeled and observed NEE or GPP. Assuming the observed NEE is the x variable in the regression, then a slope smaller than 1 indicates that the \_vmax

or `_jmax` parameters in table 4 are too small. A few other parameters in the table also affect the results. Users should read the technical documentation to understand the role of each parameter.

The next step is to modify the respiration rates or carbon storages of various components to minimize the intercept of the regression.

After the bias of the NEE becomes small, it is time to use different values for parameters related to PAR absorption and stomatal conductance to test performance. Plotting the time series NEE along with the global solar radiation is a good way to check the performance.

The key to use the model successfully is having a good understanding of the model by reading the technical documentation!

#### 4 Model Parameters

The following tables show symbols in parameter files. Their short remarks are extended to include more explanations or equation or figure numbers in the technical documentation. As tree and shrub use the same set of symbols, parameters for shrub are not listed. Similarly, parameters for fine root are not listed.

Table 1. Parameters in “`site.par`” (menu: Parameter→ Site).

Symbol	Value	Units	Remark
<code>_type</code>	0		Site type (0: no shrub; 1: has shrub).
<code>_restart</code>	0		Restart (1) from previous run or new start (0). The first time a site is simulated, the model will use the first input to initialize model variables. Later a simulation uses the last outputs of a previous simulation for initialization if <code>_restart</code> is not zero.
<code>_dt</code>	60	S	Time step for simulation.
<code>_zref</code>	30	m	Reference height of measurements above canopy.

Table 2. Parameters in “`tree.par`” (menu: Parameter→ Tree→ Plant).

Symbol	Value	Units	Remark
<code>_ztop</code>	20	m	Height of foliage top. Figure 1.
<code>_zbot</code>	5	m	Height of foliage bottom. Figure 1.
<code>_pai</code>	0.65	m <sup>2</sup> m <sup>-2</sup>	Plant area index in low growth season. The PAI increases with LAI in model simulation. Eq.27.
<code>_fpr</code>	1		Structural factor for rain interception. Eq.55.
<code>_fem</code>	1		Structural factor for emissivity. Eq.27
<code>_alloc1</code>	0.35		Fraction carbon allocation to foliage
<code>_alloc2</code>	0.25		Fraction carbon allocation to stem
<code>_alloc3</code>	0.35		fraction carbon allocation to fine root
<code>_alloc4</code>	0.05		fraction carbon allocation to coarse root

Table 3. Parameters in “tree.foliage.par” (menu: parameter→ tree→ foliage).

Symbol	Value	Units	Remark
_dynamic	0		Carbon storage mode (0: static; 1: dynamic)
_abs	0.8		Absorptivity for PAR. Eq.17
_refl	0.13		Reflectivity for PAR. Eq.18
_dim	0.1	m	Typical leaf with. Eq.15
_sla	12	m <sup>2</sup> kg <sup>-1</sup>	Specific leaf area. Eq.85
_dmc	0.5	kg kg <sup>-1</sup>	Dry matter content
_litter	0.1	kg m <sup>-2</sup>	Litter carbon from foliage
_rd25	1.0	Kg kg <sup>-1</sup> yr <sup>-1</sup>	Litter decomposition rate at 25C. Eq.84
_erd	50	KJ mol <sup>-1</sup>	Activation energy of litter decomposition. Eq.84
_rt	30	day	Residence time/life expectancy. Eq.88
_lai#		m <sup>2</sup> m <sup>-2</sup>	LAI on the #th day. LAI is the most important factor affecting gross primary production. Eq.27

Table 4. Parameters in “tree.leaf.par” (menu: parameter→ tree→ leaf).

Symbol	Value	Units	Remark
_vmax	75	umol m <sup>-2</sup> s <sup>-1</sup>	Carboxylation rate at optimal temperature. Eq.74.
_jmax	85	umol m <sup>-2</sup> s <sup>-1</sup>	Electron transport rate at optimal temperature. Eq.73.
_topt	38	C	Optimal temperature. Eq.74
_ep	220	J mol <sup>-1</sup>	Enthalpy term of the Boltzmann function. Eq.74.
_ea	55	J mol <sup>-1</sup>	Activation energy of the Boltzmann function. Eq.74.
_qn	8.5		Quantum yield coefficient. Eq.73.
_rd25	1.5	umol m <sup>-2</sup> s <sup>-1</sup>	Dark respiration rate at T=25C. Eq.84.
_erd	50	KJ mol <sup>-1</sup>	Activation energy of dark respiration. Eq.84.
_g0	0.003	mol m <sup>-2</sup> s <sup>-1</sup>	Minimum stomatal conductance of water vapor. Eq.80.
_g1	5.6		Sensitivity coefficient. Eq.80.
_gd	1		VPD coefficient. Eq.81.
_vpd	1		Use VPD (_vpd=1) or RH (_vpd=0) in surface conductivity calculation
_stress	5		Coefficient of soil moisture. Eq.63.

Table 5. Parameters in “tree.stem.par” (parameter→ tree→ stem).

Symbol	Value	Units	Remark
_dynamic	0		Carbon storage mode (0: static; 1: dynamic)
_abs	0.7		Absorptivity of PAR. Eq.17.
_refl	0.3		Reflectivity of PAR. Eq.18.
_dim	0.1	m	Typical branch dimension (diameter). Eq.15.
_dmc	0.7	kg kg <sup>-1</sup>	Dry matter content
_carbon	10	kg	Stem carbon
_ssa	0.1	m <sup>2</sup> kg <sup>-1</sup>	Specific stem area
_re25	0.4	kg kg <sup>-1</sup> yr <sup>-1</sup>	Respiration rate at T=0C. Eq.84.

_ere	50	KJ mol-1	Activation energy of _re25. Eq.84.
_litter	0.5	kgC m-2	Litter carbon
_rd25	0.4	kg kg-1 yr-1	Decomposition rate of stem litter at T=0C. Eq.84.
_erd	50	KJ mol-1	Activation energy of _rd25. Eq.84.
_rt	25	yr	Residence time/life expectancy.Eq.88.

Table 6. Parameters in “soil.par” (menu: parameter→ ground→ soil).

Symbol	Value	Units	Remark
_refl	0.1		Surface reflectivity. Eq.26.
_rgh	0.01	m	Surface roughness length
_fcv	1		Structural factor for apparent heat capacity. Eq.62.
_fgh	1		Structural factor for apparent thermal conductivity. Eq.61.
_b	6.6		Exponent coefficient of water flow between layers. Eq.58.
_psie	-3.3	J kg-1	Air entry water potential. Eq.58.
_ks	7.2e-05	kg s m-3	Saturation hydraulic conductivity. Eq.59.
_porosity	0.53	m3 m-3	Volumetric porosity
_zr	3	m	Depth of root distribution. Eq.67.
_kw	0.1		Moisture coefficient of decomposition. Eq.85.
_pw	2		Moisture power coefficient of decomposition. Eq.85.
_W0	0.32	m3 m-3	Initial water fraction in the surface layer
_Wd	0.45	m3 m-3	Permanent water fraction in the deepest layer. Figure 1.
_Td	6	C	Permanent temperature in the deepest layer. Figure 1.
_dz1	0.05	m	Thickness of layer 1
_dz2	0.1	m	Thickness of layer 2
_dz3	0.2	m	Thickness of layer 3
_dz4	0.4	m	Thickness of layer 4
_dz5	0.8	m	Thickness of layer 5
_dz6	1.6	m	Thickness of layer 6
_dz7	3.2	m	Thickness of layer 7
_dz8	6.4	m	Thickness of layer 8

Table 7. Parameters in “root.coarse.par” (menu: Parameter→ Ground→ coarse root).

Symbol	Value	Units	Remark
_dynamic	0		carbon storage mode (0: static; 1: dynamic)
_life	1	kg m-2	life root carbon storage
_dead	0.5	kg m-2	dead root carbon storage
_re25	1.5	kg kg-1 yr-1	respiration rate of life root at T=0C. Eq.84.
_ere	50	KJ mol-1	activation energy of _re25. Eq.84.
_rd25	2	kg kg-1 yr-1	decomposition rate of dead root at T=0C. Eq.84.
_erd	50	KJ mol-1	activation energy of _rd25. Eq.84.
_dmc	0.5	kg kg-1	dry matter content
_rt	25	yr	residence time/life expectancy. Eq.88.