CENTURY Parameterization Workbook

<site>.100 file

Most of the parameters in the <site>.100 file will have to be adjusted to account for the unique properties of your particular system. However, some sets of parameters are more important than others. For example, climate and soil physical are very important but the initial organic matter and water parameters are not important if you include an equilibrium block in your schedule file. See Appendix 2.12 in the Century User's Manual for definitions of the parameters in this file.

SITE INFORMATION CENTURY PARAMERERIZATION

Site Name:____
Latitude :______________________ Longitude:______________________
Elevation:____
System simulated:

Modeler:_________________________________ Date:__________________

1. PHYSICAL ENVIRONMENT

1.a. CLMATE PARAMETERS

Enter below the mean climate for the site. These are averages for each calendar month of *daily* maximum and minimum air temperatures and *monthly* total precipitation. Standard deviation and skewness of monthly precipitation totals are needed only if the stochastic precipitation option is to be used and can be generated by using the FILE100 utility.

	TEMPERATURES (°C)		PRECIPITATION (cm)		
MONTH	MINIMUM	MAXIMUM	MEAN	S.D.	SKEWNESS
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
VARIABLE	**tmn2m**	**tmx2m**	**precip**	**prcstd**	**prcskw**

Source for climate data:____

1.b. SITE AND CONTROL PARAMTERS

ivauto controls how SOM pools are initialized.
- **ivauto**=0 the initial SOM values in your <site>.100 file are used
- **ivauto**=1 an equation for native grass soil initializes SOM pools
- **ivauto**=2 an equation for cropped/disturbed soils initializes SOM pools

nelem controls the number of elements you want to model. For example, **nelem=1** means that P and S will not limit C flows.

C, N	**nelem** = 1
C, N, P	**nelem** = 2
C, N, P, S	**nelem** = 3

sitlat (lat.) ______ deg. N

sitlng (long.)______ deg. E (for reference only)

Enter the **soil texture**, **pH**, and **bulk density** for the top 20 cm of mineral soil (for organic soils use top 20 cm; enter actual mass fractions of sand, silt, and clay, these need not total to 1):

PROPERTY	VALUE	VARIABLE
SAND (fraction 0-1)		**sand**
SILT (fraction 0-1)		**silt**
CLAY (fraction 0-1)		**clay**
BULK DENSITY (g/cm^3)		**bulkd**
PH		**ph**

Check the appropriate **soil drainage class** below and circle the corresponding value for the variable DRAIN:

_____ Excessively to moderately well drained **drain** = 1.0
_____ Somewhat poorly drained **drain** = 0.75
_____ Poorly drained **drain** = 0.5
_____ Very poorly drained **drain** = 0.25
_____ No drainage from solum **drain** = 0.0

1.c. SOIL LAYERS

Enter the rooting zone depth (depth above which the large majority of fine roots are found):___________________ cm

Enter the soil thickness to be used for the soil water model:
--- For soils on deep saprolite or unconsolidated material, enter the greater of rooting zone depth or depth to base of Bt.
--- For shallow soils enter depth to lithic contact.
--- For permafrost soils enter depth of summer thaw.

Soil thickness = __________________ cm

Convert rooting zone depth and soil thickness to numbers of soil layers using the tables below. Circle the corresponding values for **nlaypg** (layers available for plant growth) and **nlayer** (total layers in solum):

DEPTH	Rooting zone **nlaypg**	Total **nlayer**
0-22 cm	1	1
23-37 cm	2	2
38-52 cm	3	3
53-74 cm	4	4
75-104 cm	5	5
105-134 cm	6	6
135-164 cm	7	7
165-194 cm	8	8
195 cm or more	9	9

Sources for soils data:____

1.d. STREAM FLOW CALBRATION

If you want, you can calibrate stream flow (**stream(1)**) by adjusting the parameters **stormf** and **basef**. These parameters control monthly distribution of streamflow, but they have no effect on water balance, decomposition, or production. **stormf** is the fraction of excess water that runs off immediately in the current month; the remainder goes to the baseflow storage pool in **asmos(nlayer+1)**. **basef** gives the fraction of this storage pool that runs off each month. These parameters can be calibrated iteratively by comparing an observed time sequence of streamflow to the model predictions. Note that to do this you must drive the model with the actual climate for the period, not simply with the mean climate.

1.e. FIELD CAPACITY AND WILTING POINT

Soil water contents at field capacity (FC) and wilting point (WP) for each soil layer can be set by the user or can be calculated based on different equations. If you want to use you own FC and WP values set **swflag=1** and enter appropriate WP and FC values for **awilt(1..10)** and **afiel(1..10)**. If you want to use an equation consult the Century User's Manual for the interpretation of different values of **swflag**, we usually recommend **swflag=2**.

1.f. CONTROLS ON PHOSPHORUS SORPTION

Set the value for **sorpmx** to the maximum P sorption capacity for the soil (0-20 cm) expressed as g P sorbed / m^2 (extreme values are 1-3 for sands and 10-20 for high sorption capacity clays):

sorpmx = ______________________

Set the value for **pslsrb** to the ratio between sorbed P and total (sorbed + labile) P (extreme values are .5 for sands to .95 for highly sorbing clays):

pslsrb = ______________________

Source for P sorption data:____

1.g. EXTERNAL NUTRIENT INPUT PARAMETERS

The <site>.100 file includes parameters for atmosphereic N and S deposition described below. Parameters controlling P and S inputs from weathering are in the fix.100 file.

1.h. NITROGEN

Enter your best estimates for rates of nitrogen input below:

Atmospheric deposition (wet + dry): ____________ g N m^{-2} yr^{-1}

Non-symbiotic biological N fixation: ____________ g N m^{-2} yr^{-1}

Symbiotic biological N fixation: ____________ g N m^{-2} yr^{-1}

For deposition and non-symbiotic fixation, you have two choices for each input:

1) Have input be fixed, constant amount each year:

epnfa(1) = deposition ____________________
epnfa(2) = 0.0
epnfs(1) = fixation ____________________
epnfs(2) = 0.0

2) Have input vary linearly with annual precipitation

epnfa(2) = ______________ * ___________ / _____________
(dependence on precipitation (fraction, 0-1)) * (average annual deposition) / (average annual precipitation)
= ________________________ g N m^{-2} $(cm\ H_2O)^{-1}$

epnfa(1) = ______________ - ___________ * _____________
(average annual deposition) - (EPNFA(2)) * (average annual precipitation)
= ________________________ g N m^{-2} yr^{-1}

epnfs(2) = ______________ * ___________ / _____________
(dependence on precipitation (fraction, 0-1)) * (average annual fixation) / (average annual precipitation)
= ________________________ g N m^{-2} $(cm\ H_2O)^{-1}$

epnfs(1) = ______________ - ___________ * ___________
(average annual fixation) - (EPNFS(2)) * (average annual precipitation)
= ________________________ g N m^{-2} yr^{-1}

1.i. SULFUR

Atmospheric deposition of S is simulated in the same manner as for N deposition (above), with a slope and intercept based on annual precipitation. You can choose fixed or variable S inputs:

Average atmospheric deposition (wet+dry) = _________ (g S m^{-2} yr^{-1})

--- Input as a fixed, constant amount each year:

satmos(1): Average deposition = _______________________
satmos(2) = 0.0

--- Have input vary linearly with annual precipitation:

satmos(2) = ______________ * ___________ / ____________
(dependence on precipitation (fraction, 0-1)) * (average annual deposition) / (average annual precipitation)
= ________________________ g S m^{-2} $(cm\ H_2O)^{-1}$

satmos(1) = ______________ - ___________ * ____________
(average annual deposition) - (**satmos(2)**) * (average annual precipitation)
= ________________________ g S m^{-2} yr^{-1}

S can also be added in irrigation water. If you are irrigating set **sirri** equal to the S concentration (mg S/l) of the water, oherwise set **sirri**=0.

2. SOIL BIOGEOCHEMISTRY

2.a. INITIAL SOIL CARBON POOLS

This parameterization is necessary only if **ivauto**=0. Two procedures are described, one for grassland/cropped soils and one for forest soils. Choose the appropriate procedure but note that precise initialization of these pools is not necessary if your schedule file includes an equilibrium block.

Grassland/cropped soils:

Enter the initial litter and soil carbon storages. Enter total in top 20 cm. Subdivisions by pedogenic horizons are not required but may help set apportioning to CENTURY SOM pools.

Observed soil carbon storages:

a. Litter _________g C/m^2

b. Mineral soil_________g C/m^2

c. TOTAL (a+b)__________g C m^2

Calculate apportioning of SOM into CENTURY pools:

I. Based on simple horizons:

Hori-zon	**som1ci(1,1)**	**som1ci(2,1)**	**som2ci(1)**	**som3ci(1)**	**clittr(1,1)**
a:	**a***.12 =	**a***.03=	**a***.40=	**a***.02=	**a***.43=
b:	0.0	**b***.03=	**b***.44	**b***.53	0.0
TOTAL:					

Forest soils:

Enter the initial forest floor and soil carbon storages. For mineral soil enter total in top 20 cm (for organic soils enter 0-20 cm totals as forest floor, divided by horizons). Forest floor excludes woody debris. This parameterization can be done using simple horizons or subhorizons.

Observed soil carbon storages:

Simple Horizons		Sub Horizons	
a. Forest floor_________g C/m^2;		**a1.** L+F layer/01	_________
		a2. H layer/02	_________
b. Mineral soil_________g C/m^2;		**b1.** A, Ap	_____________
		b2. B, Bt, E	_____________
		b3. Bh	_____________
c. TOTAL (a+b)__________g C m^2			

Calculate apportioning of SOM into CENTURY pools:

I. Based on simple horizons:

Hori-zon	**som1ci(1,1)**	**som1ci(2,1)**	**som2ci(1)**	**som3ci(1)**	**clittr(1,1)**
a:	**a***.12 =	**a***.03=	**a***.40=	**a***.02=	**a***.43=
b:	0.0	**b***.03=	**b***.65	**b***.32	0.0
TOTAL:					

II. Based on subhorizons:

Hori-zon	**som1ci(1,1)**	**som1ci(2,1)**	**som2ci(1)**	**som3ci(1)**	**clittr(1,1)**
a1:	**a1***.20=	0.0	0.0	0.0	**a1***.80=
a2:	**a2***.08=	**a2***.03=	**a2***.55=	**a2***.04=	**a2***.30=
b1:	0.0	**b1***.04=	**b1***.70=	**b1***.26=	0.0
b2:	0.0	**b2***.02=	**b2***.55=	**b2***.43=	0.0
b3:	0.0	**b3***0.2=	**b3***.80=	**b3***.18=	0.0
TOTAL:					

The values calculated from simple horizons generally indicate the "steady state" proportions of the soil pools around which the model will tend to settle over 1000's of years. Those based on horizons suggest non-steady state values for younger or disturbed soils. Usually they differ little except in organic, very young, or highly disturbed soils.

Examine the estimates for the initial pools on the previous page and enter values chosen below:

som1ci(1,1):________________________ g C/m^2
som1ci(2,1):________________________ g C/m^2
som2ci(1): ________________________ g C/m^2
som3ci(1): ________________________ g C/m^2
clittr(1,1):________________________ g C/m^2

Unless you want to simulate isotope labeling, all **som*ci(*,2)** and **clittr(*,2)** parameters should be set to zero.

Sources for soil carbon data:_____________________________________

2.b. INITIAL SOM C/N, C/P, C/S RATIOS

Enter bulk C/N, C/P, C/S ratios for SOM below (make these calculations only for those elements you intend to simulate; enter zeros for other elements):

a. Litter or Forest floor_______C/N, _______C/P, ________C/S
b. Mineral soil _______C/N, _______C/P, ________C/S
c. TOTAL _______C/N, _______C/P, ________C/S

Calculate ratios for CENTURY pool:

VARIABLE	EXPRESSION	C/N (i=1)	C/P (i=2)	C/S (i=3)
rces1(1,i)	**a** / 2.0			
rces1(2,i)	**b** * 0.7			
rces2(i)	**c** * 1.35			
rces3(i)	**c** * 0.7			
rcelit(1,i) **rcelit(2,i)**	**a** * 3.0			

Sources for soil nutrient data:___________________________________

3. BIOMASS INITIAL PARAMETERS

This parameterization is not necessary for annual grasses or crops and is only necessary for perennial grasses and crops if **ivauto**=0. If you are simulating a forest or perennial grass or crop, proper initialization of these pools is not essential if you include an equilibrium block in your schedule file. If you have biomass and nutrient concentration estimates and want to set initial conditions calculate as indicated below.

3.a. GRASS/CROP ORGANIC MATTER INITIAL PARAMETERS

Carbon pools (if you have actual carbon data rather than just biomass, use them):

BIOMASS FRACTION	EXPRESSION	VARIABLE	VALUE
aboveground	biomass * 0.50	**aglcis(1)**	
belowground	biomass * 0.50	**bglcis(1)**	
standing dead	biomass * 0.50	**stdcis(1)**	

Set all the corresponding ***cis(2)** pools to 0.0 if you are not simulating isotope labeling.

Nutrient pools P (and S calculations are necessary only if **nelem** = 2 (or 3):

Calculate each as (biomass)*(concentration)

FRACTION	VARIABLE	N **i=1**	P **i=2**	S **i=3**
aboveground	**agliv(i)**			
belowground	**bgliv(i)**			
standing dead	**stdede(i)**			

3.b. FOREST ORGANIC MATTER INITIAL PARAMETERS

Carbon pools (if you have actual carbon data rather than just biomass, use them):

BIOMASS FRACTION	EXPRESSION	VARIABLE	VALUE
LEAVES	biomass * 0.50	**rlvcis(1)**	
FINE ROOT	biomass * 0.50	**frtcis(1)**	
FINE BRANCH	biomass * 0.50	**frbcis(1)**	
LARGE WOOD	biomass * 0.50	**rlwcis(1)**	
COARSE ROOT	biomass * 0.50	**crtcis(1)**	

Set all the corresponding ***cis(2)** pools to 0.0 if you are not simulating isotope labeling.

Nutrient pools(P and S calculations are necessary only if **nelem** = 2 (or 3):

Calculate each as (biomass)*(concentration)

FRACTION	VARIABLE	N **i=1**	P **i=2**	S **i=3**
LEAVES	**rleave(i)**			
FINE ROOT	**froote(i)**			
FINE BRANCH	**fbrche(i)**			
LARGE WOOD	**rlwode(i)**			
COARSE ROOT	**croote(i)**			

3.c. INITIAL WOODY DEBRIS AND ROOT LITTER POOLS

This parameterization is only necessary for forest systems. Enter the woody debris and belowground litter pools below. Small woody debris is the "wood litter" typically measured in forest floor sampling. Large woody debris is highly clumped spatially hence measures of its mass usually only come from deliberate efforts to quantify it specifically. Data for belowground woody debris are rarely available; a rough estimate can be made by assuming the ratio of belowground:aboveground large woody debris is equal to the ratio of coarse root:large wood live biomass. In the absence of any woody debris estimates, these values can be crudely estimated as anywhere from 10-30% of their corresponding live pools. "Belowground litter" is approximately the mass of dead fine roots; in the absence of data it can be estimated as of the same order of magnitude as live fine roots. If there is no data from which to initialize these pools, they may be set to zero and will gradually equilibrate during the model run. Calculate the initial pools:

Initial woody debris and root litter pools:

Pool	Mass, g/m^2	Variable	Expression	VALUE, g/m^2
Small woody debris		**wd1cis(1)**	small wood * 0.50	
Large woody debris		**wd2cis(1)**	large wood * 0.50	
Coarse root debris		**wd3cis(1)**	dead coarse root * 0.50	
Fine root litter		**clittr(2)**	dead fine root * 0.40	

Set all the corresponding ***cis(2)** pools to **0.0** if you are not simulating isotope labeling.

Source for woody debris data:____________________________________

4. MINERAL INITIAL PARAMETERS

minerl(1..n,1) These set the initial N (g m^{-2}) in each soil layer. If you have no data or estimates for this use 1 for the layers that include the top 20 cm of soil.

minerl(1..n,2) These set the initial P (g m^{-2}) in each soil layer. If you have no data or estimates for this use 1 for the layers that include the top 20 cm of soil.

minerl(1..n,3) These set the initial S (g m^{-2}) in each soil layer. If you have no data or estimates for this use 1 for the layers that include the top 20 cm of soil.

5. WATER INITIAL PARAMETERS

This is not necessary if you include an equilibrium block in your schedule file. But if you want to include precise initial conditions then enter measured or estimated values for:

rwcf(1..n) These parameters set the initial relative water content (RWC) for each soil layer.

$$RWC = (W - WP)/(FC - WP)$$

where W is the measured soil water content, WP is the soil water content at wilting point and FC is the soil water content at field capacity.

snlq is the liquid water in the snowpack (cm H_2O)

snow is the snowpack water content (cm H_2O)

6. OTHER PARAMETERS

Check the parameters listed below and be sure they are set to the indicated values:

w1lig = 0.0
w2lig = 0.0
w3lig = 0.0

crop.100 file

The crop 100 file is used to represent cropped and grassland systems. The CENTURY installation package contains a crop.100 file for many common crops (corn, wheat, etc.) and grasses (C3, C4, etc.) that have been used in the past. Most of the grasses were parameterized with data from LTER sites while many of the crop parameterizations use data from VEMAP sites. We suggest that you use one of these existing parameterizations as a starting point and use the following suggestions to modify the parameters as needed to represent the vegetation in your particular system. Do not hesitate to change the recommended values of parameters to better represent your vegetation, especially if you have data. See Appendix 2.1 in the Century User's Manual for definitions of the parameters in this file.

1. MAXIMUM PRODUCTION

Maximum production is rarely directly observed in either the model or reality and must be inferred. Maximum net production is expressed as the theoretical maximum net biomass production per month in terms of total mass, not C. Values of 200-300 for grasses and slow growing crops (e.g. winter wheat) and up to 600 g biomass m^{-2} mo^{-1} for fast growing crops (corn) have been used.

prdx(1) = ____________________________

2. TEMPERATURE RESPONSES

The effect of temperature on production is controlled by the parameter **ppdf**. Typical values for vegetation types are listed below. For temperate crops, **ppdf(1)** is approximately equal to the mean temperature of the warmest month. **ppdf(2)** is ~15 degrees higher. **ppdf(3)** and **ppdf(4)** affect production mostly at the extremes; values near 1.0 and 3.0 will serve adequately in most cases.

PARAMETER	**ppdf(1)**	**ppdf(2)**	**ppdf(3)**	**ppdf(4)**
MEANING	Optimum temp.	Maximum temp.	Left shape	Right shape
Winter wheat/ barley	18	35	0.7	5.0
Corn	30	45	1.0	2.5
Soy bean	27	40	1.0	2.5
C4 grass	30	45	1.0	2.5
C3 grass	15	32	1.0	3.5
Alfalfa	22	35	0.8	3.5
VALUE CHOSEN				

3. REDUCTION FACTORS

CENTURY allows for growth to be restricted due to physical obstruction of above ground live and standing dead material. Growth may also be reduced during the planting month. Values for these parameters that we have used include:

bioflg	0 for crop, 1 for grass
biok5	1800 for crops, 60-200 for grass
pltmrf	0.4-0.5 for annual crops, 1 for annual grass, and 0 for perennial grass or crops (see Fig. 3-10 in the Century User's Manual)
fulcan	100-150 (see Fig. 3-10 in the Century User's Manual)

4. C ALLOCATION

CENTURY accounts for variable allocation of C as plants mature. The user specifies the initial allocation, final allocation, and the number of months after the planting month when the final value is reached. These parameters only apply to crops and annual grasses (see Fig. 3.11 in the Century User's Manual).

frtc(1)	0.4-0.6 for crops, 0 for grass
frtc(2)	0.1 for most crops, 0 for grass
frtc(3)	3 for most crops, 0 for grass

5. C/E RATIOS

CENURY allows for flexibility in the ranges of C/E ratios as above ground biomass increases. The following parameters (**pramn(i,j)** and **pramx(i,j)**) control the maximum and minimum C/E ratios (E = N, P, or S) for shoots when plant biomass is above and below **biomax.** The following table shows values that we have used for **pramn** and **pramx. biomax**=400 for most grasses and crops. (See Fig. 3-13 in the Century User's Manual).

	Tall grass	Winter wheat	Short grass	Alfalfa	Soy bean	Corn
pramn(1,1)	20	12	30	8.5	7.55	10
pramn(2,1)	390	100	390	100	150	150
pramn(1,2)	30	40	90	8.5	30	40
pramn(2,2)	390	160	390	100	150	150
pramx(1,1)	30	25	35	15	10	20
pramx(2,1)	440	200	440	133	230	230
pramx(1,2)	80	100	95	15	40	60
pramx(2,2)	440	260	440	133	230	230

prbmn(i,j) and **prbmx(i,j)** control the minimum and maximum C/E (E = N, P, or S) of roots. We believe these parameters are mainly a function of plant type and commonly use a slope of 0.0. However, users have the option of making C/N of roots vary with precipitation (see parameter definitions).

	Tall grass	Winter wheat	Short grass	Alfalfa	Soy bean	Corn
prbmn(1,1)	60	45	50	17	24	34
prbmn(2,1)	390	390	390	100	390	390
prbmn(1,2)	0	0	0	0	0	0
prbmn(2,2)	0	0	0	0	0	0
prbmx(1,1)	80	60	55	22	28	60
prbmx(2,1)	420	420	420	133	420	420
prbmx(1,2)	0	0	0	0	0	0
prbmx(2,2)	0	0	0	0	0	0

6. LIGNIN CONTENTS

The lignin content of above and below ground material can be constant or made a function of annual rainfall. See parameter definitions. This table shows values we have used.

	Tall grass	Winter wheat	Short grass	Alfalfa	Soy bean	Corn
fligni(1,1)	0.02	0.15	0.02	0.04	0.12	0.12
fligni(2,1)	0.012	0.0	0.012	0.0	0.06	0
fligni(1,2)	0.26	0.06	0.26	0.12	0	0.06
fligni(2,2)	-0.0015	0	-0.0015	0.4	0	0

7. HARVEST/SENESCENCE PARAMETERS

The user controls the amount of C and nutrients allocated to grain, effects of water stress on harvest, and N volatilized at harvest or senescence through the following parameters. See parameter definitions and Fig. 3-15 the Century User's Manual.

	Tall grass	Winter wheat	Short grass	Alfalfa	Soy bean	Corn
himax	0	0.5	0	0	0.4	0.6
hiwsf	0	0.42	0	0	0	0
himon(1)	0	1	0	2	2	2
himon(2)	0	1	0	1	1	1
efgrn(1)	0.5	0.75	0	0	0.67	0.75
efgrn(2)	0.5	0.6	0	0	0.6	0.6
vlossp	0.04	0.04	0.15	0.02	0.04	0.04

8. SHOOT AND ROOT DEATH RATES AND NUTRIENT RETRANSLOCATION PARAMETERS

The user controls the maximum monthly shoot death rate, senescence month shoot death rate, the influence of shading on death rate, shoot fall rate, maximum root death rate, and the fraction of nutrients retranslocated from leaves at death. See Fig. 3-16 the Century Users's Manual.

	Tall grass	Winter wheat	Short grass	Alfalfa	Soy bean	Corn
fsdeth(1)	0.2	0	0.2	0.3	0	0
fsdeth(2)	0.95	0	0.95	0.4	0	0
fsdeth(3)	0.2	0	0.2	0.1	0	0
fsdeth(4)	150	200	150	500	500	500
fallrt	0.15	0.12	0.15	0.5	0.1	0.1
rdr	0.07	0.05	0.05	0.2	0.05	0.05
rtdtmp	2	2	2	2	2	2
crprtf(1)	0.5	0	0	0	0	0
crprtf(2)	0	0	0	0	0	0

9. SYMBIOTIC BIOLOGICAL N FIXATION

N fixation is parameterized as **snfxmx**(2) = maximum g N fixed per g C NPP. This can be approximated as (symbiotic N fixation)/(annual NPP g C). Remember to set this to the maximum value; it will be reduced if nitrogen availability is high enough. Enter the value used below

snfxmx(2) = ________________________ (g N fixed)/(g C NPP)

10. DOUBLED CO_2 PARAMETERS

CENTURY allows simulations to be conducted assuming a doubling of atmospheric CO_2 concentration from 350 ppm to 700 ppm. The following parameters control the effects of doubled CO_2 on NPP, transpiration, C/E ratios, and root/shoot ratios.

co2ipr(1) is the multiplier that represents the effect of doubled CO_2 on NPP.

co2ipr(1) = 1 for C4 and ~1.3 for C3

co2itr(1) is the multiplier that represents the effect of doubled CO_2 on transpiration rate.

co2itr(1) = ~0.6

co2ice(1,i,j) is the multiplier that represents the effect of doubled CO_2 on minimum and maximum C/E ratios.

co2ice(1,i,j) = ~1.0

co2irs(1) is the multiplier that represents the effect of doubled CO_2 on root/shoot ratio.

co2irs(1) <= ~1.3

tree.100

The CENTURY installation package contains tree.100 parameterizations for deciduous, coniferous, and tropical systems that have been used in the past. We suggest that you use one of those files as a starting point and use the following procedure to modify parameters as needed to represent the trees in your particular system. See Appendix 2.10 in the Century User's Manual for definitions of the parameters in this file.

1. FOREST TYPE

Decide whether to simulate your forest as evergreen, deciduous, or drought deciduous. In evergreen systems, allocation is fixed through the year and leaf fall is calculated each month. In deciduous forests, 80% of first month production goes to leaves and a given percentage of leaves senesce and fall at the end of the growing season which occurs when the days are shortening and temperatures are dropping into the fall seasonal range. In a drought deciduous forest, allocation is fixed throughout the year and a given percentage of leaves senesce and fall at the end of the growing season which is marked when the soil moisture reaches wilting point. In general, if the large majority of the canopy is deciduous (say 80% or greater) one of the deciduous system options will be adequate; otherwise use the evergreen option.

For evergreen or semi-evergreen systems:
decid = 0

For deciduous systems:
decid = 1

For drought deciduous systems:
decid = 2

2. MAXIMUM PRODUCTION

There are two maximum production values, one for gross production and the other for net production. Either of these can be disabled by setting it to a very high value (e.g. 10000) and allowing the other to control production. Maximum production is rarely directly observed in either the model or reality and must be inferred.

--- Maximum gross production

This is expressed as the theoretical maximum gross production per month *in terms of total organic matter produced, NOT in terms of carbon*. Common values are 1200-1500 g m^{-2} mo^{-1}.
prdx(2) = ____________________________

--- Maximum net production

This is expressed as the theoretical maximum net biomass production per month *in terms of carbon, NOT total mass*. Common values are 300-400 g C m^{-2} mo^{-1}.

prdx(3) = ____________________________

3. CONTROLS ON PRODUCTION

3.a. TEMPERATURE RESPONSES

The effect of temperature on production is controlled by the parameter **ppdf**. Typical values for generalized forest types are listed below (the example genera listed are heavily northamericano biased and are general guidelines only). For temperate forests, **ppdf(1)** is approximately equal to the mean temperature of the warmest month. **ppdf(2)** is at least 15 degrees higher. **ppdf(3)** and **ppdf(4)** affect production mostly at the extremes; 1.0 and 3.0 will serve adequately in most cases.

Select values for **ppdf**:

PARAMETER	**ppdf(1)**	**ppdf(2)**	**ppdf(3)**	**ppdf(4)**
MEANING	Optimum temp.	Maximum temp.	Left shape	Right shape
Arctic/alpine shrub (*Ledum, Betula, Salix*)	10	25	1.0	3.5
Boreal/subalpine conifer (*Picea, Abies, Pinus*)	18	35	1.0	3.0
Northern hardwoods (*Betula, Populus, Acer*)	22	42	1.0	3.5
Temperate conifer (*Pinus, Juniperus*)	27	45	1.0	3.0
Temperate hardwood (*Quercus, Carya*, etc.)	25	45	1.0	3.0
Tropical and subtropical hardwood and conifer	30	45	1.0	2.5
VALUE CHOSEN				

3.b. BIOMASS CHEMISTRY

You have three options for calculating the biomass C/E. If you have actual carbon data instead of just biomass, then use C data instead of the generalized carbon percentages listed below. Select which option you prefer, mark it with a check, calculate the C/E ratios and retranslocation controls, and fill in the table with the values for **cerfor**.

__1. Simulate tissue chemistry as fixed, with no retranslocation or response to nutrient availability:

Record the values for **cerfor** below:

VARIABLE	EXPRESSION	**C/N i=1**	**C/P i=2**	**C/S i=3**
cerfor (*,1,i)	55%/leaf litter conc			
cerfor (*,2,i)	50%/fine root conc			
cerfor (*,3,i)	50%/fine branch conc			
cerfor (*,4,i)	50%/large wood conc.			
cerfor (*,5,i)	50%/coarse root conc.			

Set all values for **forrtf** equal to 0.

__2. Use fixed tissue chemistry (no response to nutrient availability) but simulate retranslocation of nutrients from senescent leaves before litterfall:

Record the values for **cerfor** below:

VARIABLE	EXPRESSION	**C/N i=1**	**C/P i=2**	**C/S i=3**
cerfor (*,1,i)	45%/green leaf conc			
cerfor (*,2,i)	50%/fine root conc			
cerfor (*,3,i)	50%/fine branch conc			
cerfor (*,4,i)	50%/large wood conc.			
cerfor (*,5,i)	50%/coarse root conc.			

Set values for **forrtf** as

forrtf(1): 1-(leaf litter %N)/(green leaf %N) = ______
forrtf(2): 1-(leaf litter %P)/(green leaf %P) = ______
forrtf(3): 1-(leaf litter %S)/(green leaf %S) = ______

__3. Use both variable tissue chemistry and retranslocation: Based on data from fertilization trials, site comparisons, literature, and/or educated guesses widen the allowable range for one or more of the biomass fractions. Foliar N content has the most extensive data, but this option can be implemented for any or all biomass pool(s) and nutrient(s). Assign the minimum C/E ratio (maximum nutrient content) to **cerfor(1,*,*)**, the maximum C/E ratio (minimum nutrient content) to **cerfor(2,*,*)** and the initial C/E ratio to **cerfor(3,*,*)**. Note that the maximum C/E ratio will never actually be achieved in practice, so it must be set higher than the observed highest value.

Record the values for **cerfor** below:

VARIABLE	**C/N** **i=1**	**C/P** **i=2**	**C/S** **i=3**
cerfor(1,1,i) **cerfor(2,1,i)** **cerfor(3,1,i)**			
cerfor(1,2,i) **cerfor(2,2,i)** **cerfor(3,2,i)**			
cerfor(1,3,i) **cerfor(2,3,i)** **cerfor(3,3,i)**			
cerfor(1,4,i) **cerfor(2,4,i)** **cerfor(3,4,i)**			
cerfor(1,5,i) **cerfor(2,5,i)** **cerfor(3,5,i)**			

Set values for **forrtf** as in option 2 above.

4. WOOD DECOMPOSITION RATES

No good general scheme exists for estimating wood decomposition rates from chemical or physical properties of the wood; therefore CENTURY sets wood decomposition as a system-specific parameter. To set this, first estimate the mean turnover times of each wood pool, then calculate the values for **decw**. Mean turnover times can be estimated as the half-life (in terms of mass loss) of an average piece of woody debris, or assuming steady state (questionable for large wood) as (standing stock)/(input rate). Again, for belowground woody debris there is often very little data; a value similar to that for large wood can be used in the absence of other information.

Calculate values for **decw**:

Perform a 3 year simulation using default parameters and mean weather for your system. Output and calculate average values of **defac** and **anerb** for the third year and complete the table:

DEBRIS COMPONENT	TURNOVER TIME, yr	EXPRESSION	**decw**
FINE BRANCH		2.5/(turnover* **defac**)	**decw1=**
LARGE WOOD		2.5/(turnover* **defac**)	**decw2=**
BELOWGROUND		2.5/(turnover* **defac*anerb**)	**decw3=**

5. BIOMASS AND WOODY DEBRIS

5.a. BIOMASS AND NPP DATA

Enter below your best estimates for biomass pool sizes, chemistry, annual production, and turnover (comments on estimating values follow):

FRACTION	BIOMASS g/m^2	NPP $g\ m^{-2}\ yr^{-1}$	LITTER $g\ m^{-2}\ yr^{-1}$	%N	%P	%S
GREEN LEAF			XXXXXXX XXXXXXX			
LEAF LITTER	XXXXXXX XXXXXXX	XXXXXXX XXXXXXX				
FINE BRANCH*						
LARGE WOOD*						
COARSE ROOT**						
FINE ROOT**						
TOTALS				XXXXXXX	XXXXXXX	XXXXXXX

* Large wood is branch and stem wood > 10 cm diameter
**Fine roots are < 2 mm diameter

Measured "wood litterfall" collected in traps usually indicates fine branch litterfall, and can be used as an estimate of fine branch production in older forests. Large wood litterfall is rarely measured and must be estimated from guesses about turnover time and tree longevity. Coarse root production is likewise rarely measured; often even biomass data are lacking. Educated guesses as to biomass and turnover rates must be used in these cases.

Sources for biomass and production data:________________________

5.b. PRODUCTION ALLOCATION PATTERN

CENTURY allows for different C allocation patterns for juvenile and mature forests. Age indicator, i, is 1 for early forest, 2 for late forest. If you are simulating only 1 types of forest set **swold** = 0.0 and **fcfrac** the same for i = 1 and 2. Otherwise, perform the following calculations for each forest type and set **swold =** number of years after beginning of simulation when the forest changes from juvenile to mature:

fcfrac(1,i):(leaf production)/(total NPP)= ____________
fcfrac(2,i):(fine root production)/(total NPP)= ____________
fcfrac(3,i):(fine branch production)/(total NPP)= ____________
fcfrac(4,i):(large wood production)/(total NPP)= ____________
fcfrac(5,i):(coarse root production)/(total NPP)= ____________

6. BIOMASS TURNOVER RATES

6.a. SET LEAF DEATH RATES

Monthly leaf turnover is set in **leafdr**. In a deciduous or drought deciduous system, the values of **leafdr** indicate mortality during the growing season from causes such as herbivory, physical damage, or early senescence. The leaf mortality at the end of the growing season for deciduous or drought deciduous trees is determined by the value entered for **wooddr(1)**. In an evergreen or semievergreen system, **leafdr** indicates all leaf turnover including seasonal senescence and litterfall. In any case, these values are the fraction of leaves that are transferred to litter each month. These values should be estimated from observed rates of litterfall in comparison to observed or estimated leaf biomass.

In deciduous and drought deciduous systems **wooddr(1)** is the fraction of leaves that are lost during the month of leaf drop. For temperature deciduous systems the months of leaf out and leaf drop are controlled by temperature and day length while for drought deciduous systems leaf drop occurs when monthly soil water content is below the wilting point. Typical values for **wooddr(1)** for are ~0.95 for temperature deciduous and ~0.3 for drought deciduous but use estimates that best represent your system.

All forest systems:

leafdr(1) = ________________ **leafdr(7)** = ________________
leafdr(2) = ________________ **leafdr(8)** = ________________
leafdr(3) = ________________ **leafdr(9)** = ________________
leafdr(4) = ________________ **leafdr(10)** = ________________
leafdr(5) = ________________ **leafdr(11)** = ________________
leafdr(6) = ________________ **leafdr(12)** = ________________

Sources for litterfall/seasonality information:________________________
____

6.b ROOT AND WOOD DEATH RATES

Turnover of other pools is constant through the year and is in the parameter **wooddr**.

Monthly fine root death rate, **wooddr(2)**, is equal to

$$\frac{\text{(annual fine root production)/(fine root biomass)}}{12} = \_\_\_\_\_\_\_\_$$

Monthly fine branch death rate, **wooddr(3)**, is equal to

$$\frac{\text{(annual f. branch litterfall)/(f. branch biomass)}}{12} = \_\_\_\_\_\_\_\_$$

Monthly large wood death rate, **wooddr(4)**, is equal to

$$\frac{\text{(annual l. wood litterfall)/(l. wood biomass)}}{12} = \_\_\_\_\_\_\_;$$

It may also be estimated as approximately the rate of whole tree mortality per month.

Monthly coarse root death rate, **wooddr(5)**, is very difficult to estimate directly. It is typically similar in magnitude to large wood death, **wooddr(3)**. Enter the value used here:_______________

Sources:____

6.c. LEAF AREA CONTROLS

Set the leaf area to biomass ratio (based on *biomass*, not carbon):

btolai = (leaf area, m^2 projected)/(leaf dry mass, g)
= ___________________________ m^2/g

Set the allometric controls on LAI as follows:

maxlai: maximum allowable LAI = ___________________ m^2/m^2
klai: large wood mass (g C/m^2) at which half of the maximum LAI is achieved = ___________________ g C/m^2

Source for LAI data:____

6.d. SAPWOOD ALLOMETRIES

Set the relationship between sapwood and total wood as:

sapk: Maximum sapwood mass in mature stand; can be approximately estimated as 10 years worth of wood production = __________________________________ g C/m^2

Symbiotic biological N fixation is parameterized as **snfxmx(2)** = maximum g N fixed per g C NPP. This can be approximated as (symbiotic N fixation)/(annual NPP g C). Remember to set this to the maximum value; it will be reduced if nitrogen availability is high enough. Enter the value used below:

snfxmx(2) = ______________________ (g N fixed)/(g C NPP)

Sources for N input data:_______________________________________

7. LIGNIN FRACTION OF FOREST COMPONENTS

The lignin content of tree components is system specific. The following table shows ranges of values we have used:

tree component	parameter	lignin fraction
leaves	**wdlig(1)**	0.14 - 0.18
fine roots	**wdlig(2)**	0.09 - 0.28
fine branches	**wdlig(3)**	0.20 - 0.35
large wood	**wdlig(4)**	0.20 - 0.35
coarse roots	**wdlig(5)**	0.20 - 0.35

8. DOUBLED CO_2 PARAMETERS

CENTURY allows simulations to be conducted assuming a doubling of atmospheric CO_2 concentration from 350 ppm to 700 ppm. The following parameters control the effects of doubled CO_2 on NPP, transpiration, C/E ratios, and root/shoot ratios.

co2ipr(2) is the multiplier that represent the effect of doubled CO_2 on NPP.

co2ipr(2) = ~1.3

co2itr(2) is the multiplier that represent the effect of doubled CO_2 on transpiration rate.

co2itr(2) = ~0.75 for deciduous and ~0.9-0.95 for coniferous

co2ice(2,i,j) is the multiplier that represent the effect of doubled CO_2 on minimum and maximum C/E ratios.

co2ice(2,i,j) = ~1.2

co2irs(2) is the multiplier that represent the effect of doubled CO_2 on root/shoot ratio.

co2irs(2) <= ~1.3

9. SAVANNA MODEL PARAMETERS

CENTURY allows the user to simulate competition between trees and grasses. If you are not simulating a savanna (i.e. are only growing trees) set the following 3 parameters to 1.

basfc2 relates tree basal area to grass N fraction.
    basfc2 = ~ 0.5

basfct ratio between basal area and wood biomass.
    basfct = ~400

sitpot relates grass N fraction to N availability. This represents the above ground peak standing grass biomass without tree competition. Units are pounds/acre and values range from 1000-4000.
    sitpot = ~2400

10. OTHER PARAMETERS

Check the parameters listed below and be sure they are set to the indicated values:

    laitop = -0.5
    del13c = -15 to −28

fix.100

If you want to simulate the effects of changes in atmospheric CO_2 concentration you must specify the initial parts per million (**co2ppm(1)**) and final parts per million (**co2ppm(2))** of CO_2 concentration and set **co2rmp** to specify a step (=0) or ramp (=1) function. Most of the other parameters in the fix.100 should not be changed. However, some parameters may need to be adjusted to represent differences in C/N ratios of SOM inputs for grasslands and forests and differences in P and S availability among various systems. No other parameters in the fix.100 should be changed unless the user has strong experimental evidence to justify the change. See Appendix 2.5 in the Century User's Manual for definitions of parameters in the fix.100 file.

1. FLOATING C/N RATIOS IN SOM POOLS

The parameters controlling the C/N ratios may need to be adjusted from the default values, particularly for temperate forest soils. The default values listed in the table below are for grass/crop soils and forest soils with a bulk C/N < 15. In most cases you will use the default values from the table. If, however, your soil has a bulk C/N > ~15 use the alternate values from the table.

Parameter	Default	Bulk soil C/N > 15
pcemic(1,1)	16	16
pcemic(2,1)	10	10
varat1(1,1)	14	16
varat1(2,1)	3	8
varat2(1,1)	20	40
varat2(2,1)	12	12
varat3(1,1)	8	20
varat3(2,1)	6	8

2. C/E OF NEWLY FORMED SOM

The parameter **rad1p** is used to adjust the C/E ratio of newly formed slow SOM produced from surface active SOM. This value is calculated from the parameter **rad1p** as a function of C/E ratios of the surface active SOM pool. You can either set it up as fixed values or let it float. When using fixed values for **rad1p** it is a prescribed value that is generally higher when leaf litter is of lower initial quality.

Typical fixed values for different systems are:

	Grass/ crops	Conifers forest	Temperate hardwood	Tropical hardwood
rad1p(1,1)	5	14	12	5
rad1p(2,1)	0	0	0	0
rad1p(3,1)	5	5	5	5
rad1p(1,2)	220	300	100	200
rad1p(2,2)	0	0	0	0
rad1p(3,2)	100	100	100	100
rad1p(1,3)	220	300	200	200
rad1p(2,3)	0	0	0	0
rad1p(3,3)	100	100	100	100

Typical floating values for different systems are:

	Grass/ crops	Conifers forest	Temperate hardwood	Tropical hardwood
rad1p(1,1)	12	-6	-5	0
rad1p(2,1)	3	3	3	3
rad1p(3,1)	5	5	5	5
rad1p(1,2)	220	-200	-200	-200
rad1p(2,2)	5	5	5	5
rad1p(3,2)	100	200	200	200
rad1p(1,3)	220	-200	-200	-200
rad1p(2,3)	5	5	5	5
rad1p(3,3)	100	100	100	100

3. PHOSPHORUS (AND SULFUR)

If you are only modeling N (see **nelem** in your <site>.100 file) then these parameters are irrelevant. If you do want to model P (and S) then there are 2 ways to supply P inputs and 3 ways to supply S inputs. P (and S) can be supplied by weathering of parent material in which case you should appropriately adjust **parent(2)** (and **parent(3)**) in your <site>.100 file and **pparm(2)** (and **pparm(3)**) in the fix.100 file. **parent(i)** controls the amount of P (or S) in parent material and **pparm(i)** controls the weathering rate in units of the fraction of parent material weathered to mineral form per year. P (and S) can be supplied as fertilizer inputs in which case you should make an appropriate option in the fert.100 file. Atmospheric S inputs are accounted for in your <site>.100 file.

If you have estimates of parent material P (and S) and atmospheric deposition of S you can use the following table to parameterize **parent(i)** and **pparm(i**) (this scheme is not necessarily appropriate for detailed examination of long-term P dynamics and pedogenesis).

First, run the model for 3 years using mean weather and monthly output. Calculate the average value of **defac** then complete:

	Phosphorus i = 2	Sulfur i = 3
a. Atmospheric deposition, wet + dry (g m^{-2} yr^{-1})		
Literature source:		
b. Weathering inputs that occur within the rooting zone (g m^{-2} yr^{-1})		
Literature source:		
c. TOTAL INPUTS = **a** + **b**		
d. **defac** (avg.)		
e. parent(i) {*<site>.100*}		
pparm(i)=c/(d*e) {*fix.100*}		

Set the flag for texture effect on parent P mineralization for no effect:

TEXEPP(1) = 0.0

Sources for P (and S) input data:________________________________