national carbon
accounting system

technical report no. 26

Carbon Accounting Model for Forests (*CAMFor*) User Manual Version 3.35

Gary Richards

David Evans

AUSTRALIAN
Greenhouse
Office

The lead Commonwealth agency on greenhouse matters

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November 2000

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1. INTRODUCTION

The Carbon Accounting Model for Forests (*CAMFor*) is a model developed for the Australian Greenhouse Office (AGO) for tracking the carbon associated with a stand of trees. *CAMFor Estate* is a related model that allows for the summing of estates (composites of different stand types) and for the derivation of a carbon ledger across a composite of estates.

CAMFor calculates the carbon flows associated with a stand of trees, including the wood products made from wood harvested from that stand. It calculates the carbon in the various tree, debris, soil and product components, and the carbon exchanged with the atmosphere, for several hundred years - through thinnings, multiple rotations, and fires.

1.1 CREDITS

This spreadsheet finds its conceptual foundations in a public domain FORTRAN program called 'CO_2*Fix*', published in October 1990 by Frits Mohren, Kees Klein Goldewik, "De Dorrchamp", Wageningen.

The model expressed by this workbook was enhanced by Dr Gary Richards (02 6274 1926 or +612 6274 1926, gary.richards@greenhouse.gov.au) of the Australian Greenhouse Office, GPO Box 621, Canberra ACT 2601 Australia.

The model was compiled by Dr David Evans, Science Speak

This user manual was prepared by Jeremy Alcorn of Spatial Vision Innovations Pty Ltd.

1.2 LICENCE AGREEMENT

IMPORTANT: YOU MUST READ THE LICENCE CONDITIONS BEFORE USING THIS WORKBOOK.

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8.4 The Licensee assumes responsibility for the interpretation of any results obtained from use of *CAMFor*, and must exercise all appropriate precautions before placing reliance on those results.

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11.1 If the Licensee breaches any of these Conditions, the AGO may terminate the Agreement immediately by notice in writing to the Licensee.

11.2 The termination of the Agreement under Condition 11.1 shall be without prejudice to the rights of either party accrued under the Agreement prior to termination.

11.3 The Licensee shall cease using *CAMFor* for any purpose from the date of termination of the Agreement and shall return *CAMFor* and any copies made of it to the AGO within 30 days of the date of termination.

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12.1 The Agreement supersedes all prior agreements and understandings between the parties relating to *CAMFor* and constitutes the entire agreement between the parties.

12.2 No addition to or modification of any provision of the Agreement shall be binding unless in writing signed by both parties.

12.3 The Agreement shall be governed by and construed in accordance with the laws for the time being in force in the Australian Capital Territory.

12.4 No forbearance, delay or indulgence by a party in enforcing the provisions of the Agreement shall prejudice or restrict the rights of that party, nor shall waiver of those rights operate as a waiver of any subsequent breach.

12.5 Any reading down or severance of a particular provision does not affect the remaining provisions of the Agreement.

13. Definitions

13.1 In these Conditions, unless the contrary intention appears:

"AGO" means the Australian Greenhouse Office, and includes any agency which succeeds to the functions of that agency.

"Commercialise" includes communicating, distributing, giving away, selling, letting for hire, or by way of trade, offering or exposing for sale or hire any article embodying a product, and sub-licensing of intellectual property rights in that product to the extent necessary for the ordinary use of the product.

"*CAMFor*" means the *CAMFor* stand-based carbon assessment model which is licensed under these conditions.

"Derivative" means an adapted form, or a product derived from or incorporating *CAMFor*, made pursuant to clause 7.

"Licence" means the licence referred to in Condition 3.

2. *CAMFOR* AND *CAMFOR ESTATE*

The Carbon Accounting Model for Forests comprises two EXCEL Workbooks: *CAMFor* and *CAMFor Estate*. The *CAMFor* workbook allows you to enter parameters for a single species and management regime. The *CAMFor Estate* workbook enables you to combine the carbon mass results of one or more of these *CAMFor* workbooks into a single carbon mass result, and can also combine the carbon mass results of *CAMFor Estate* workbooks.

2.1 *CAMFOR* WORKBOOK

The *CAMFor* model is implemented in this spreadsheet. This workbook (designed to be read in conjunction with the associated Excel file) implements the *CAMFor* model for one species and one management regime. You will need a separate workbook for each combination of management regime and species.

Each workbook contains several sheets. The sheets are listed as tabs at the bottom of the workbook. Each workbook is independent of any other workbook or file (that is, it does not get any information by 'linking' to any other workbook). This workbook has several inputs:

1. The stand and management descriptions, and information about the authorities and assumptions used can be recorded in the 'Descrip' sheet.
2. General information about the management regime, which you enter in the 'In-General' sheet.
3. Information about the thinning regime, which you enter in the 'In-Thin' sheet.
4. Information about the timing and impact of fires, which you enter in the 'In-Fire' sheet.
5. Information about the species of tree, which you enter in the 'In-Species' sheet.

6. Information about the growth rates and distribution of growth, which you enter in the 'In-Growth' sheet.

7. Information about the age and area of stands of this type can be entered in the 'Group' sheet.

The workbook calculations occur immediately, so once you have entered the appropriate information in the input sheets you may go to the output sheets and view the results.

- After you have entered information in the 'Input' and 'Group' sheets the output is in the 'Calc-Prelim' and 'Calc-Sim' sheets (lots of numbers) and the 'Out-Graph' sheet (a graph of the carbon per hectare in each year).
- After you have entered information in these input sheets, carbon masses are presented for the 'typical' stand in the 'Out-Sim' and 'Out-Graph' sheets. Carbon masses for all stands of the type are presented, the total stock 'Group CM Totals' and carbon increments in the 'Group CM Increments' sheets.

In a given *CAMFor* workbook, you can copy input data from other *CAMFor* workbooks that have the same type of management regime and species:

- DO NOT copy in whole sheets (you will confuse the naming system that this workbook uses to communicate data between sheets)
- DO copy and paste the values of individual cells or arrays of cells.

The simplest way to create a new *CAMFor* workbook is to make a copy of a given *CAMFor* workbook file then enter the appropriate species and management regime data (that is, clone and modify a *CAMFor* workbook).

On the input sheets, only enter data in cells that have a light blue background (see the Key). If you change a cell to an obviously illegal value, it or a nearby cell will light up in bright red - so change it (or an associated cell, such as another fraction that should sum with the cell you just changed to one) to something sensible.

Names of quantities, noted in dark green, are used to refer to that quantity elsewhere in the spreadsheet. The naming system is used to make this workbook easily-readable. (See 'Name:Define' in the 'Insert' menu but do not change anything in here!).

2.2 *CAMFOR ESTATE* WORKBOOKS

Use a *CAMForEstate* workbook to combine the results of one or more *CAMFor* workbooks, or existing *CAMFor Estate* workbooks into a single carbon mass result. This allows you to calculate carbon masses for an estate (and across estates) containing mixed management regimes and species.

3. HOW TO USE *CAMFOR*

This file is an Excel 'workbook'. This workbook consists of several spreadsheets ('sheets'), which are described in the next section. This workbook is independent of any other workbook or file (that is, it does not get any information by 'linking' to any other workbook or file).

There are several types of sheets:

1. Input sheets. Names start with 'In-'. You enter data on these sheets.
2. Calculation sheets. Names start with 'Calc-'. All the calculations are in formulae in the cells in these sheets. Do not enter data on these sheets.
3. Output sheets. Names start with 'Out-'. Where you can view the results of the calculations. Do not enter data on these sheets.
4. Stand aggregation sheets. Names start with 'Stand'. Sheets for specifying stands with the same input data as in this workbook, and finding the combined carbon masses of this group of stands. You enter some data on these sheets.
5. Other sheets. Documentation and explanations mainly.

Go to the input sheets and enter numbers in the light-blue cells (and only the light blue cells - see the 'Key' on this sheet). The workbook (almost) instantly calculates the results as you enter the data, so when you have finished entering the data the results will be waiting for you. The simulation results are in the 'Out-Sim' and the 'Out-Graph' sheets (and if you want more details, see the 'Calc-Sim' sheet). The 'Out-Sim' sheet is designed to be printed out, the graphs may be printed out, and any sheet can be printed out (although the 'Calc-' sheets may not fit on single pages).

This workbook implements the *CAMFor* model for one set of inputs (the data entered in the 'In-' sheets). You will need a separate workbook for each different combination of inputs. Enter a set of inputs in one workbook, and if you wish to keep that set of inputs then save the workbook. Then, to do another combination of inputs, copy the first workbook file and enter the new inputs in the second workbook (that is, clone and modify). Always keep a copy of this original workbook, in case some accident befalls your working copies.

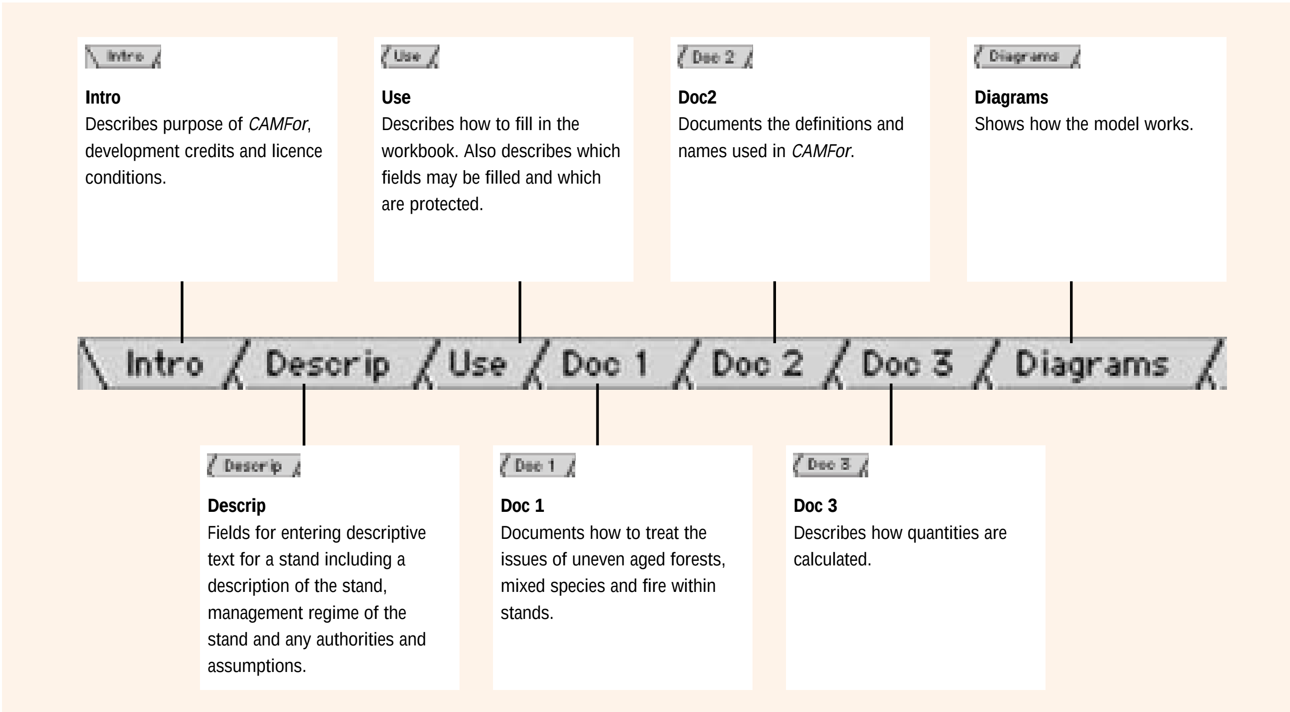
You can copy and paste input data between workbooks, but we STRONGLY URGE you to only paste using 'Paste Special' choice on the 'Edit' menu (then choose Paste 'Values' and Operations 'None'). Pasting normally can foul up the system of named cells in this workbook. If you ever open this workbook and Excel asks you whether you want to 'update' or mentions 'links' or 'linking' then the naming system has been corrupted by pasting something in normally from another workbook - just start from the original workbook, copy in your input data by pasting by value, and trash the corrupted workbook.

Use a *CAMForEstate* workbook to combine the carbon mass results of one or more of these *CAMFor* workbooks and several *CAMFor Estate* workbooks into a single carbon mass result (this workbook becomes a linked input into the *CAMFor Estate* workbook). This allows you to calculate carbon masses for an estate containing mixed management regimes and species.

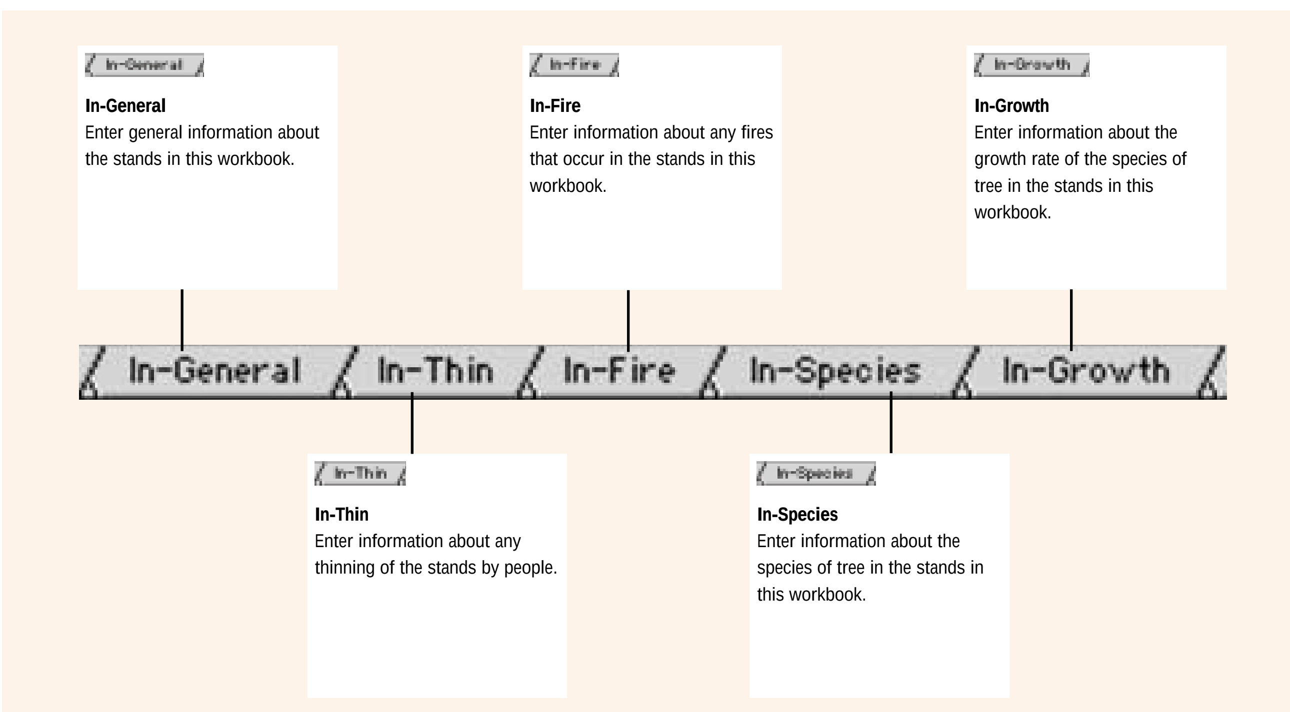
Try opening this workbook in two windows at once (choose 'New Window' from the 'Window' menu). You can then look at two sheets at once. Open the 'Out-Graph' sheet and an input sheet. When you change an input cell the graph is immediately recalculated, so you see the effect on the simulation of changing that input almost immediately. This technique is most beneficial when you have two computer screens (somewhat problematic on computers running Windows; Macs handle two screens at once simply and reliably).

3.1 *CAMFOR* SHEETS

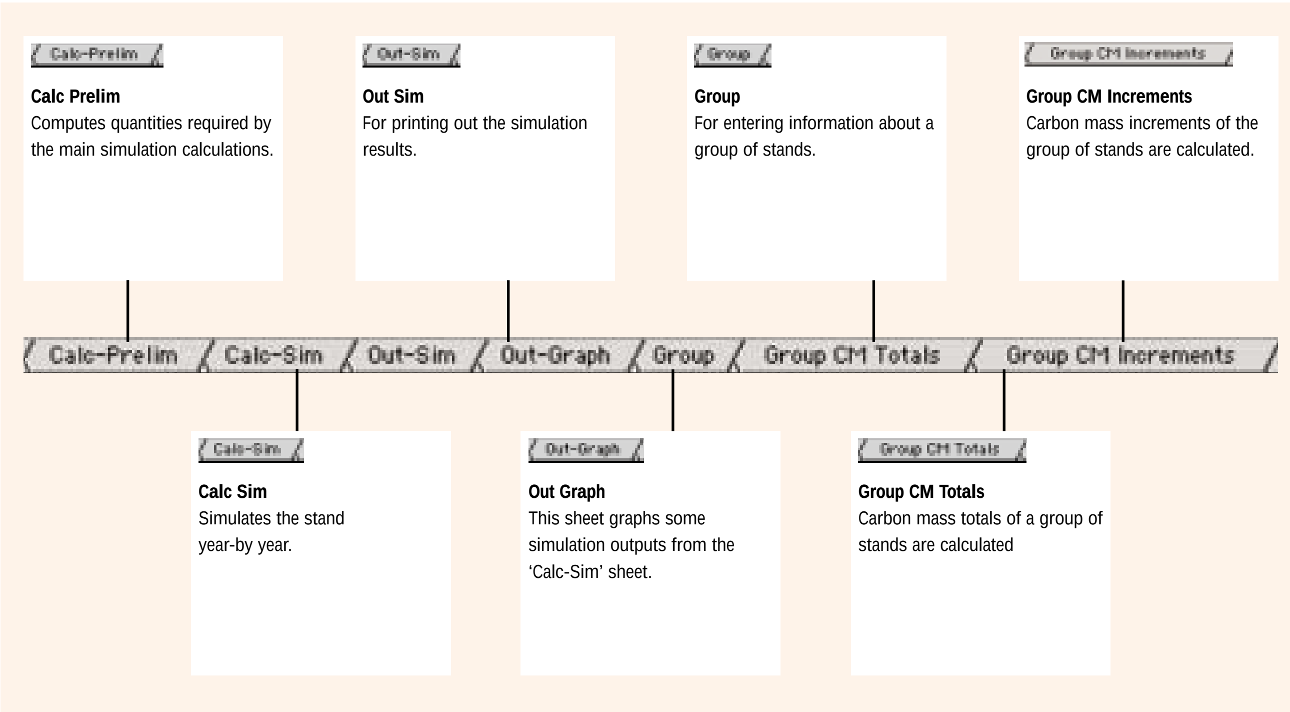
The *CAMFor* ‘workbook’ consists of about a dozen ‘spreadsheets’ (or ‘sheets’). Each sheet has a corresponding ‘tab’ near the bottom of the window. Click on the tab to display the sheet.



The next five tabs are for inputting data on which the Carbon Mass totals will be calculated

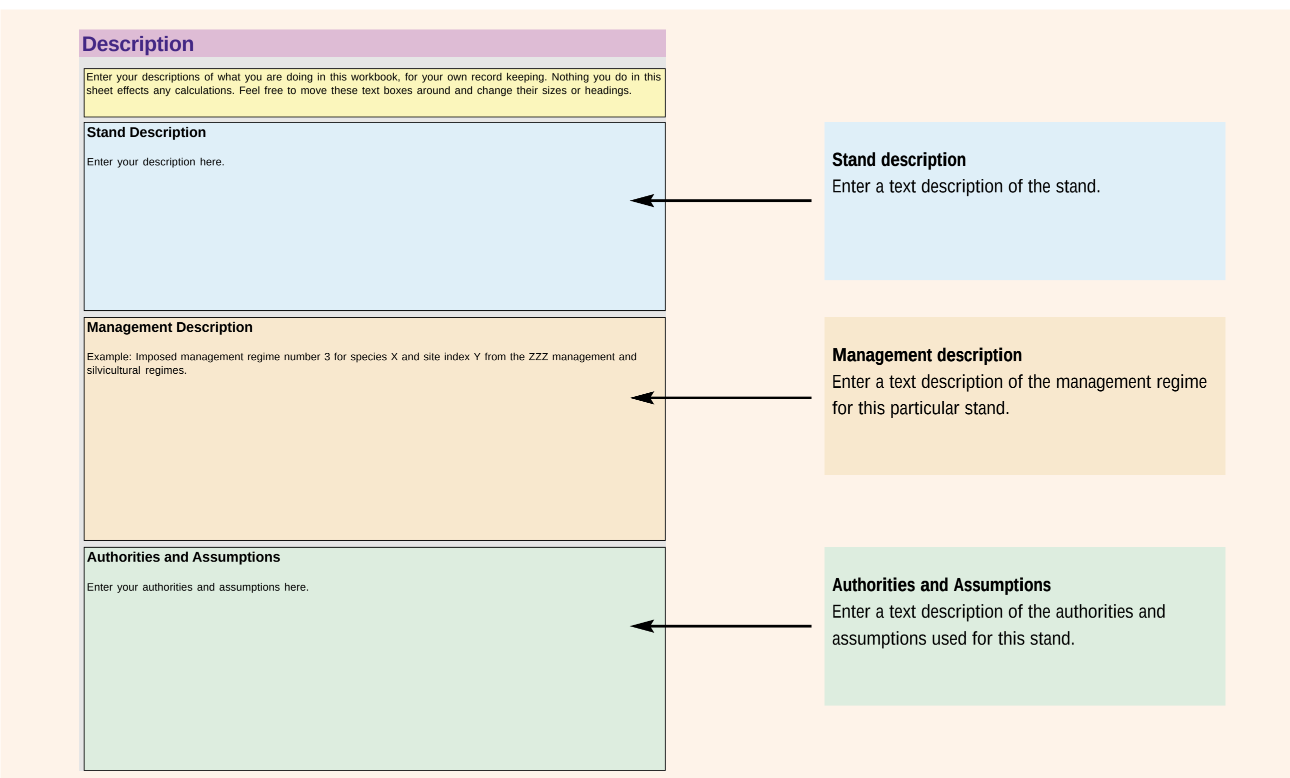


The next five tabs are for displaying outputs from *CAMFor*.



3.2 DESCRIPTION SHEET

Enter your descriptions of what you are doing in this workbook, for your own record keeping. Nothing you do in this sheet effects any calculations. Feel free to move these text boxes around and change their sizes or headings.



This is the sheet where you enter management information for the stands in the workbook.

There are five sheets for entering data (Input or 'In'-sheets);

1. In-General. Enter general information about the stands in this workbook.
2. In-Thin. Enter information about any thinning of the stands by people.
3. In-Fire. Enter information about any fires that occur in the stands in this workbook.
4. In-Species. Enter information about the species of tree in the stands in this workbook.
5. In-Growth. Enter information about the growth rate of the species of tree in the stands in this workbook.

Only enter data in cells coloured light blue. If a cell becomes bright red then there is a problem with the data you have entered.

3.3 IN-GENERAL SHEET

Input 1/5: General

This sheet is for entering general information about the stands in the workbook.

3.3.1 Stand Description

Box for entering a description of the stand in this worksheet. This box is optional and data entered here will not appear in any calculations.

Stand Description

Name	Example Stand
Notes	This input data is purely for illustrating how CAMFor works. Any resemblance to any real stand is purely accidental.

3.3.2 Management

Table for entering whether the stand is managed and thinned by people or is left alone and natural.

Management

Name	*Description*	*Value*	*Units*
ManagedText	Stand 'Managed' (managed and thinned by people) or 'Natural'	Managed	-

3.3.3 Site

Site			
Name	*Description*	*Value*	*Units*
Growth Relative to Standard Site			
SiteAdjustStem	Stem-growth site adjustment	1.05	-
SiteAdjustBran	Branch-growth site adjustment	0.95	-
SiteAdjustBark	Bark-growth site adjustment	1.10	-
SiteAdjustLeaf	Leaf and twig-growth site adjustment	1.20	-
SiteAdjustCRot	Coarse-root-growth site adjustment	0.90	-
SiteAdjustFRot	Fine-root-growth site adjustment	0.95	-

3.3.4 Timing and Initial Conditions

If the stand is never cleared then there is only one rotation and so the rotation length is huge (enter 1,000 years perhaps).

Timing and Initial Conditions			
Name	*Description*	*Value*	*Units*
Timing (only relevant if the stand is 'Managed')			
RotLen	Rotation length (time from planting to final 100% thin)	30	y
RotAgeInit	Age of rotation at start of simulation	3	y
Initial Tree Components			
StemVolInit	Initial volume of stems	7.00	m3 / ha
BranMInit	Initial mass of branches	4.00	t / ha
BarkMInit	Initial mass of bark	1.00	t / ha
LeafMInit	Initial mass of leaves and twigs	5.00	t / ha
CRootMInit	Initial mass of coarse roots	3.00	t / ha
FRootMInit	Initial mass of fine roots	2.00	t / ha
Initial Debris Components			
DeFDcyCMInit	Initial carbon mass of decomposable fine decay	1.00	t / ha
ReFDcyCMInit	Initial carbon mass of resistant fine decay	2.00	t / ha
DeCDcyCMInit	Initial carbon mass of decomposable coarse decay	3.00	t / ha
ReCDcyCMInit	Initial carbon mass of resistant coarse decay	4.00	t / ha
DeLLitCMInit	Initial carbon mass of decomposable leaf litter	5.00	t / ha
ReLLitCMInit	Initial carbon mass of resistant leaf litter	6.00	t / ha
DeBLitCMInit	Initial carbon mass of decomposable bark litter	7.00	t / ha
ReBLitCMInit	Initial carbon mass of resistant bark litter	8.00	t / ha
DeDwdCMInit	Initial carbon mass of decomposable deadwood	9.00	t / ha
ReDwdCMInit	Initial carbon mass of resistant deadwood	12.00	t / ha
Initial Soil Components			
ActvCMInit	Initial carbon mass of active pool	12.00	t / ha
InrtCMInit	Initial carbon mass of inert pool	43.00	t / ha

3.3.5 Soil Carbon Source

Choose the source for the soil carbon mass model.

Soil Carbon Source
SoilCMType
1

Choose the source for the soil carbon mass data:
1 = Let CAMFor calculate it
2 = Use the data in the 'Soil Carbon' table instead

<--- Enter '1' or '2'

3.3.6 Soil Carbon

You may wish to externally generate your soil carbon mass data. If so, this is where you enter that data.

If you set the 'Soil Carbon Source' to 1 then *CAMFor* calculates the soil carbon mass according to the *CAMFor* model and the data in the 'Soil Carbon' table is ignored.

If you set the 'Soil Carbon Source' to 2 then *CAMFor* copies the data in the 'Soil Carbon' table into the soil carbon mass column in the 'Main' sheet, thereby replacing the soil carbon mass that *CAMFor* calculates. In this case *CAMFor* still goes ahead and calculates the masses of carbon in the active and inert pools - but it ignores those calculations when it comes to computing the soil carbon mass because it gets the soil carbon mass from the 'Soil Carbon' table instead. You should copy the data you have externally calculated for the soil carbon mass into the 'Soil Carbon' table (use 'Paste Special:By Value' in the 'Edit' menu). The 'Year' in the 'Soil Carbon' table is the number of years since the start of the simulation; year 0 is the initial condition. You can extend the table as required (copy down the last row using 'Fill:Down' in the 'Edit' menu).

Note that externally calculated data may not reflect the thinning or fires that *CAMFor* knows about.

Relative Growth Adjustments allow for variation in biomass allocation within trees as affected by site conditions.

Initial Components refers to the carbon present at the site prior to the commencement of accounting, in effect, the starting condition.

Soil Carbon

Year	Soil Carbon
yr	t / ha
	SoilCMTbl
0	0.0
1	0.2
2	0.4
3	0.6
4	0.8
5	1.0
6	1.2
7	1.4
8	1.6
9	1.8
10	2.0

3.4 IN-THIN SHEET

Input 2/5: Thinnings

This sheet is where you enter information about any thinning of the stands by people. Only managed stands are thinned; natural stands are instead self thinning (see the 'TreeMortFrac' in the species inputs). The 'Thinnings' table specifies the schedule for thinning the type of stand, and what the harvest material is made into.

3.4.1 How to Fill in the 'In-Thin' Sheet

Each row specifies one thinning, occurring at the 'Rotation Age' (the number of years since the rotation was planted, whole numbers only, no more than one thinning per rotation age), and the 'Fraction of Trees Thinned', in the proportions shown in the rest of the line. The thinning whose rotation age is 'Final' is for the final thinning, a 100% thin that removes all of the trees and ends the rotation. The rows may be in any order, except the 'Final' thin must be first. Each set of allocation fractions in a thin (such as the allocation fractions of stem wood) must sum to 1 (the row sum turns red whenever they do not add to 1, which will happen as you edit them - when you are finished no row sum should be red).

If there is no thinning, set all the rotation ages at which thinning occurs higher than the rotation length (so the simulation never gets to those rotation ages), or delete the rows (but do not delete the first two rows, because then you might not be able to recreate them if you need them later).

You can delete or copy any rows after the 'Final' row and the next row:

- For more rows: Select the last row and the blank rows below it that you want to contain new rows, then choose 'Fill:Down' from the 'Edit' menu.
- To delete rows: Select any rows, except the 'Final' row and the one after, then choose 'Delete' from the 'Edit' menu.

Sort the rows by selecting them (do NOT include the first row, that is, do not sort with the 'final' row) and by choosing 'Sort...' from the 'Data' menu, then sorting by 'ThinAge' (col A).

Thinnings

		Fractions of Thinned Stem Weight Allocated to Debris or Products								
Rotation Age	Fraction of Trees Thinned	Dead-wood	Bio-Fuel	Paper	Packing	Furn-iture	Fibre Board	Const-ruction	Mill Residue	Row Sum
Thin Age	ThinFrac Tbl	ThinStem Dwd	ThinStem Fuel	ThinStem Papr	ThinStem Pack	ThinStem Furn	ThinStem Fibr	ThinStem Cons	ThinStem Resi	
Final	1.00	0.10	0.03	0.02	0.16	0.18	0.16	0.15	0.20	1.00
16	0.17	0.10	0.20	0.40	0.10	0.10	0.10	0.00	0.00	1.00
20	0.22	0.10	0.20	0.40	0.10	0.10	0.10	0.00	0.00	1.00
25	0.21	0.10	0.20	0.40	0.10	0.10	0.10	0.00	0.00	1.00
125	0.18	0.10	0.20	0.40	0.10	0.10	0.10	0.00	0.00	1.00
130	0.17	0.10	0.20	0.40	0.10	0.10	0.10	0.00	0.00	1.00
145	0.15	0.10	0.20	0.40	0.10	0.10	0.10	0.00	0.00	1.00
150	0.13	0.10	0.20	0.10	0.10	0.10	0.10	0.20	0.10	1.00
155	0.11	0.10	0.20	0.10	0.10	0.10	0.10	0.20	0.10	1.00
160	0.10	0.10	0.20	0.10	0.10	0.10	0.10	0.20	0.10	1.00
165	0.08	0.10	0.20	0.10	0.10	0.10	0.10	0.20	0.10	1.00
170	0.07	0.10	0.20	0.10	0.10	0.10	0.10	0.20	0.10	1.00
175	0.06	0.10	0.20	0.10	0.10	0.10	0.10	0.20	0.10	1.00
180	0.05	0.10	0.20	0.10	0.10	0.10	0.10	0.20	0.10	1.00
185	0.04	0.10	0.20	0.10	0.10	0.10	0.10	0.20	0.10	1.00
190	0.04	0.10	0.20	0.10	0.10	0.10	0.10	0.20	0.10	1.00
195	0.00	0.10	0.20	0.10	0.10	0.10	0.10	0.20	0.10	1.00

	Fractions of Thinned Branch Weight Allocated to Debris or Products									Allocated Fractions of Thinned Bark				
Rotation Age	Dead-wood	Bio-Fuel	Paper	Packing	Furn-iture	Fibre Board	Const-ruction	Mill Residue	Row Sum	Litter	Bio-Fuel	Paper	Mill Residue	Row Sum
Thin Age	ThinBran Dwd	ThinBran Fuel	ThinBran Papr	ThinBran Pack	ThinBran Furn	ThinBran Fibr	ThinBran Cons	ThinBran Resi		ThinBark Lit	ThinBark Fuel	ThinBark Papr	ThinBark Resi	
Final	0.24	0.13	0.09	0.02	0.14	0.14	0.21	0.03	1.00	0.10	0.12	0.53	0.25	1.00
16	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00
20	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00
25	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00
125	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00
130	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00
145	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00
150	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00
155	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00
160	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00
165	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00
170	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00
175	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00
180	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00
185	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00
190	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00
195	0.37	0.10	0.07	0.09	0.07	0.13	0.14	0.03	1.00	0.25	0.39	0.06	0.30	1.00

3.5 IN-FIRE SHEET

Input 3/5: Fire

Enter information about any fires that occur in the stands in this workbook. The Fire table specifies the fires that occur in this type of stand. Each fire is specified as occurring at a stand age (such as 10 years after the stand was first planted) rather than a specific year (such as 1985), so fires in *CAMFor* are treated as typical events rather than as historical events.

Only enter data in the cells coloured light blue. If a cell becomes bright red then there is some problem with the data you have entered.

3.5.1 How to Fill in the 'In-Fire' Sheet

Each row specifies one fire, occurring at the 'Stand Age' (the number of years since the first rotation was planted, whole numbers only, no more than one fire per age), and as described in the rest of the row. There are two types of fires:

1. Stand replacing: Complete mortality. Trees and debris burn, and what remains of the tree is then 100% thinned by people (using the 'Final' row in the 'Thinning' table). Begin a new rotation immediately.
2. Regenerating: No mortality. Either a ground or a crown-and-ground fire (a ground fire just burns the debris; a crown-and-ground fire also burns the trees). Any burnt tree material (which should mainly be leaves and twigs) is replaced immediately. Has no effect on age or growth. No thinning.

See the diagrams for an exact specification of where all the material flows in a fire. If a fire occurs in the same year as a thinning, then the thinning occurs first (so there's not as much to go up in flames).

Fire

Year of Simulated Period in Which Fire Occurs	Stand-Replacing or Regenerating Fire?	If Regenerating: Crown-and-Ground Fire or Ground-Only Fire ?	Fraction of Stem, Branch and Bark Carbon Mass That Becomes Gas	Fraction of Stem, Branch and Bark Carbon Mass That Becomes Debris	Fraction of Pre-Fire Stem, Branch and Bark Carbon Mass That is Thinned	Fraction of De. Fine Decay Carbon Mass Burnt in Fire	Fraction of Re. Fine Decay Carbon Mass Burnt in Fire	Fraction of De. Coarse Decay Carbon Mass Burnt in Fire	Fraction of Re. Coarse Decay Carbon Mass Burnt in Fire	Fraction of De. Leaf Litter Carbon Mass Burnt in Fire	Fraction of Re. Leaf Litter Carbon Mass Burnt in Fire	Fraction of De. Bark Litter Carbon Mass Burnt in Fire	Fraction of Re. Bark Litter Carbon Mass Burnt in Fire	Fraction of De. Deadwood Carbon Mass Burnt in Fire	Fraction of Re. Deadwood Carbon Mass Burnt in Fire
y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
FireTime Yr	Fire StdRTbl	Fire CrwnTbl	Fire GasFrac	Fire DebrFrac	Fire ThinFrac	FireFrac DeFDcy	FireFrac ReFDcy	FireFrac DeCDcy	FireFrac ReCDcy	FireFrac DeLLit	FireFrac DeLLit	FireFrac DeBLit	FireFrac ReBLit	FireFrac DeDwd	FireFrac ReDwd
8	Stand Replacing	Ground Only	0.25	0.33	0.42	0.12	0.12	0.12	0.12	0.95	0.90	0.85	0.80	0.75	0.60
17	Regenerating	Crown and Ground	0.09	0.10	0.00	0.11	0.11	0.11	0.11	0.95	0.90	0.85	0.80	0.75	0.60
20	Regenerating	Ground Only	0.00	0.00	0.00	0.03	0.03	0.03	0.03	0.95	0.90	0.85	0.80	0.75	0.60
122	Regenerating	Ground Only	0.01	0.00	0.00	0.05	0.05	0.05	0.05	0.95	0.90	0.85	0.80	0.75	0.60
125	Regenerating	Crown and Ground	0.05	0.05	0.00	0.10	0.10	0.10	0.10	0.95	0.90	0.85	0.80	0.75	0.60
128	Stand Replacing		0.20	0.20	0.60	0.15	0.15	0.15	0.15	0.95	0.90	0.85	0.80	0.75	0.60
120	Regenerating	Ground Only	0.01	0.02	0.00	0.03	0.03	0.03	0.03	0.95	0.90	0.85	0.80	0.75	0.60
145	Regenerating	Crown and Ground	0.04	0.04	0.00	0.09	0.09	0.09	0.09	0.95	0.90	0.85	0.80	0.75	0.60
175	Regenerating	Crown and Ground	0.06	0.08	0.00	0.08	0.08	0.08	0.08	0.95	0.90	0.85	0.80	0.75	0.60
179	Stand Replacing		0.30	0.12	0.58	0.20	0.20	0.20	0.20	0.95	0.90	0.85	0.80	0.75	0.60
201	Regenerating	Ground Only	0.01	0.02	0.00	0.03	0.03	0.03	0.03	0.95	0.90	0.85	0.80	0.75	0.60
227	Regenerating	Crown and Ground	0.04	0.04	0.00	0.09	0.09	0.09	0.09	0.95	0.90	0.85	0.80	0.75	0.60
275	Regenerating	Crown and Ground	0.06	0.08	0.00	0.08	0.08	0.08	0.08	0.95	0.90	0.85	0.80	0.75	0.60
276	Stand Replacing		0.30	0.12	0.58	0.20	0.20	0.20	0.20	0.95	0.90	0.85	0.80	0.75	0.60
288	Regenerating	Crown and Ground	0.05	0.05	0.00	0.07	0.07	0.07	0.07	0.95	0.90	0.85	0.80	0.75	0.60
289	Regenerating	Ground Only	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.95	0.90	0.85	0.80	0.75	0.60
338	Regenerating	Crown and Ground	0.06	0.02	0.00	0.05	0.05	0.05	0.05	0.95	0.90	0.85	0.80	0.75	0.60
349	Stand Replacing		0.19	0.23	0.58	0.14	0.14	0.14	0.14	0.95	0.90	0.85	0.80	0.75	0.60
390	Regenerating	Crown and Ground	0.05	0.05	0.00	0.05	0.05	0.05	0.05	0.95	0.90	0.85	0.80	0.75	0.60

Enter any number of fires, one per row, in any order. You can delete or copy any rows after the first row:

- For more rows: Select the last row and the blank rows below it that you want to contain new rows, then choose 'Fill:Down' from the 'Edit' menu.
- To delete rows: Select any rows, except the first, then choose 'Delete' from the 'Edit' menu.

If there are no fires, set the 'Fire Time' beyond the years simulated (so the simulation never gets to those years), or delete the rows (but do not delete the first two rows, as you might not be able to recreate them if you need them later).

Sort the rows by selecting them (including the first row) and choosing 'Sort...' from the 'Data' menu, then by sorting by 'FireTimeYr'. This table calculates the effects of fires on the stand.

3.6 IN-SPECIES SHEET

Input 4/5: Species

This is the sheet where you enter information about the species of tree in the stand (excluding growth data, which goes on the next sheet). Only enter data in the light blue cells.

There are two tables you should enter data into (scroll down to find them):

1. 'Species Description' – Optional. Does not effect calculations.
2. 'Species Parameters' – General information about the species.

For many users, there will be more parameters than you want. If that is the case, just make many of the parameters the same (for example, if you make no distinction between fine roots and coarse roots, make each fine root parameter equal to the corresponding coarse root parameter). However for users who need to make finer distinctions, the machinery is there (for example, you might want to take into account that coarse roots have a different lignin content than fine roots).

3.6.1 Species Description

Box for entering a description of the species of stands in this worksheet. Data entered here will not appear in any calculations.

Species Description	
Name	Example Species
Notes	This species data is purely for illustrating how CAMFor works. Any resemblance to any species of tree is purely accidental.

3.6.2 Species Parameters

Table for entering data relating to the species of trees within the stand.

Species Parameters			
Name	*Description*	*Value*	*Units*
Densities			
BasicDensKg	Density of stem wood	440	kg / m3
Self Thinning (only relevant if the stand is 'Natural')			
TreeMortFrac	Fraction of trees that die each year naturally	0.02	1 / yr
Encapsulation Fractions (fractions lost due to encapsulation by clay each year)			
EncpFracActv	Encapsulation fraction of the active pool in the soil	0.005	1 / y
Carbon Fractions (fractions that are carbon, by weight)			
CFracStem	Carbon fraction of stem	0.45	-
CFracBran	Carbon fraction of branches	0.55	-
CFracBark	Carbon fraction of bark	0.50	-
CFracLeaf	Carbon fraction of leaves and twigs	0.60	-
CFracCRoot	Carbon fraction of coarse roots	0.40	-
CFracFRoot	Carbon fraction of fine roots	0.60	-
Turnover Fractions (average fractions lost due to turnover each year)			
BranTurnFrac	Turnover fraction of branches	0.03	1 / y
BarkTurnFrac	Turnover fraction of bark	0.10	1 / y
LeafTurnFrac	Turnover fraction of leaves and twigs	0.50	1 / y
CRootTurnFrac	Turnover fraction of coarse roots	0.05	1 / y
FRootTurnFrac	Turnover fraction of fine roots	0.09	1 / y
Decomposable Fractions (fractions not resistant to decomposition)			
DeFracStem	Decomposable fraction of stems	0.10	-
DeFracBran	Decomposable fraction of branches	0.15	-
DeFracBark	Decomposable fraction of bark	0.35	-
DeFracLeaf	Decomposable fraction of leaves and twigs	0.65	-
DeFracCRoot	Decomposable fraction of coarse roots	0.80	-
DeFracFRoot	Decomposable fraction of fine roots	0.55	-
Breakdown Fractions (fractions of debris that breakdown each year)			
BkdnFracDeFDcy	Breakdown fraction of decomposable fine decay	0.80	1 / y
BkdnFracReFDcy	Breakdown fraction of resistant fine decay	0.70	1 / y
BkdnFracDeCDcy	Breakdown fraction of decomposable coarse decay	0.75	1 / y
BkdnFracReCDcy	Breakdown fraction of resistant coarse decay	0.65	1 / y
BkdnFracDeLLit	Breakdown fraction of decomposable leaf litter	0.95	1 / y
BkdnFracReLLit	Breakdown fraction of resistant leaf litter	0.92	1 / y
BkdnFracDeBLit	Breakdown fraction of decomposable bark litter	0.60	1 / y
BkdnFracReBLit	Breakdown fraction of resistant bark litter	0.52	1 / y
BkdnFracDeDwd	Breakdown fraction of decomposable deadwood	0.15	1 / y
BkdnFracReDwd	Breakdown fraction of resistant deadwood	0.12	1 / y
Breakdown Ratios (ratios of carbon masses of gas to solid in breakdown products)			
RatioGasDeFDcyBkdn	Breakdown ratio of decomposable fine decay	4.5	-
RatioGasReFDcyBkdn	Breakdown ratio of resistant fine decay	5.5	-
RatioGasDeCDcyBkdn	Breakdown ratio of decomposable coarse decay	4.6	-
RatioGasReCDcyBkdn	Breakdown ratio of resistant coarse decay	5.6	-
RatioGasDeLLitBkdn	Breakdown ratio of decomposable leaf litter	4.7	-
RatioGasReLLitBkdn	Breakdown ratio of resistant leaf litter	5.7	-
RatioGasDeBLitBkdn	Breakdown ratio of decomposable bark litter	4.8	-
RatioGasReBLitBkdn	Breakdown ratio of resistant bark litter	5.8	-
RatioGasDeDwdBkdn	Breakdown ratio of decomposable deadwood	4.9	-
RatioGasReDwdBkdn	Breakdown ratio of resistant deadwood	5.9	-
Burning Ratios (ratios of carbon masses of gas to solid in burning products)			

3.7 IN-GROWTH SHEET

Input 5/5: Growth

This sheet is where you enter the data about the growth rate of the species of tree in the stand. Only enter data in the light blue cells (which cells are light blue depends on the choice in the 'Growth Type' table).

3.7.1 Growth Driver

Choose the type of data you are using in the growth table to specify how these trees grow.

1. Yearly increases in stem volume.
2. Yearly increases in aboveground mass (mass of stem, branches, bark and leaves, post turnover).

Enter 1 or 2 in the growth driver table.

Growth Type	
GrthType	Choose the type of data you are using in the 'Growth Inputs' table: 1 = Yearly increases in stem volume, year-on-year measurements 2 = Yearly increases in aboveground mass (mass of stem, branches, bark, leaves and twigs; equal to growth less turnover), year-on-year measurements
1	<--- Enter '1' or '2'

3.7.2 Growth Table

Fill in ALL the light blue cells in the 'Growth' table, for at least as many years are possible in a rotation (for a managed stand), or for as many years as the length of the simulation (for a natural stand). You can add or delete any rows after the second row (never delete or alter the first two rows):

- For more rows: Select the last row and the blank rows below it that you want to contain new rows, then choose 'Fill:Down' from the 'Edit' menu.
- To delete rows: Select any rows, except the first two, then choose 'Delete' from the 'Edit' menu.

The age of rotation is the number of years since the trees in the current rotation were planted, and is thus the maximum age of any tree in the stand.

To enter new data, clear all the cells in a column (select the cells and choose 'Clear: Contents' from the 'Edit' menu) then enter the values you know (presumably only at some ages) then fill in the remaining cells by linear interpolation: Select two known data points in a column and all the blank cells in between then choose 'Fill:Series:Trend (linear)' from the 'Edit' menu.

With a little care, the 'Growth' table allows you to model uneven age stands (coordinate it with the 'Thinning' table) and mixed species stands (use weighted averages).

The stem mass is assumed to be always proportional to the stem volume:

StemM = BasicDens * StemVol.

In the 'Growth' table, the 'Yearly Increase in Aboveground Mass' and the 'Increase in Mass Relative to Increase in Mass of Stem' BOTH include both production and turnover. Further, they are both for a site where all the 'relative growth adjustments for non-standard sites' (see the 'In-General' sheet) are equal to 1. Thus these growth figures are NOT for growth (production) alone, but are year-on-year standing measurements that include the effect of mass loss due to turnover. The 'Yearly Increase in Aboveground Mass' is what you would measure if you simply measured the aboveground mass at the same time of year, each year. We stress this point because some other models use growth-only relative factors (which do not take turnover into account). Forestry measurements typically include growth and turnover, and thus are the figures you enter into the 'Growth' table.

Growth Inputs

			Increase in Mass Relative to Increase in Mass of Stem*				
Age of Rotation	Yearly Increase in Stem Volume	Yearly Increase in Aboveground Mass*	Bran-ches	Bark	Leaves & Twigs	Coarse Roots	Fine Roots
yr	m3 / ha	t / ha	-	-	-	-	-
	StemVol IncTbl	AbgM IncTbl	BranM IncTbl	BarkM IncTbl	LeafM IncTbl	CRootM IncTbl	FRootM IncTbl
1	0.50	0.13	0.98	0.98	1.90	1.45	1.90
2	1.00	1.45	0.96	0.96	1.80	1.40	1.80
3	1.50	2.33	0.94	0.94	1.70	1.35	1.70
4	2.00	2.97	0.92	0.92	1.60	1.30	1.60
5	2.50	3.47	0.90	0.90	1.50	1.25	1.50
6	3.00	3.89	0.88	0.88	1.40	1.20	1.40
7	3.50	4.24	0.86	0.86	1.30	1.15	1.30
8	4.00	4.56	0.84	0.84	1.20	1.10	1.20
9	4.50	4.84	0.82	0.82	1.10	1.05	1.10
10	5.00	5.09	0.80	0.80	1.00	1.00	1.00
11	5.50	5.50	0.77	0.77	0.98	0.95	0.98
12	6.00	5.81	0.74	0.74	0.96	0.90	0.96
13	6.50	6.05	0.71	0.71	0.94	0.85	0.94
14	7.00	6.25	0.68	0.68	0.92	0.80	0.92
15	7.50	6.41	0.65	0.65	0.90	0.75	0.90
16	8.36	7.09	0.62	0.62	0.88	0.70	0.88
17	9.22	7.62	0.59	0.59	0.86	0.65	0.86
18	10.08	8.05	0.56	0.56	0.84	0.60	0.84
19	10.94	8.41	0.53	0.53	0.82	0.55	0.82
20	11.80	8.72	0.50	0.50	0.80	0.50	0.80
21	12.28	8.77	0.49	0.49	0.79	0.50	0.79
22	12.76	8.87	0.48	0.48	0.78	0.50	0.78
23	13.24	9.00	0.47	0.47	0.77	0.50	0.77
24	13.72	9.14	0.46	0.46	0.76	0.50	0.76
25	14.20	9.28	0.45	0.45	0.75	0.50	0.75
26	14.30	8.95	0.44	0.44	0.74	0.50	0.74
27	14.40	8.71	0.43	0.43	0.73	0.50	0.73
28	14.50	8.52	0.42	0.42	0.72	0.50	0.72
29	14.60	8.37	0.41	0.41	0.71	0.50	0.71
30	14.70	8.23	0.40	0.40	0.70	0.50	0.70

3.8 CALC PRELIM SHEET

Calculations: Preliminary

This sheet computes some quantities that are needed by the main simulation calculations. The values in this table are calculated from the data entered into the 'Input tables'.

Assorted

Name	*Description*	*Value*	*Units*
Assorted			
BasicDens	Density of stem wood (using tonnes)	0.440	t / m3
StdPrdCMInit	Initial carbon mass of stand and products	121.49	t / ha
Managed	Stand managed by people?	TRUE	-
Resistant Fractions (fractions of material that are resistant to decomposition)			
ReFracStem	Resistant fraction of stems	0.90	-
ReFracBran	Resistant fraction of branches	0.85	-
ReFracBark	Resistant fraction of bark	0.65	-
ReFracLeaf	Resistant fraction of leaves and twigs	0.35	-
ReFracFRoot	Resistant fraction of coarse roots	0.45	-
ReFracCRoot	Resistant fraction of fine roots	0.20	-
Gas Fractions of Breakdown Carbon in Debris (fractions emitted as gas)			
FracGasDeFDcyBkdn	Decomposable fine decay	0.818	-
FracGasReFDcyBkdn	Resistant fine decay	0.846	-
FracGasDeCDcyBkdn	Decomposable coarse decay	0.821	-
FracGasReCDcyBkdn	Resistant coarse decay	0.848	-
FracGasDeLLitBkdn	Decomposable leaf litter	0.825	-
FracGasReLLitBkdn	Resistant leaf litter	0.851	-
FracGasDeBLitBkdn	Decomposable bark litter	0.828	-
FracGasReBLitBkdn	Resistant bark litter	0.853	-
FracGasDeDwdBkdn	Decomposable deadwood	0.831	-
FracGasReDwdBkdn	Resistant deadwood	0.855	-
Solid Fractions of Breakdown Carbon in Debris (fractions not emitted as gas)			
FracSolidDeFDcyBkdn	Decomposable fine decay	0.182	-
FracSolidReFDcyBkdn	Resistant fine decay	0.154	-
FracSolidDeCDcyBkdn	Decomposable coarse decay	0.179	-
FracSolidReCDcyBkdn	Resistant coarse decay	0.152	-
FracSolidDeLLitBkdn	Decomposable leaf litter	0.175	-
FracSolidReLLitBkdn	Resistant leaf litter	0.149	-
FracSolidDeBLitBkdn	Decomposable bark litter	0.172	-
FracSolidReBLitBkdn	Resistant bark litter	0.147	-
FracSolidDeDwdBkdn	Decomposable deadwood	0.169	-
FracSolidReDwdBkdn	Resistant deadwood	0.145	-
Gas Fractions of Burning Carbon in Debris (fractions emitted as gas)			
FracGasDeFDcyBurn	Decomposable fine decay	0.750	-
FracGasReFDcyBurn	Resistant fine decay	0.756	-
FracGasDeCDcyBurn	Decomposable coarse decay	0.762	-
FracGasReCDcyBurn	Resistant coarse decay	0.767	-
FracGasDeLLitBurn	Decomposable leaf litter	0.952	-
FracGasReLLitBurn	Resistant leaf litter	0.955	-
FracGasDeBLitBurn	Decomposable bark litter	0.957	-
FracGasReBLitBurn	Resistant bark litter	0.958	-
FracGasDeDwdBurn	Decomposable deadwood	0.833	-
FracGasReDwdBurn	Resistant deadwood	0.875	-
Solid Fractions of Burning Carbon in Debris (fractions not emitted as gas)			
FracSolidDeFDcyBurn	Decomposable fine decay	0.250	-
FracSolidReFDcyBurn	Resistant fine decay	0.244	-
FracSolidDeCDcyBurn	Decomposable coarse decay	0.238	-
FracSolidReCDcyBurn	Resistant coarse decay	0.233	-
FracSolidDeLLitBurn	Decomposable leaf litter	0.048	-
FracSolidReLLitBurn	Resistant leaf litter	0.045	-
FracSolidDeBLitBurn	Decomposable bark litter	0.043	-

3.9 CALC SIM SHEET

Calculations: Simulation

This sheet simulates the stand, year by year from year 0. Each year starts on the anniversary of the planting of the stand. Each normal row (white) computes the state of the stand for one year; each thinning row (purple) computes the effect of a thinning; each fire row (pinky-red) computes the effect of a fire. Each row shows the state of the stand at the end of the year in the 'Year' column; thus thinings and fires occur at the end of the year. Each row of the table is a separate calculation, depending only on the previous row. The first row (light yellow) is the initialization row. All rows from the second onwards have identical formulae.

You can delete or copy any rows after the second row (never delete or alter the first two rows), to change the length of the simulated period:

- For more rows: Select the last row and the blank rows below it that you want to contain new calculation rows, then choose 'Fill:Down' from the 'Edit' menu.
- To delete rows : Select any rows, except the first two, and choose 'Delete' from the 'Edit' menu. [Some computations/instructions may take some time to process, as the files increase in size.]

Timing, Thinning, and Fire

Year of Simulation y Yr	Age of Current Rotation y RotAge	Average Age of Trees in Stand - Stand AgeAvg	Stand Cleared Last Year? - Clear Last	Last Row's State - State Last	Age of Current Rotation, Ignoring Effect of Row y RotAgeYr	Final Thin Due This Year ? - FinalThin Due	Thin This Year? - Thin Year	Fire This Year? - Fire Year	State - State	Normal Row? - Norm Row	Thinning Row? - Thin Row	Fire Row? - Fire Row	Row Index into the Fire Table - Fire Index	Stand Replacing Fire? - Fire StdR	Fire in Crown ? - Fire Crwn	Row Index into the Thinning Table - Thin Index	Row Index into the Growth Table - Grth Index	Fraction of Trees that are Thinned Thin Frac	Stand Cleared This Year ? - Clear
0	3	3.0			3				-1										FALSE
1	4	4.0	FALSE	-1	4	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		4	0.00	FALSE
2	5	5.0	FALSE	-1	5	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		5	0.00	FALSE
3	6	6.0	FALSE	-1	6	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		6	0.00	FALSE
4	7	7.0	FALSE	-1	7	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		7	0.00	FALSE
5	8	8.0	FALSE	-1	8	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		8	0.00	FALSE
6	9	9.0	FALSE	-1	9	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		9	0.00	FALSE
7	10	10.0	FALSE	-1	10	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		10	0.00	FALSE
8	11	11.0	FALSE	-1	11	FALSE	FALSE	TRUE	2	TRUE	FALSE	FALSE		FALSE	FALSE		11	0.00	FALSE
8	0	0.0	FALSE	2	11	FALSE			-3	FALSE	FALSE	TRUE	1	TRUE	TRUE	1	1	0.42	TRUE
9	1	1.0	TRUE	-3	1	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		1	0.00	FALSE
10	2	2.0	FALSE	-1	2	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		2	0.00	FALSE
11	3	3.0	FALSE	-1	3	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		3	0.00	FALSE
12	4	4.0	FALSE	-1	4	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		4	0.00	FALSE
13	5	5.0	FALSE	-1	5	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		5	0.00	FALSE
14	6	6.0	FALSE	-1	6	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		6	0.00	FALSE
15	7	7.0	FALSE	-1	7	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		7	0.00	FALSE
16	8	8.0	FALSE	-1	8	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		8	0.00	FALSE
17	9	9.0	FALSE	-1	9	FALSE	FALSE	TRUE	2	TRUE	FALSE	FALSE		FALSE	FALSE		9	0.00	FALSE
17	9	9.0	FALSE	2	9	FALSE			-3	FALSE	FALSE	TRUE	2	FALSE	TRUE		9	0.00	FALSE
18	10	10.0	FALSE	-3	10	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		10	0.00	FALSE
19	11	11.0	FALSE	-1	11	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		11	0.00	FALSE
20	12	12.0	FALSE	-1	12	FALSE	FALSE	TRUE	2	TRUE	FALSE	FALSE		FALSE	FALSE		12	0.00	FALSE
20	12	12.0	FALSE	2	12	FALSE			-3	FALSE	FALSE	TRUE	3	FALSE	FALSE		12	0.00	FALSE
21	13	13.0	FALSE	-3	13	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		13	0.00	FALSE
22	14	14.0	FALSE	-1	14	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		14	0.00	FALSE
23	15	15.0	FALSE	-1	15	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		15	0.00	FALSE
24	16	16.0	FALSE	-1	16	FALSE	TRUE	FALSE	3	TRUE	FALSE	FALSE		FALSE	FALSE		16	0.00	FALSE
24	16	13.3	FALSE	3	16	FALSE			-2	FALSE	TRUE	FALSE		FALSE	FALSE	2	13	0.17	FALSE
25	17	14.3	FALSE	-2	17	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		14	0.00	FALSE
26	18	15.3	FALSE	-1	18	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		15	0.00	FALSE
27	19	16.3	FALSE	-1	19	FALSE	FALSE	FALSE	-1	TRUE	FALSE	FALSE		FALSE	FALSE		16	0.00	FALSE
28	20	17.3	FALSE	-1	20	FALSE	TRUE	FALSE	3	TRUE	FALSE	FALSE		FALSE	FALSE		17	0.00	FALSE

3.10 OUT-SIM SHEET

Output: Simulation Results

This sheet reports the highlights of the simulation by copying results from the 'Calc-Sim' sheet. It is intended to be printed on a black and white printer (and of course it can be viewed on the screen). You can delete or add more rows after the first and second rows (but never delete or alter the first two rows):

- For more rows: Select the last row and the blank rows below it that you want to contain new rows, then choose 'Fill' then 'Down' from the 'Edit' menu.
- To delete rows: Select any rows, except the first and second, and then choose 'Delete' from the 'Edit' menu.

For more detailed results, see the 'Calc-Sim' sheet directly.

Stand State Summary: Yearly

Site: Example Stand

Species: Example Species

Year	Rotation Age	Tree Carbon Mass	Debris Carbon Mass	Soil Carbon Mass	Product Carbon Mass	Total Carbon Mass	Fraction of Total Carbon Mass In Products	*Calc-Sim Table Row Index*
	y	t / ha	t / ha	t / ha	t / ha	t / ha	t / ha	-
0	3.0	9.49	57.00	55.00	0.00	121.49	0.0%	1
1	4.0	13.00	30.31	59.44	0.00	102.76	0.0%	2
2	5.0	17.20	22.36	60.91	0.00	100.47	0.0%	3
3	6.0	22.03	18.91	61.76	0.00	102.70	0.0%	4
4	7.0	27.40	17.23	62.47	0.00	107.10	0.0%	5
5	8.0	33.23	16.43	63.19	0.00	112.86	0.0%	6
6	9.0	39.47	16.14	63.99	0.00	119.60	0.0%	7
7	10.0	46.03	16.18	64.90	0.00	127.11	0.0%	8

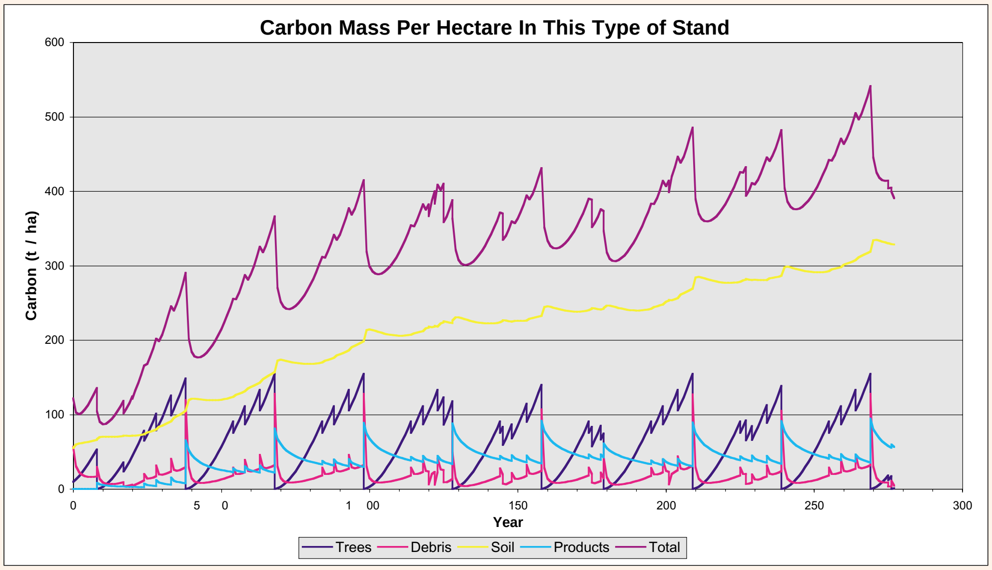
3.11 OUT-GRAPH SHEET

Output: Graphs

This sheet graphs some simulation outputs from the 'Calc-Sim' sheet. You can change a lot about the appearance of the graphs relatively easily. For example, double-click on the axis labels or graph lines to edit them. You can also resize, move, copy and paste graphs.

1. You may want to change the scales on the graphs. Double-clicking on the numbers of an axis will open the 'Format Axis' dialog box, then choose the 'Scale' tab.
2. You may want to change the data sources. Select the graph by clicking on it, choose 'Source Data' from the 'Chart' menu, the choose the 'Series' tab. This shows where the data is coming from. [It's an unwieldly interface that only accepts cell references.]

3. To print, choose a graph by clicking on it once then choose 'Print' from the 'File' menu.



3.12 GROUP SHEET

Stand Aggregation: Specify a Group of Stands

This sheet is where you enter information about a group of stands. A 'group' of stands is a number of stands with the same management regime and species (and are thus in the same *CAMFor* workbook). Each stand in the group is as described in the input ('In-') sheets. For each stand, enter:

1. The year it was started (notice that the simulation just used years 0,1,2,... of the stand's life).
2. Its area (notice that the simulation calculated masses in tonnes per hectare).
3. A description (optional, no effect on calculations).

The carbon masses of the group of stands specified in this sheet are calculated on the 'Group CM' sheet.

Only fill in the light blue cells. Enter as many stands as you like. If you do not want a stand in a given row of the table, leave that row blank (no start-year or area). You can delete or copy any rows after the first row (never delete or alter the first row):

- For more rows: Select the last row and the blank rows below it that you want to contain new data rows, then choose 'Fill' then 'Down' from the 'Edit' menu.
- To delete rows: Select any rows, except the first, and then choose 'Delete' from the 'Edit' menu.

Stands		
Starting Year of Stand	*Area of Stand*	*Stand Description*
-	ha	
Group StartYr	Group Area	
1980	100	
1984	310	
1986	130	
1987	430	
1988	230	
1990	130	
1990	270	

3.13 GROUP CM TOTALS SHEET

Stand Aggregation: Carbon Mass Totals for the Group of Stands

This sheet is where the carbon mass totals of the group of stands specified on the ‘Group’ sheet are calculated. A ‘group’ of stands is a number of stands with the same management regime and species (and are thus in the same *CAMFor* workbook). Note the graph over the page.

This sheet is mainly an output sheet; do not enter anything on this sheet - except in the light blue cells (name and notes in the ‘Group Description’ table, and the years in the ‘Group Carbon Masses in Years of Special Interest’ table). The name and notes are optional and have no effect on calculations.

A ‘carbon mass (total)’ is the carbon mass on the site once the stand has started to grow, but is zero before the stand starts. That is, the ‘carbon mass total’ is the total carbon due to the stand itself and ignores the carbon on a stand site before the stand is started.

A ‘carbon mass increment’ is the carbon mass on the site less the carbon on the site that was there before the stand was started. That is, the ‘carbon mass increment’ is the change in non-atmospheric carbon due to planting the stand. The ‘carbon on the site that was there before the stand was started’ is defined by the initial conditions of the site when the stand was started.

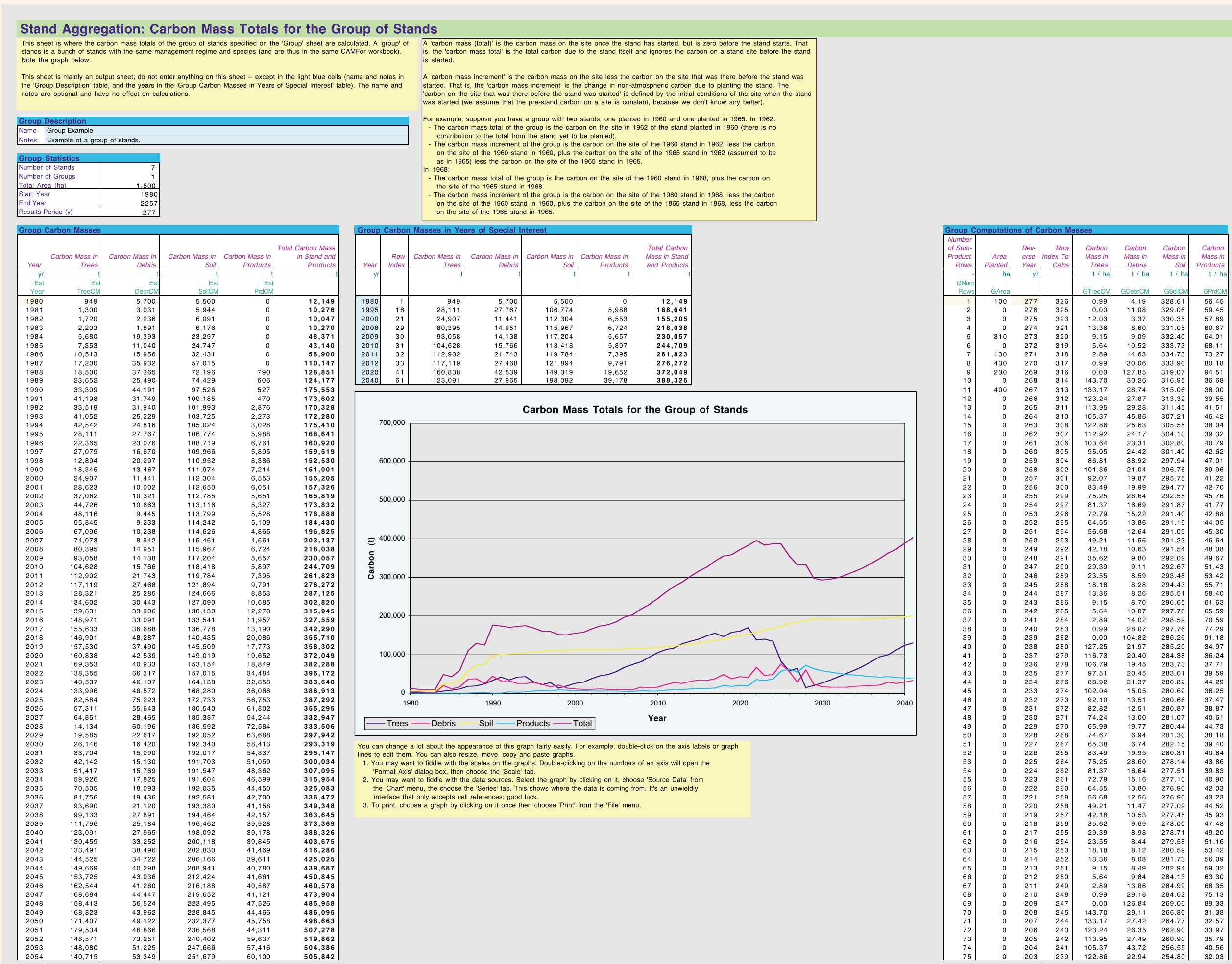
For example, suppose you have a group with two stands, one planted in 1960 and one planted in 1965.

In 1962:

- The carbon mass total of the group is the carbon on the site in 1962 of the stand planted in 1960 (there is no contribution to the total from the stand yet to be planted).
- The carbon mass increment of the group is the carbon on the site of the 1960 stand in 1962, less the carbon on the site of the 1960 stand in 1960, plus the carbon on the site of the 1965 stand in 1962 (assumed to be as in 1965) less the carbon on the site of the 1965 stand in 1965.

In 1968:

- The carbon mass total of the group is the carbon on the site of the 1960 stand in 1968, plus the carbon on the site of the 1965 stand in 1968.
- The carbon mass increment of the group is the carbon on the site of the 1960 stand in 1968, less the carbon on the site of the 1960 stand in 1960, plus the carbon on the site of the 1965 stand in 1968, less the carbon on the site of the 1965 stand in 1965.



3.14 GROUP CM INCREMENTS SHEET

Stand Aggregation: Carbon Mass Increments for the Group of Stands

This sheet is where the carbon mass increments of the group of stands specified on the 'Group' sheet are calculated. A 'group' of stands is a bunch of stands with the same management regime and species (and are thus in the same *CAMFor* workbook). Note the graph below.

This sheet is mainly an output sheet; do not enter anything on this sheet - except in the light blue cells (name and notes in the 'Group Description' table, and the years in the 'Group Carbon Masses in Years of Special Interest' table). The name and notes are optional and have no effect on calculations.

A 'carbon mass (total)' is the carbon mass on the site once the stand has started to grow, but is zero before the stand starts. That is, the 'carbon mass total' is the total carbon due to the stand itself and ignores the carbon on a stand site before the stand is started.

Stand Aggregation: Carbon Mass Increments for the Group of Stands

This sheet is where the carbon mass increments of the group of stands specified on the 'Group' sheet are calculated. A 'group' of stands is a bunch of stands with the same management regime and species (and are thus in the same CAMFor workbook). Note the graph below.

This sheet is mainly an output sheet; do not enter anything on this sheet -- except in the light blue cells (name and notes in the 'Group Description' table, and the years in the 'Group Carbon Masses in Years of Special Interest' table). The name and notes are optional and have no effect on calculations.

A 'carbon mass (total)' is the carbon mass on the site once the stand has started, but is zero before the stand starts. That is, the 'carbon mass total' is the total carbon due to the stand itself and ignores the carbon on a stand site before the stand is started.

A 'carbon mass increment' is the carbon mass on the site less the carbon on the site that was there before the stand was started. That is, the 'carbon mass increment' is the change in non-atmospheric carbon due to planting the stand. The 'carbon on the site that was there before the stand was started' is defined by the initial conditions of the site when the stand was started (we assume that the pre-stand carbon on a site is constant, because we don't know any better).

For example, suppose you have a group with two stands, one planted in 1960 and one planted in 1965. In 1962:
- The carbon mass total of the group is the carbon on the site in 1962 of the stand planted in 1960 (there is no contribution to the total from the stand yet to be planted).
- The carbon mass increment of the group is the carbon on the site of the 1960 stand in 1962, less the carbon on the site of the 1960 stand in 1960, plus the carbon on the site of the 1965 stand in 1962 (assumed to be as in 1965) less the carbon on the site of the 1965 stand in 1965.

In 1968:
- The carbon mass total of the group is the carbon on the site of the 1960 stand in 1968, plus the carbon on the site of the 1965 stand in 1968.
- The carbon mass increment of the group is the carbon on the site of the 1960 stand in 1968, less the carbon on the site of the 1960 stand in 1960, plus the carbon on the site of the 1965 stand in 1968, less the carbon on the site of the 1965 stand in 1965.

Group Description

Name	Group Example
Notes	Example of a group of stands.

Group Statistics

Number of Stands	7
Number of Groups	1
Total Area (ha)	1,600
Start Year	1980
End Year	2257
Results Period (y)	277

Group Computations - Pre-Stand Carbon Masses

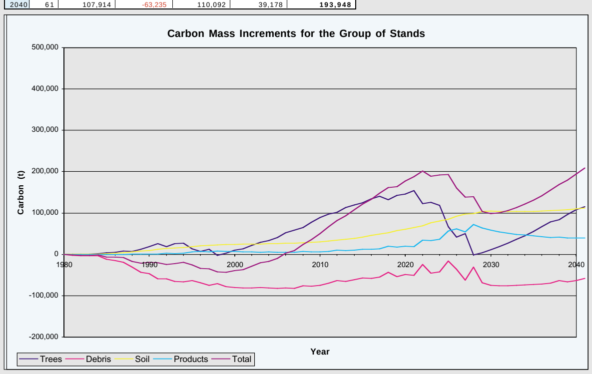
Initial Carbon Masses		
TreeCMInit	Initial carbon mass of trees	9.49
DebrCMInit	Initial carbon mass of debris	57.00
SoilCMInit	Initial carbon mass of soil	55.00
PrdCMInit	Initial carbon mass of products	0.00

Group Carbon Mass Increments

Year	Carbon Mass Increment in Trees	Carbon Mass Increment in Debris	Carbon Mass Increment in Soil	Carbon Mass Increment in Products	Total Carbon Mass Increment in Stand and Products
yr	t	t	t	t	t
	Est TreeCMInc	Est DebrCMInc	Est SoilCMInc	Est PrdCMInc	
1980	0	0	0	0	0
1981	351	-2,669	444	0	-1,873
1982	772	-3,464	591	0	-2,101
1983	1,254	-3,809	676	0	-1,878
1984	1,791	-3,977	747	0	-1,439
1985	3,464	-12,330	2,197	0	-6,670
1986	5,391	-14,824	2,731	0	-6,702
1987	7,998	-19,358	3,665	0	-7,694
1988	7,117	-31,035	6,196	790	-16,932
1989	12,269	-42,910	8,429	606	-21,606
1990	18,131	-47,009	9,526	527	-18,825
1991	26,020	-59,451	12,185	470	-20,775
1992	18,341	-59,260	13,993	2,876	-24,049
1993	25,874	-65,971	15,725	2,273	-22,098
1994	27,364	-66,384	17,024	3,028	-18,968
1995	12,933	-63,433	18,774	5,988	-25,737
1996	7,187	-68,124	20,719	6,761	-33,457
1997	11,901	-74,530	21,966	5,805	-34,859
1998	-2,283	-70,903	22,952	8,386	-41,848
1999	3,168	-77,733	23,974	7,214	-43,377
2000	9,729	-79,759	24,304	6,553	-39,173
2001	13,445	-81,198	24,650	6,051	-37,052
2002	21,884	-80,879	24,785	5,651	-28,558
2003	29,548	-80,537	25,116	5,327	-20,546
2004	32,938	-81,755	25,799	5,528	-17,489
2005	40,667	-81,967	26,242	5,109	-9,948
2006	51,918	-80,962	26,626	4,865	2,447
2007	58,895	-82,258	27,461	4,661	8,759
2008	65,218	-76,249	27,967	6,724	23,660
2009	77,881	-77,062	29,204	5,657	35,679
2010	89,450	-75,434	30,418	5,897	50,331
2011	97,724	-69,457	31,784	7,395	67,446
2012	101,942	-63,732	33,894	9,791	81,895
2013	113,144	-65,915	36,666	8,853	92,748
2014	119,425	-60,757	39,090	10,685	108,442
2015	124,453	-57,294	42,130	12,278	121,568
2016	133,793	-58,109	45,541	11,957	133,182
2017	140,456	-54,512	48,778	13,190	147,912
2018	131,724	-42,913	52,435	20,086	161,332
2019	142,352	-53,710	57,509	17,773	163,924
2020	145,661	-48,661	61,019	19,652	177,671
2021	154,175	-50,267	65,154	18,849	187,911
2022	123,178	-24,883	69,015	34,484	201,794
2023	125,360	-45,093	76,138	32,858	189,262
2024	118,819	-42,628	80,280	36,066	192,535
2025	67,406	-15,977	84,733	56,753	192,914
2026	42,133	-35,557	92,540	61,802	160,918
2027	49,673	-62,735	97,387	54,244	138,569
2028	-1,044	-31,004	98,592	72,584	139,128
2029	4,407	-68,583	104,052	63,688	103,564
2030	10,969	-74,780	104,340	58,413	98,941
2031	18,526	-76,110	104,017	54,337	100,770
2032	26,965	-76,070	103,703	51,059	105,656
2033	36,240	-75,431	103,547	48,362	112,718
2034	44,748	-73,375	103,604	46,599	121,577
2035	55,327	-73,107	104,035	44,450	130,705
2036	66,578	-71,764	104,581	42,700	142,095
2037	78,512	-70,080	105,380	41,158	154,971
2038	83,955	-63,309	106,464	42,157	169,268
2039	96,618	-66,016	108,462	39,928	178,991
2040	107,914	-63,235	110,092	39,178	193,948

Group Carbon Mass Increments in Years of Special Interest

Year	Row Index	Carbon Mass Increment in Trees	Carbon Mass Increment in Debris	Carbon Mass Increment in Soil	Carbon Mass Increment in Products	Total Carbon Mass Increment in Stand and Products
yr		t	t	t	t	t
1980	1	0	0	0	0	0
1995	16	12,933	-63,433	18,774	5,988	-25,737
2000	21	9,729	-79,759	24,304	6,553	-39,173
2008	29	65,218	-76,249	27,967	6,724	23,660
2009	30	77,881	-77,062	29,204	5,657	35,679
2010	31	89,450	-75,434	30,418	5,897	50,331
2011	32	97,724	-69,457	31,784	7,395	67,446
2012	33	101,942	-63,732	33,894	9,791	81,895
2020	41	145,661	-48,661	61,019	19,652	177,671
2040	61	107,914	-63,235	110,092	39,178	193,948



You can change a lot about the appearance of this graph fairly easily. For example, double-click on the axis labels or graph lines to edit them. You can also resize, move, copy and paste graphs.
1. You may want to fiddle with the scales on the graphs. Double-clicking on the numbers of an axis will open the 'Format Axis' dialog box, then choose the 'Scale' tab.
2. You may want to fiddle with the data sources. Select the graph by clicking on it, choose 'Source Data' from the 'Chart' menu, the choose the 'Series' tab. This shows where the data is coming from. It's an unwieldly interface that only accepts cell references; good luck.
3. To print, choose a graph by clicking on it once then choose 'Print' from the 'File' menu.

Group Computations of Carbon Mass Increments

Number of Sum-Product Rows	Area Planted	Rev-erse Year	Row Index To Calcs	Carbon Mass in Trees	Carbon Mass in Debris	Carbon Mass in Soil
-	ha	yr		t / ha	t / ha	t / ha
1	100	277	326	-8.50	-52.81	273.61
2	0	276	325	-9.49	-45.92	274.06
3	0	275	323	2.54	-53.63	275.35
4	0	274	321	3.87	-48.40	276.05
5	310	273	320	-0.33	-47.91	277.40
6	0	272	319	-3.85	-46.48	278.73
7	130	271	318	-6.59	-42.37	279.73
8	430	270	317	-8.50	-26.94	278.90
9	230	269	316	-9.49	70.85	264.07
10	0	268	314	134.21	-26.74	261.95
11	400	267	313	123.69	-28.26	260.06
12	0	266	312	113.75	-29.13	258.32
13	0	265	311	104.47	-27.72	256.45
14	0	264	310	95.88	-11.14	252.21
15	0	263	308	113.37	-31.37	250.55
16	0	262	307	103.44	-32.83	249.10
17	0	261	306	94.15	-33.69	247.80
18	0	260	305	85.57	-32.58	246.40
19	0	259	304	77.32	-18.08	242.94
20	0	258	302	91.87	-35.96	241.76
21	0	257	301	82.59	-37.13	240.75
22	0	256	300	74.01	-37.01	239.77
23	0	255	299	65.76	-28.36	237.55
24	0	254	297	71.89	-40.31	236.87
25	0	253	296	63.31	-41.78	236.40
26	0	252	295	55.06	-43.14	236.15
27	0	251	294	47.19	-44.36	236.09
28	0	250	293	39.72	-45.44	236.23
29	0	249	292	32.69	-46.37	236.54
30	0	248	291	26.14	-47.20	237.02
31	0	247	290	19.90	-47.89	237.67
32	0	246	289	14.06	-48.41	238.48
33	0	245	288	8.69	-48.72	239.43
34	0	244	287	3.87	-48.74	240.51
35	0	243	286	-0.33	-48.30	241.65
36	0	242	285	-3.85	-46.93	242.78
37	0	241	284	-6.59	-42.98	243.59
38	0	240	283	-8.50	-28.93	242.76
39	0	239	282	-9.49	47.82	231.26
40	0	238	280	117.76	-35.03	230.20
41	0	237	279	107.24	-36.60	229.38
42	0	236	278	97.31	-37.55	228.73
43	0	235	277	88.02	-36.55	228.01
44	0	234	276	79.44	-25.63	225.82
45	0	233	274	92.55	-41.95	225.62
46	0	232	273	82.62	-43.49	225.66
47	0	231	272	73.33	-44.49	225.87
48	0	230	271	64.75	-44.00	226.07
49	0	229	270	56.51	-37.23	225.44
50	0	228	268	65.18	-50.06	226.30
51	0	227	267	55.90	-50.26	227.15
52	0	226	265	74.01	-37.05	225.31
53	0	225	264	65.76	-28.40	223.14
54	0	224	262	71.89	-40.36	222.51
55	0	223	261	63.31	-41.84	222.10
56	0	222	260	55.06	-43.20	221.90
57	0	221	259	47.19	-44.44	221.90
58	0	220	258	39.72	-45.53	222.09
59	0	219	257	32.69	-46.47	222.45
60	0	218	256	26.14	-47.31	223.00
61	0	217	255	19.90	-48.02	223.71

A ‘carbon mass increment’ is the carbon mass on the site less the carbon on the site that was there before the stand was started. That is, the ‘carbon mass increment’ is the change in non-atmospheric carbon due to planting the stand. The ‘carbon on the site that was there before the stand was started’ is defined by the initial conditions of the site when the stand was started.

For example, suppose you have a group with two stands, one planted in 1960 and one planted in 1965.

In 1962:

- The carbon mass total of the group is the carbon on the site in 1962 of the stand planted in 1960 (there is no contribution to the total from the stand yet to be planted).
- The carbon mass increment of the group is the carbon on the site of the 1960 stand in 1962, less the carbon on the site of the 1960 stand in 1960, plus the carbon on the site of the 1965 stand in 1962 (assumed to be as in 1965) less the carbon on the site of the 1965 stand in 1965.

In 1968:

- The carbon mass total of the group is the carbon on the site of the 1960 stand in 1968, plus the carbon on the site of the 1965 stand in 1968.
- The carbon mass increment of the group is the carbon on the site of the 1960 stand in 1968, less the carbon on the site of the 1960 stand in 1960, plus the carbon on the site of the 1965 stand in 1968, less the carbon on the site of the 1965 stand in 1965.

3.15 APPEARANCE AND CELL SIZE

Always adjust the zoom, not the font or cell sizes. A zoom setting of 75% or 100% is most suitable for most screen resolutions.

The font and cell sizes in this document are such that everything is efficiently presented, and correctly formatted. If you adjust some font sizes or some cell sizes then you change the relative sizes and positions of the various screen elements, and chances are that the document will not look as good. If you want the writing to be smaller and the information to be denser then choose a lower zoom (typically 50% or 75%); if you want the writing to be bigger and the information to be more spread out, choose a higher zoom (typically 100% or 150%).

3.16 CELL PROTECTION

The sheets in this workbook are protected to varying degrees. You need the passwords to be able to make structural changes to the calculations.

Intro:	Protected
In- sheets:	All protected, except the light-blue cells (which are used for input data).
Calc- sheets:	All protected, except that you may add and delete rows after the first two rows in the ‘Calc-Sim’ sheet.
Out- sheets:	Not protected. Clone and modify as you please.
Stand sheets:	All protected, except the light blue cells (which are used for input data), and except that you may add and delete rows after the first two rows in the ‘Carbon Masses’ tables.
Other sheets:	Not protected.

3.17 ISSUES IN *CAMFOR*

3.17.1 Uneven Aged Forests

CAMFor can be used to simulate growth in uneven aged forests by adjusting the values in two tables:

1. The "Growth" table, which describes tree growth in terms of current annual increments (CAI's) in stem volumes or annual increments in aboveground masses.
2. The "Thinning" table, which describes a harvesting regime - when to thin, how much to thin, how much to leave in the forest, and how much to remove for milling.

By choosing the values of the two tables together, any growth and thinning scheme can be simulated.

The removal of an age or stem class is a conversion to % of volume of standing stock for the "thinning table". The growth would then be expected to revert to a previous point in the curve formed by plotting CAI against time (presumably to a point of higher CAI) reflecting more robust regrowth in response to disturbance. This CAI cycle can be imposed over time through the volume based "Growth" table.

3.17.2 Mixed Species

Each *CAMFor* workbook is constructed to deal with only one management regime and one species at a time, but even a single *CAMFor* workbook can simulate a mixed stand if you use weighted averages in its inputs. This will still provide a robust reflection of "species" and "management regime" characteristics, but care should be taken if selective harvest changes the species composition (and therefore the weighted averages) during thinning.

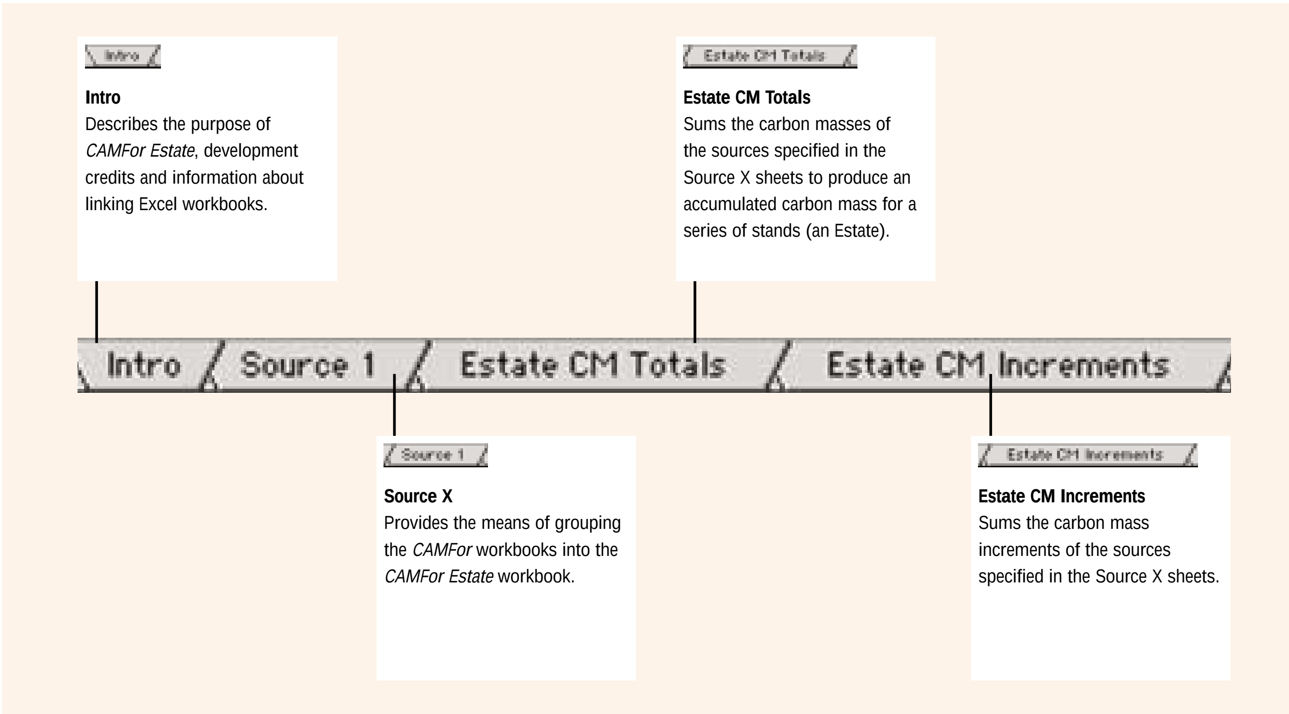
Alternatively, use a *CAMFor Estate* workbook to add and graph the carbon masses calculated in separate *CAMFor* workbooks.

3.17.3 Fire

CAMFor simulates ground fires and or crown-and-ground fires. In a ground fire, a proportion of deadwood and litter will be combusted (or "decomposed", with its carbon released to the atmosphere) and a further proportion will become charcoal and enter the "inert" pool. Branches, stemwood, bark and root are left, and can be considered to regenerate (lignotubers etc.) or be put as "thinning" (in the case of mortality), with "bark" entering "litter" and "stemwood" and "branch" as either "deadwood" or "product". The volume based "growth table" should be adjusted to account for the impact of the fire. In a crown fire, the leaves and twigs are combusted and presumed to regrow the following year.

4. HOW TO USE *CAMFOR ESTATE*

4.1 *CAMFor Estate* Sheets



4.2 INTRO SHEET

This tab provides basic information and credits for the *CAMFor Estate* workbook. There is also some general information about linking workbooks in Excel.

Linking is where one Excel workbook (file) uses results in another workbook. *CAMFor Estate* links to the various *CAMFor* workbooks whose carbon masses it is adding.

Take special care when dealing with workbooks (such as this one) that link to others, because they can crash or slow down DRASTICALLY when you rearrange links, or open or save the file. Excel works well when all the workbooks referenced by a given workbook are open, but if they are closed then you often get performance problems. So, always open the files that are linked to before the file that links to them.

We recommend:

- Always keep this workbook and all the *CAMFor* and *CAMFor Estate* workbooks that it links to in the same folder (directory).
- Always open the *CAMFor* and *CAMFor Estate* workbooks that this workbook is linked to before saving this workbook or pasting links in this workbook. In particular, open the *CAMFor* or *CAMFor Estate* workbooks that this workbook links to before copying a ‘Group X’ (X = 1,2,3,...) sheet.
- Always open the *CAMFor* workbooks that this workbook is linked to before opening this workbook.

- If, when opening this workbook, Excel asks you if you want to update links, it means that not all the files that this workbook is linked to are open or are not in the same folder. Say 'No', then close this file, open the files whose data it accesses, then reopen this file.
- Save this file frequently.
- Set your Workbook options (on the 'Calculation' tab of the 'Options' or 'Preferences' in the 'Tools' menu) so both 'Update remote references' and 'Save external link values' are on.

Initially this file opens to a workbook called '*CAMFor* 335.xls', so when you opened this file Excel asked about updating links (unless a file called '*CAMFor* 335.xls' happened to be open). Go to the 'Source 1' sheet now and change '*CAMFor* 334.xls' to one of your OPEN *CAMFor* or *CAMFor Estate* workbooks.

If you follow these precautions you are unlikely to have any serious problems. Apart from opening and saving files and pasting links when the referenced file is closed, everything works fine.

4.3 GROUP X (X= 1,2,3,…) SHEET

Source 1

This sheet copies the carbon masses, carbon mass increments, description and statistics from one source; that source is either the 'Group CM' sheet of a *CAMFor* workbook or the 'Estate' sheet of a *CAMFor Estate* workbook. Do not move any cells, or delete or insert any rows or columns in this sheet.

Only enter data in the light blue cells, which are all in the 'multiplier' column. The purpose of the multiplier is to mix different stands in varying proportions - for example, you might have two management regimes, each in its own *CAMFor* workbook, and want to combine them in a 60:40 ratio some years (multipliers of 0.6 and 0.4, respectively) and 90:10 in other years (multipliers of 0.9 and 0.1, respectively).

The information source for this sheet is shown in the top row of the 'Group or Estate Description' table. This sheet gets its data from that source by including the name of the chosen *CAMFor* or *CAMFor Estate* workbook in its formulae. To choose a different source:

1. Ensure that the source is a *CAMFor* or *CAMFor Estate* workbook, that it is in the same folder as this workbook, and that it is currently open.
2. Select any cell in this sheet, then choose 'Replace' from the 'Edit' menu. The Replace window appears.
3. In the 'Find What' box, type in the name of the currently chosen workbook (exactly as it appears in the 'Group or Estate Description' table, no spaces before or after the name).
4. In the 'Replace With' box, type the name of the source file (exact name of the Excel file, with no spaces before or after).
5. Ensure that the 'Find Entire Cells Only' option is NOT checked. Press the 'Replace All' button.

(Warning: Be sure that the 'Replace With' name is correct, because Excel is very ungraceful if you make a mistake - you will want to escape Excel.) This sheet should now be filled with the data for its source.

To make new sheets to copy in new sources, copy this sheet exactly as follows:

1. Ensure that the *CAMFor* workbook referenced by this sheet is currently open in Excel.

2. Create a new, blank sheet.

   Select any cell in this sheet, then choose 'Worksheet' from the 'Insert' menu.

3. Move the new, blank sheet to between the 'Source 1' and 'Estate' sheets.

   Grab and drag the tab for the new sheet along the line of tabs at the bottom of the window with the mouse.

4. Rename the new, blank sheet to 'Source X', where X = 1, 2, 3, ...

   Double click on the name of the sheet in its tab at the bottom of the window and type in the new name.

5. Copy all the cells in this sheet to the new sheet.

   Go to this sheet by clicking on the tab for this sheet at the bottom of the window.

   Select all the cells in this sheet by clicking in the grey rectangle at the upper left of the window where the row and column headers meet.

   Choose 'Copy' from the 'Edit' menu.

   Go to the new sheet by clicking on its tab at the bottom of the window.

   Select cell A1 (upper left) by clicking in it. Choose 'Paste' from the edit menu.

6. Change the multiplier values if necessary.

   The multipliers will generally be 1, in which case change the top cell in the 'Multiplier' column to '1', select the whole column, and choose 'Fill:Down' from the 'Edit' menu.

In the new sheet, change the *CAMFor* workbook it copies from (see above) and change the heading in cell A1 as required.

Important:

- Each source sheet must be between the 'Source 1' sheet and the 'Estate' sheet.
- The 'Source 1' sheet should never be deleted or renamed.
- We recommend naming the source sheets 'Source X', where X = 1, 2, 3, ...

This sheet may be copied up to 253 times; you can have up to 254 sources in one *CAMFor Estate* workbook (usually less due to the limits of your machine's memory). If limits are reached a simple solution is to make an 'Estate' of Estates. The same processes can be used for summing *CAMFor* and *CAMFor Estate* workbooks. They can even be mixed in any one peak Estate workbook. Note that when summing 'Estates' they should be saved as the sum of the individual *CAMFor* workbooks. The *CAMFor* workbooks can then be closed. This saves considerable memory usage.

4.4 ESTATE CM TOTALS

Estate

This sheet is where we calculate the carbon masses of the sources specified in the 'Group X' sheets (X = 1,2,3,...).

This sheet is mainly an output sheet; do not enter anything on this sheet - except in the light blue cells (name and notes in the 'Estate' table, years in the 'Carbon Masses in Years of Special Interest' table). You can find the carbon masses for a particular year by typing in the year in the 'Carbon Masses in Years of Special Interest' table. The name and notes are optional and have no effect on calculations.

Estate Description	
Name	Estate Example
Notes	Example of an estate.

Estate Statistics	
Number of Stands	7
Number of Groups	1
Total Area (ha)	0
Start Year	0
End Year	0
Results Period (y)	0

Estate Carbon Masses

Year	Sum of Source Multipliers	Carbon Mass in Trees	Carbon Mass in Debris	Carbon Mass in Soil	Carbon Mass in Products	Total Carbon Mass in Stand and Products
yr	t	t	t	t	t	t
Est Year		Est TreeCM	Est DebrCM	Est SoilCM	Est PrdCM	
0	1.00	0	0	0	0	**0**
1	1.00	0	0	0	0	**0**
2	1.00	0	0	0	0	**0**
3	1.00	0	0	0	0	**0**
4	1.00	0	0	0	0	**0**
5	1.00	0	0	0	0	**0**
6	1.00	0	0	0	0	**0**

Estate Carbon Masses in Years of

Year	Row Index	Carbon Mass in Trees
y r		t
1980	401	0
1995	401	0
2000	401	0
2008	401	0
2009	401	0
2010	401	0
2011	401	0

4.5 ESTATE CM INCREMENTS

This sheet is where the carbon mass increments of the sources specified on the 'Source X' sheets, X = 1,2,3,... , are calculated. Note the graph starting around cell Q43.

This sheet is mainly an output sheet; do not enter anything on this sheet - except in the light blue cells (name and notes in the 'Estate Description' table, and the years in the 'Group Carbon Masses in Years of Special Interest' table). The name and notes are optional and have no effect on calculations.

5. CALCULATIONS IN *CAMFOR*

We have developed this model so that you do NOT need a background in computer science to understand how it works. Although this is a moderately complex model, with a basic understanding of what a spreadsheet is and a little effort you can figure out exactly how any quantity is calculated. We intend this model to be understood by non-programmers.

ALL the calculations in the model are implemented as formulae in cells. Thus, you can uncover every single computation by looking at the formulae in the cells in this workbook. Admittedly there are a lot of cells in the 'Calc-Sim' sheet, but each row is identical to the one above. There is no programming language or macros used in this model (in particular, there is no use of Visual Basic). Some of the formulae may seem a little complicated at first, if so, look up the Excel help index regarding the relevant functions (mainly 'IF' and 'INDEX') and you'll find them more understandable.

We mainly used names to refer to cells or tables, rather than direct cell references (such as 'C9'), because:

1. In such a large workbook they are a lot easier to read.
2. They make intersheet communication much more understandable, and make sheets relatively independent of one another.

5.1 HOW QUANTITIES ARE CALCULATED

To find out how a quantity is calculated, you need to understand the naming system described in the 'Doc 2' sheet. Every quantity is systematically named according to this scheme, and the name is usually written (in dark green) beside or above the quantity.

We recommend studying the diagrams on the 'Diagrams' sheet. These diagrams essentially tell you how all the calculations are made. For most purposes, you will need to go no further than the naming scheme and the diagrams. For a bit more detail, consult the calculations notes opposite. For even more detail about how a quantity is calculated, find where the quantity is calculated or defined:

- If it is defined then it is typed in as a number in one of the input ('In-') sheets.
- If it is calculated then it will either be in one of the calculation ('Calc-') sheets:
- If the quantity is calculated on the 'Calcs-Prelim' sheet then its computation is a simple matter, so just look at the formula in its cell.
- If the quantity is calculated on the 'Calc-Sim' sheet then look at the formula in its cell. Names here usually refer to the cell in the same row in the column with the given name. Consult the Excel help index as necessary to understand functions such as 'IF' or 'INDEX.' Consult the diagram to see how the quantity is formed. Consult the column heading above the name for clues about what the quantity is and how it is calculated.

Quantities are calculated from other quantities, so you may need to repeat the process just described a number of times until you relate everything back to quantities defined on the input sheets.

There is little point in this documentation of describing more precisely how every quantity is calculated, because:

1. It would just duplicate the actual calculations, which are only a few clicks away anyway.
2. In most cases the diagrams are what you want. (We designed the calculations from the diagrams; the calculations just implement the diagrams.)

5.2 NAMES OF CELLS

Communication between different spreadsheets within this workbook is achieved entirely by named quantities. Most cells that are named have the name (in green) close by. You can view all the names and their definitions by choosing 'Names' then 'Define...' from the 'Insert' menu (command-L on a Mac, but you have to use the menu on a PC).

5.3 SOME CLUES ABOUT HOW THE CALCULATIONS ARE MADE

It would take too much space to describe how every calculation is made. However, here are a few remarks that might help if you try to figure out how the workbook works.

We compute tree component growth from the increase in stem volume per hectare (defined in the Growth table in the 'In-Species' sheet). We convert this volume increase to a weight increase using the stem density (basic density). Then we compute the increases in weight of the branches, bark, leaves and roots by their weight increases relative to stem weight increases (these relativities are also specified in the Growth table). If you specify growth as increases in aboveground mass in the Growth table, *CAMFor* simply converts these to yearly increases in stem volume in the Growth table.

The main calculations are in the 'Calc-Sim' sheet. Further comments all refer to this sheet.

The initial conditions are in the first row of the table, year 0. The next row, year 1, contains ALL of the formulas used by this sheet. All of the remaining rows of this sheet are made by filling down from this row (use 'Fill:Down' in the 'Edit' menu), so you can insert and delete rows as you like in this sheet so long as you leave the year 0 and year 1 rows untouched and fill down from there. It is crucial to note that you can inspect all of the calculations of this sheet just by inspecting the year 1 row. The chain of causation is strictly top to bottom, and never looks back further than the previous row.

Each row is either:

1. 'Normal'

   The row calculates growth, decomposition, turnover, breakdown, humification and encapsulation for the current year. See the first diagram.

2. 'Thinning'

   The row calculates the effects of this year's thinning, if any. See the second diagram.

3. 'Fire'

   The row calculates the effects of this year's fire, if any. See the third diagram.

Each year has a normal row. If a year has thinning or fire rows then they are always in the order normal then thinning then fire (as if the thinning or fire occured at the end of the year).

The ‘Timing, Thinning and Fire’ columns are the most complicated in the workbook. The flow of causality is left to right, top to bottom, with the exceptions that the ‘Age of Stand’ and ‘Age of Current Rotation’ columns are at the left for greater voisibilty (the former should go after the ‘Last Rows State’ column, while the latter should be the last column in the section). Only the ‘Clear Last’, ‘Last Rows State’, ‘Age’ and ‘RotAge’ columns from one row are accessed by the next. To track what needs doing in each row, we defined a state for each row:

4 = Normal row, with thinning and fire rows later that year

3 = Normal row, with thinning row (only) later that year

2 = Normal row, with fire row (only) later that year

1 = Thinning row, with fire row (only) later that year

-1 = Normal row, with no more rows this year

-2 = Thinning row, with no more rows this year

-3 = Fire row, with no more rows this year

The state numbering was chosen to match the Excel conditional statements (there is no particular pattern).

The ‘Timing, Thinning and Fire’ section is more complex than necessary in order to work around two bugs in Excel:

1. OR(FALSE, FALSE) = TRUE sometimes. Hence we did not use ‘OR’.
2. AND(TRUE, TRUE) = FALSE sometimes. Hence we did not use ‘AND’.
3. Circular references arise falsely sometimes when you refer to a cell in the same row by the name of the column containing the cell.

Columns only depend on columns to their left, with a few exceptions. Thus the chain of causation is generally left to right, and always top to bottom.

‘INDEX(StemVolIncTbl, RotAge, 1)’ is value ‘RotAge’ in table ‘StemVolIncTbl’, that is, the value of the ‘StemVolIncTbl’ table that is indexed by ‘RotAge’. For example, if RotAge = 3 then it is the third value in StemVolIncTbl (the one for year 3).

‘INDEX(ThinStemDwd, MATCH(RotAge, ThinAge, 0), 1)’ is the value ‘MATCH(RotAge, ThinAge, 0)’ in the table ‘ThinStemDwd’, and ‘MATCH(RotAge, ThinAge, 0)’ is the row number (or index) of the table ThinAge that contains (or matches) the value ‘RotAge’. Thus ‘INDEX(ThinStemDwd, MATCH(RotAge, ThinAges, 0), 1)’ is the value in the ‘ThinStemDwd’ table where the thinning age is ‘RotAge’.

There is a column for each material transfer from pool to pool, but not necessarily for other transfers (such as a CO_2 transfer to the atmosphere). The transfer amount is labelled as a decrease in the sending pool, and is calculated where the sending pool is calculated. The transfer amount is subtracted from the sending pool and added to the receiving pool. For example, the leaf turnover is calculated in the ‘Tree Masses’ section and called ‘LeafMDecTurn’ (leaf mass decrease due to turnover), and is subtracted from ‘LeafM’ (leaf mass) and, after multiplying by carbon fraction ‘CFracLeaf’ and splitting into decomposable and resistant, is added to DeLLitCM (decomposable leaf litter carbon mass) and ReLLitCM (resistant leaf litter carbon mass).

APPENDIX A

DEFINITIONS AND NAMING SYSTEM

The tables below describe:

1. The definitions *CAMFor* uses to understand the world (the 'Definition' column). You need to know the definitions in order to use *CAMFor* properly, so please read them.

2. The naming system (the 'Short Name' column). You do not need to know the naming system to use *CAMFor*, but you do need to know it in order to understand exactly how *CAMFor* makes its calculations (just as someone can drive a car without knowing how an internal combusiton engine works).You should know the definitions here in order to use *CAMFor*.

ABBREVIATIONS

You must know these abbreviations to use the model:

DPM = Decomposable plant material

HUM = Humus (in the soil)

RPM = Resistant plant material (resistant to decomposition)

You must know these abbreviations to understand how the model makes its calculations:

The following abbreviations are used in the names of quantities:

Abg = Aboveground (see Blg)

Atm = Atmosphere

Avg = Average = Mean

Blg = Belowground (see Abg)

C = Carbon = Material whose every atom has six protons

CFrac = Carbon fraction = Fraction of the material that is carbon (by weight)

CM = Carbon mass of material = Mass of carbon atoms in the material

Dec = Decrease; positive if quantity decreases (see Inc)

Dens = Density

Frac = Fraction of a specified part of a whole (a number from 0 to 1 inclusive)

Grth = Growth

Inc = Increase; positive if quantity increases (see Dec)

Init = Initial = Value at start of simulated period

Last = Last row's = of the previous row of the 'Calc-Sim' sheet (which often means the last year)

M = Mass (measured as dry weight)

Prev = Previous

Root = Root, usually either a CRoot (coarse root) or FRoot (fine root)

Rot = Rotation

StdR = Stand replacing (a type of fire)

Tbl = Table (omitted if no ambiguity)

Vol = Volume

Wood = Stem, branches, barks, leaves and twigs

Yr = Year

System

Name	Short Name	Definition
System	Sys	Ecosystem consisting of a stand of trees, its products, and atmospheric carbon exchanged with the stand and its products.

System Components

Name	Short Name	Definition
Solids	Solid	Everything in the system that is not in the atmosphere, namely the stand of trees and its products.
Atmospheric carbon	Atmos	Carbon in the atmosphere, considered to be zero before the stand exists (that is, we only consider the carbon exchanged with the solids).

Solids Components

Name	Short Name	Definition
Stand	Std	All the tree-related biomass (above and below ground) in a one-hectare stand of trees. All of the trees in the stand are either of the same species or can be characterised by a single (same or weighted averaged) growth table or input parameter set.
Products	Prd	Products made from the wood harvested from the stand.

Stand Components

Name	Short Name	Definition
Tree	Tree	Living tree matter (above and below ground).
Debris	Debr	Dead organic matter that is not sufficiently decayed to be considered part of the soil.
Soil	Soil	Dead organic matter that is sufficiently decayed to be considered part of the soil. ('Soil' here is only the organic matter in the ground that is associated with the stand - not the minerals and not the organic matter that is not associated with the stand.)

Tree Components

Name	Short Name	Definition
Stem	Stem	The parts of the trees that are above ground, non-bark, merchantable (that is, sellable as products to manufacturers), and large enough to be made into high-value products.
Branches	Bran	The parts of the trees that are above ground, non-bark, and merchantable, and too small to be made into high-value products.
Stem Bark	Bark	Bark over stem.
Leaves and Twigs	Leaf	The non-merchantable parts of the trees where photosynthesis occurs (leaves) or are fine structures that support the parts of the tree where photosynthesis occurs (twigs).
Roots	Root	The parts of the trees that are below ground.

Debris Components

Name	Short Name	Definition
Decomposable Fine Decay	DeFDcy	Dead fine roots that haven't decayed much, and which will decompose easily.
Resistant Coarse Decay	ReFDcy	Dead fine roots that haven't decayed much, but which are resistant to decomposition.
Decomposable Coarse Decay	DeCDcy	Dead coarse roots that haven't decayed much, and which will decompose easily.
Resistant Coarse Decay	ReCDcy	Dead coarse roots that haven't decayed much, but which are resistant to decomposition.
Decomposable Leaf Litter	DeLLit	Fallen leaves and twigs that haven't decayed much, and which will decompose easily.
Resistant Leaf Litter	ReLLit	Fallen leaves and twigs that haven't decayed much, but which are resistant to decomposition.
Decomposable Bark Litter	DeBLit	Fallen bark that hasn't decayed much, and which will decompose easily.
Resistant Bark Litter	ReBLit	Fallen bark that hasn't decayed much, but which is resistant to decomposition.
Decomposable Deadwood	DeDwd	Dead stem and branch wood that hasn't decayed much, and which will decompose easily.
Resistant Deadwood	ReDwd	Dead stem and branch wood that hasn't decayed much, but which is resistant to decomposition.

Soil Components

Name	Short Name	Definition
Active Pool	Actv	Carbon in the soil that is available to decompose back into the atmosphere by microbial action (without a major disturbance of the soil such as ploughing).
Inert Pool	Inrt	Carbon in the soil that is not in the active pool. This carbon is mainly either encapsulated by clay (and thus physically unavailable) or in charcoal (where the carbon is chemically inaccessible).

Product Components

Name	Short Name	Definition*
Bio-fuel	Fuel	Wood used for bio-fuel.
Pulp and paper	Papr	Paper products.
Packing wood	Pack	Includes pallets and palings.
Furniture	Furn	Includes poles and preservatives.
Fibre board	Fibr	Includes composite board, partcle board, and MDF.
Construction wood	Cons	Includes framing timber.
Mill Residue	Resi	Tailings from milling. Includes bark.

* All the wood in a given category returns its carbon to the atmosphere on a similar timescale, which is the criterion used to determine what category a given product belongs to. The definitions should more properly be written as ranges of decomposition times.

Movements of Carbon Within the System

Name	Short Name	Definition and Notes
Growth	Grth	Growth of trees. Moves carbon from the atmosphere to the tree components.
Turnover	Turn	Loss of part of the non-stem tree components to the litter, due to dropping leaves, twigs, and branches, abandoning roots, and so on. Moves carbon from the non-stem tree components to the litter (deadwood in the case of branches).
Breakdown	Bkdn	Transformation of debris from its initial state (which is immediately after it dies and is no longer attached to the tree). Moves carbon from the debris holding pools (of debris material that is unavailable to microbes and so on) to the atmosphere, the active soil pool, or other debris pools.
Decomposition	Dcmp	Process by which carbon in debris or products is oxidized and then transferred into the atmosphere. Produces CO_2, which is the gas that causes the greenhouse effect that warms the earth. Moves carbon from the debris and products to the atmospere.

Movements of Carbon Within the System (continued)

Name	Short Name	Definition and Notes
Burning	Fire	A fire burns (oxidizes) some tree components, thereby destoying them and transferring most of their carbon to the atmosphere as CO_2 and the rest as charcoal to the inert pool. The 'Burning' process here refers to any direct effects of fire. Essentially the same as decomposition, only faster and with the side effect of producing charcoal that transfers carbon to the inert pool. Moves carbon from the trees, debris and products to the atmosphere or inert pool.
Humification	Humf	Processing of litter into humus, typically by insects that physically transport the material into the soil. Moves carbon from the debris to the active pool in the soil.
Encapsulation	Encp	Formation of inert material from active material by smoothering in clay. Moves carbon from the active pool to the inert pool.
Thinning	Thin	Conversion of stem wood to deadwood or products and the accompanying harvest slash converts bark, branches, and leaves and twigs into deadwood and litter. Also called 'harvesting'. A '100% thin' removes all of the stem wood in the stand. Moves carbon from the stems to products and deadwood.
Removal	Remv	Removal of carbon from the atmosphere. Any movement of carbon from the atmosphere into the trees.
Emission	Emit	Emission of carbon to the atmosphere. Any movement of carbon from the trees, debris, soil or products into the atmosphere.

Time

Name	Short Name	Definition and Notes
Year	Year	Unit of time. The model simulates from 0 years to several hundred years, in one year steps.
Age	Age	The age of the trees in the stand that were planted at the beginning of the current rotation (in years).
Rotation	Rot	A rotation is all that happens from the initial planting of trees in the stand to when the stand is next 100% thinned (including the effects of a stand replacing fire).

Units

Name	Short Name	Definition
hectare	ha	10,000 square metres, about 2.471054 acres
kilogram	kg	1,000 g, about 2.204623 pounds
tonne	t	1,000 kg = 1,000,000 g, about 0.9842065 (US long) tons
year	yr	
cubic metre	m^3 or m^3	About 1.307950619 cubic yards

Preliminary Calculations

Name	Calculated As…	Units
BasicDens	Density of stem wood, using tonnes (because tonnes are used for every mass in the model). BasicDens = BasicDensKg / 1000	t / ha
StdPrdCMInit	Initial carbon mass of stand and products. StdPrdCMInit = StemVolInit * BasicDens * CFracStem + BranMInit * CFracBran + BarkMInit * CFracBark + LeafMInit * CFracLeaf + CRootMInit * CFracCRoot + FRootMInit * CFracFRoot + DeFDcyCMInit + ReFDcyCMInit + DeCDcyCMInit + ReCDcyCMInit + DeLLitCMInit + ReLLitCMInit + DeBLitCMInit + ReBLitCMInit + DeDwdCMInit + ReDwdCMInit + ActvCMInit + InrtCMInit	t / ha
Managed	Stand managed by people? Managed = Is ManagedInput equal to "Managed"?	-
ReFracStem	Resistant fraction of stems (similarly for branches, bark, leaf, coarse root and fine root). ReFracStem = 1 – DeFracStem	-
FracGasDeFDcyBkdn	Gas fraction of breakdown carbon (fraction of broken-down carbon that is gas, by mass) for decomposable fine decay (similarly for the other nine debris types). FracGasDeFDcyBkdn = RatioGasDeFDcyBkdn / (1 + RatioGasDeFDcyBkdn)	-
FracSoildDeFDcyBkdn	Solid fraction of breakdown carbon (fraction of broken-down carbon that is solid, by mass) for decomposable fine decay (similarly for the other nine debris types). FracSoildDeFDcyBkdn = 1 – FracGasDeFDcyBkdn	-
FracGasDeFDcyBurn	Gas fraction of burning carbon (fraction of burnt carbon that is gas, by mass) for decomposable fine decay (similarly for the other nine debris types). FracGasDeFDcyBurn = RatioGasDeFDcyFire / (1 + RatioGasDeFDcyFire)	-
FracSolidDeFDcyBurn	Solid fraction of burning carbon (fraction of burnt carbon that is solid, by mass) for decomposable fine decay (similarly for the other nine debris types). FracSoildDeFDcyBurn = 1 – FracGasDeFDcyBurn	-

Timing, Thinning and Fire

Name	Calculated As…	Units
Year	Year of the simulation, that is, the number of years since the simulated period started. Equal to the Year in the previous row plus one, except if this is a fire or thinning row in which case it is equal to the Year of the previous row.	yr
RotAgeProper	The age of the current rotation (that is, the age of the trees that were planted at the beginning of the current rotation) at the end of the row. Equal to RotAge, except that it is zero if the stand was cleared that year.	yr

Timing, Thinning and Fire (continued)

Name	Calculated As…	Units
ClearLast	Copy of Clear from the previous row.	
StateLast	Copy of State from the previous row.	
RotAge	The age of the current rotation (that is, the age of the trees that were planted at the beginning of the current rotation) at the end of the row, but ignoring the effect of the row itself (which might clear the stand and thereby reset the rotation age to zero). Equal to the RotAge in the previous row plus one, except if this is a fire or thinning row in which case it is equal to the RotAge of the previous row, or except that it is reset to 1 if the stand was cleared in the previous year.	
ThinYear	TRUE if and only if there is a scheduled thin this year (does not include a thin that is prompted by a stand-replacing fire).	
Fire	TRUE if and only if there is a fire this year.	
State	The state of the rows. See the 'Some Clues About How the Calculations are Made' text box opposite for what the numbers mean. If State < 0 then start a new year in the next row.	
NormRow	TRUE if and only if the spreadsheet row is a normal row (implements all processes for the year except for thinning and fire). Computed from the State.	
ThinRow	TRUE if and only if the spreadsheet row is a thinning row. Computed from the State.	
FireRow	TRUE if and only if the spreadsheet row is a fire row. Computed from the State.	
FireIndex	Row number (or index) of the row in the Fire table for this year, or blank if there is no such row.	
StdRFire	TRUE if and only if the spreadsheet row is a fire row and the fire is a stand-replacing fire. Looks up the fire table.	
CrwnFire	TRUE if and only if the spreadsheet row is a fire row and the fire is a stand-replacing fire or crown-and-ground regenerating fire. Looks up the fire table.	
ThinIndex	Row number (or index) of the row in the Thinning table for this rotation age, or blank if there is no such row.	
ThinFrac	The fraction of trees thinned, either by a regular thinning or as the aftermath of a stand-replacing fire. Computed from thinning table and StdRFire.	
Clear	TRUE if and only if this is the last row for the year and that year the stand was cleared (for any reason).	

Tree Masses

Name	Calculated As…	Units
BasicMIncGrth	Basic mass increase due to growth (used to calculate mass increases due to growth of all of the tree masses). BasicMIncGrth = StemVolIncTbl(RotAge) * BasicDens	t / ha
StemMIncGrth	Stem mass increase due to growth. StemMIncGrth = BasicMIncGrth * SiteAdjustStem	t / ha
BranMIncGrth	Branch mass increase due to growth. BranMIncGrth = BasicMIncGrth * BranMIncTbl(RotAge) * SiteAdjustBran + BranMDecTurn	t / ha
BarkMIncGrth	Bark mass increase due to growth. BarkMIncGrth = BasicMIncGrth * BarkMIncTbl(RotAge) * SiteAdjustBark + BarkMDecTurn	t / ha
LeafMIncGrth	Leaf and twig mass increase due to growth. LeafMIncGrth = BasicMIncGrth * LeafMIncTbl(RotAge) * SiteAdjustLeaf + LeafMDecTurn	t / ha
CRootMIncGrth	Coarse root mass increase due to growth. CRootMIncGrth = BasicMIncGrth * CRootMIncTbl(RotAge) * SiteAdjustCRoot + CRootMDecTurn	t / ha
FRootMIncGrth	Fine root mass increase due to growth. FRootMIncGrth = BasicMIncGrth * FRootMIncTbl(RotAge) * SiteAdjustFRoot + FRootMDecTurn	t / ha
BranMDecTurn	Branch mass decrease due to turnover. BranMDecTurn = BranTurnFrac * BranM	t / ha
BarkMDecTurn	Bark mass decrease due to turnover. BarkMDecTurn = BarkTurnFrac * BarkM	t / ha
LeafMDecTurn	Leaf and twig mass decrease due to turnover. LeafMDecTurn = LeafTurnFrac * LeafM	t / ha
CRootMDecTurn	Coarse root mass decrease due to turnover. CrootMDecTurn = CRootTurnFrac * CRootM	t / ha
FRootMDecTurn	Fine root mass decrease due to turnover. FrootMDecTurn = FRootTurnFrac * FRootM	t / ha
StemMDecThin	Stem mass decrease due to thinning. StemMDecThin = ThinFrac * StemM	t / ha
BranMDecThin	Branch mass decrease due to thinning. BranMDecThin = ThinFrac * BranM	t / ha
BarkMDecThin	Bark mass decrease due to thinning. BarkMDecThin = ThinFrac * BarkM	t / ha
LeafMDecThin	Leaf and twig mass decrease due to thinning. LeafMDecThin = ThinFrac * LeafM	t / ha
CRootMDecThin	Coarse root mass decrease due to thinning. CrootMDecThin = ThinFrac * CRootM	t / ha
FRootMDecThin	Fine root mass decrease due to thinning. FrootMDecThin = ThinFrac * CRootM	t / ha
StemMDecBurnAtm	Stem mass decrease due to fire (goes up in smoke). StemMDecBurnAtm = FireGasFrac(Year) * StemM	t / ha

Tree Masses (continued)

Name	Calculated As…	Units
BranMDecBurnAtm	Branch mass decrease due to fire (goes up in smoke). BranMDecBurnAtm = FireGasFrac(Year) * BranM	t / ha
BarkMDecBurnAtm	Bark mass decrease due to fire (goes up in smoke). BarkMDecBurnAtm = FireGasFrac(Year) * BarkM	t / ha
LeafMDecBurnAtm	Leaf and twig mass decrease due to fire (goes up in smoke). LeafMDecBurnAtm = LeafM	t / ha
StemMDecBurnDebr	Stem mass decrease due to fire (falls into debris). StemMDecBurnDebr = FireDebrFrac(Year) * StemM	t / ha
BranMDecBurnDebr	Branch mass decrease due to fire (falls into debris). BranMDecBurnDebr = FireDebrFrac(Year) * BranM	t / ha
BarkMDecBurnDebr	Bark mass decrease due to fire (falls into debris). BarkMDecBurnDebr = FireDebrFrac(Year) * BarkM	t / ha
StemM	Stem mass. StemM = StemM + StemMIncGrth – StemMDecThin – StemMDecBurnAtm – StemMDecBurnDebr	t / ha
BranM	Branch mass. BranM = BranM + BranMIncGrth – BranMDecTurn – BranMDecThin – BranMDecBurnAtm – BranMDecBurnDebr	t / ha
BarkM	Bark mass. BarkM = BarkM + BarkMIncGrth – BarkMDecTurn – BarkMDecThin – BarkMDecBurnAtm – BarkMDecBurnDebr	t / ha
LeafM	Leaf and twig mass. LeafM = LeafM + LeafMIncGrth – LeafMDecTurn – LeafMDecThin – LeafMDecBurnAtm	t / ha
CRootM	Coarse root mass. CRootM = CRootMLast + CRootMIncGrth – CRootMDecTurn – CRootMDecThin	t / ha
FRootM	Fine root mass. FRootM = FRootMLast + FRootMIncGrth – FRootMDecTurn – FRootMDecThin	t / ha
TreeM	Tree mass. TreeM = StemM + BranM + BarkM + LeafM + CRootM + FRootM	t / ha
TreeMIncGrth	Tree mass increase due to growth. = StemMIncGrth + BranMIncGrth + BarkMIncGrth + LeafMIncGrth + CRootMIncGrth + FRootMIncGrth	t / ha
TreeMDecTurn	Tree mass decrease due to turnover. = BranMDecTurn + BarkMDecTurn + LeafMDecTurn + CRootMDecTurn + FRootMDecTurn	t / ha
TreeCM	Tree carbon mass. TreeM = CFracStem * StemM + CFracBran * BranM + CFracBark * BarkM + CFracLeaf * LeafM + CFracCRoot * CRootM + CFracFRoot * FRootM	t / ha

Stem Volume

Name	Calculated As…	Units
StemVol	Stem volume. StemVol = StemM / BasicDens	m^3 / ha
StemVolGrthRot	Stem volume increase due to growth, from the beginning of the current rotation to now. StemVolGrthRot = StemVolGrthRot + StemMIncGrth / BasicDens	m^3 / ha
StemVolThinRot	Stem volume decrease due to thinning, from the beginning of the current rotation to now. StemVolThinRot = StemVolThinRot + StemVolDecThin	m^3 / ha
StemVolIncGrthAvg	Average of the yearly stem volume increases due to growth, from the beginning of the current rotation to now. StemVolIncGrthAvg = StemVolGrthRot / RotAge	m^3 / ha

Debris Masses

Name	Calculated As…	Units
DeFDcyCMDecBkdn	Decomposable fine decay carbon mass decrease due to breakdown. Similarly for the other nine debris types. DeFDcyCMDecBkdn = DeFDcyCM * BkdnFracDeFDcy	t / ha
DeFDcyCMDecBurn	Decomposable fine decay carbon mass decrease due to burning. Similarly for the other nine debris types. DeFDcyCMDecBurn = DeFDcyCM * FireFracDeFDcy(Year)	t / ha
DeFDcyCM	Decomposable fine decay carbon mass. DeFDcyCM = DeFDcyCM + (FRootMDecTurn + FRootMDecThin) * CFracFRoot * DeFracFRoot – DeFDcyCMDecBkdn – DeFDcyCMDecBurn	t / ha
ReFDcyCM	Resistant fine decay carbon mass. ReFDcyCM = ReFDcyCM + (FRootMDecTurn + FRootMDecThin) * CFracFRoot * ReFracFRoot – ReFDcyCMDecBkdn – ReFDcyCMDecBurn	t / ha
DeCDcyCM	Decomposable coarse decay carbon mass. DeCDcyCM = DeCDcyCM + (CRootMDecTurn + CRootMDecThin) * CFracCRoot * DeFracCRoot – DeCDcyCMDecBkdn – DeCDcyCMDecBurn	t / ha
ReCDcyCM	Resistant coarse decay carbon mass. ReCDcyCM = ReCDcyCM + (CRootMDecTurn + CRootMDecThin) * CFracCRoot * ReFracCRoot – ReCDcyCMDecBkdn – ReCDcyCMDecBurn	t / ha
DeLLitCM	Decomposable leaf litter carbon mass. DeLLitCM = DeLLitCM + (LeafMDecTurn + LeafMDecThin) * CFracLeaf * DeFracLeaf – DeLLitCMDecBkdn – DeLLitCMDecBurn	t / ha
ReLLitCM	Resistant leaf litter carbon mass. ReLLitCM = ReLLitCM + (LeafMDecTurn + LeafMDecThin) * CFracLeaf * ReFracLeaf – ReLLitCMDecBkdn – ReLLitCMDecBurn	t / ha

Debris Masses (continued)

Name	Calculated As…	Units
DeBLitCM	Decomposable bark litter carbon mass. DeBLitCM = DeBLitCM + (BarkMDecTurn + BarkMDecThin * ThinBarkLit(ThinIndex) + BarkMDecBurnDebr) * CFracBark * DeFracBark – DeBLitCMDecBkdn – DeBLitCMDecBurn	t / ha
ReBLitCM	Resistant bark litter carbon mass. ReBLitCM = ReBLitCM + (BarkMDecTurn + BarkMDecThin * ThinBarkLit(ThinIndex) + BarkMDecBurnDebr) * CFracBark * ReFracBark – ReBLitCMDecBkdn – ReBLitCMDecBurn	t / ha
DeDwdCM	Decomposable deadwood carbon mass. DeBLitCM = DeDwdCM + (BranMDecTurn + BranMDecThin * ThinBranDwd(ThinIndex) + BranMDecBurnDebr) * CFracBran * DeFracBran + (StemMDecThin * ThinStemDwd(ThinIndex) + StemMDecBurnDebr) * CFracStem * DeFracStem – DeDwdCMDecBkdn – DeDwdCMDecBurn	t / ha
ReDwdCM	Resistant deadwood carbon mass. ReBLitCM = ReDwdCM + (BranMDecTurn + BranMDecThin * ThinBranDwd(ThinIndex) + BranMDecBurnDebr) * CFracBran * ReFracBran + (StemMDecThin * ThinStemDwd(ThinIndex) + StemMDecBurnDebr) * CFracStem * ReFracStem – ReDwdCMDecBkdn – ReDwdCMDecBurn	t / ha
DebrCM	Debris carbon mass. DebrCM = DeFDcyCM + ReFDcyCM + DeCDcyCM + ReCDcyCM + DeLLitCM + ReLLitCM + DeBLitCM + ReBLitCM + DeDwdCM + ReDwdCM	t / ha
DebrDPM	Carbon mass of material leaving debris as DPM. DebrDPM = DeFDcyCMDecBkdn * FracSolidDeFDcyBkdn + DeCDcyCMDecBkdn * FracSolidDeCDcyBkdn	t / ha
DebrRPM	Carbon mass of material leaving debris as RPM. DebrRPM = ReFDcyCMDecBkdn * FracSolidReFDcyBkdn + ReCDcyCMDecBkdn * FracSolidReCDcyBkdn	t / ha
DebrHUM	Carbon mass of material leaving debris as humus. DebrHUM = DeLLitCMDecBkdn * FracSolidDeLLitBkdn + ReLLitCMDecBkdn * FracSolidReLLitBkdn + DeBLitCMDecBkdn * FracSolidDeBLitBkdn + ReBLitCMDecBkdn * FracSolidReBLitBkdn + DeDwdCMDecBkdn * FracSolidDeDwdBkdn + ReDwdCMDecBkdn * FracSolidReDwdBkdn	t / ha

Soil Masses

Name	Calculated As…	Units
ActvCMDecEncp	Active carbon mass decrease due to encapsulation. ActvCMDecEncp = EncpFracActv * ActvCM	t / ha
ActvCM	Carbon mass of the active soil pool. ActvCM = ActvCM + DebrDPM + DebrRPM + DebrHUM – ActvCMDecEncp – DcmpFracActv * ActvCMLast	t / ha
InrtCM	Carbon mass of the inert soil pool. InrtCM = InrtM + ActvCMDecEncp + DeFDcyCMDecBurn * FracSolidDeFDcyBurn + ReFDcyCMDecBurn * FracSolidReFDcyBurn + DeCDcyCMDecBurn * FracSolidDeCDcyBurn + ReCDcyCMDecBurn * FracSolidReCDcyBurn + DeLLitCMDecBurn * FracSolidDeLLitBurn + ReLLitCMDecBurn * FracSolidReLLitBurn + DeBLitCMDecBurn * FracSolidDeBLitBurn + ReBLitCMDecBurn * FracSolidReBLitBurn + DeDwdCMDecBurn * FracSolidDeDwdBurn + ReDwdCMDecBurn * FracSolidReDwdBurn	t / ha
SoilCM	Soil carbon mass. SoilCM = ActvCM + InrtCM	t / ha

Product Masses

Name	Calculated As…	Units
FuelCM	Bio-fuel carbon mass. FuelCM = FuelCM – DcmpFracFuel * FuelCM + ThinStemFuel(ThinIndex) * StemMDecThin * CFracStem + ThinBranFuel(ThinIndex) * BranMDecThin * CFracBran + ThinBarkFuel(ThinIndex) * BarkMDecThin * CFracBark	t / ha
PaprCM	Pulp and paper carbon mass. PaprCM = PaprCM – DcmpFracPapr * PaprCM + ThinStemPapr(ThinIndex) * StemMDecThin * CFracStem + ThinBranPapr(ThinIndex) * BranMDecThin * CFracBran + ThinBarkPapr(ThinIndex) * BarkMDecThin * CFracBark	t / ha
PackCM	Packing wood and furniture carbon mass. PackCM = PackCM – DcmpFracPack * PackCM + ThinStemPack(ThinIndex) * StemMDecThin * CFracStem + ThinBranPack(ThinIndex) * BranMDecThin * CFracBran	t / ha
FurnCM	Furniture carbon mass. FurnCM = FurnCM – DcmpFracFurn * FurnCM + ThinStemFurn(ThinIndex) * StemMDecThin * CFracStem + ThinBranFurn(ThinIndex) * BranMDecThin * CFracBran	t / ha
FibrCM	Fibre board carbon mass. FibrCM = FibrCM – DcmpFracFibr * FibrCM + ThinStemFibr(ThinIndex) * StemMDecThin * CFracStem + ThinBranFibr(ThinIndex) * BranMDecThin * CFracBran	t / ha
ConsCM	Construction wood carbon mass. ConsCM = ConsCM – DcmpFracCons * ConsCMLast + ThinStemCons(ThinIndex) * StemMDecThin * CFracStem + ThinBranCons(ThinIndex) * BranMDecThin * CFracBran	t / ha

Product Masses (continued)

Name	Calculated As…	Units
ResiCM	Mill residue carbon mass. ResiCM = ResiCM – DcmpFracResi * ResiCMLast + ThinStemResi(ThinIndex) * StemMDecThin * CFracStem + ThinBranResi(ThinIndex) * BranMDecThin * CFracBran + ThinBarkResi(ThinIndex) * BarkMDecThin * CFracBark	t / ha
PrdCM	Products carbon mass.	
	PrdCM = FuelCM + PaprCM + PackCM + FurnCM + FibrCM + ConsCM + ResiCM	t / ha

Carbon Exchanges with the Atmosphere

Name	Calculated As…	Units
CMFixTreeGrth	Carbon mass fixed by trees, due to growth. CMFixTreeGrth = CFracMain * (StemMIncGrth + BranMIncGrth) + CFracLit * (BarkMIncGrth + LeafMIncGrth) + CFracDcy * RootMIncGrth	t / ha
CMRelTreeFire	Carbon mass released by trees, due to fire. CMRelTreeFire = CFracLit * LeafMDecFire	t / ha
CMRelDebrFire	Carbon mass released by debris, due to fire. CMRelDebrFire = CFracMain * DwdMDecFire + CFracLit * LitMDecFire + CFracDcy * DcyMDecFire	t / ha
CMRelDebrFire	Carbon mass released by debris due to decomposition. CMRelDebrDcmp = CFracMain * DwdMDecDcmp + CFracLit * LitMDecDcmp + CFracDcy * DcyMDecDcmp	t / ha
CMRelSoilDcmp	Carbon mass released by soil due to decomposition. CMRelSoilDcmp = CFracHum * HumMDecDcmp	t / ha
CMRelPrdDcmp	Carbon mass released by products due to decomposition. CMRelPrdDcmp = CFracMain * PrdMDecDcmp	t / ha
CMFixStd	Carbon mass fixed by the stand. CMFixStd = CMFixTreeGrth – CMRelTreeFire – CMRelDebrFire – CMRelDebrDcmp – CMRelSoilDcmp	t / ha
CMFixSolid	Carbon mass fixed by the solids. CMFixSolid = CMFixStd – CMRelPrdDcmp	t / ha

Carbon Masses

Name	Calculated As…	Units
CMRemvTreeGrth	Carbon mass removed by trees due to growth. CMRemvTreeGrth = CFracStem * StemMIncGrth + CFracBran * BranMIncGrth + CFracBark * BarkMIncGrth + CFracLeaf * LeafMIncGrth + CFracCRoot * CRootMIncGrth + CFracFRoot * FRootMIncGrth	t / ha
CMEmitDebrDcmp	Carbon mass emitted by debris due to breakdown. CMEmitDebrDcmp = DeFDcyCMDecBkdn * FracGasDeFDcyBkdn + ReFDcyCMDecBkdn * FracGasReFDcyBkdn + DeCDcyCMDecBkdn * FracGasDeCDcyBkdn + ReCDcyCMDecBkdn * FracGasReCDcyBkdn + DeLLitCMDecBkdn * FracGasDeLLitBkdn + ReLLitCMDecBkdn * FracGasReLLitBkdn + DeBLitCMDecBkdn * FracGasDeBLitBkdn + ReBLitCMDecBkdn * FracGasReBLitBkdn + DeDwdCMDecBkdn * FracGasDeDwdBkdn + ReDwdCMDecBkdn * FracGasReDwdBkdn	t / ha
CMEmitSoilDcmp	Carbon mass emitted by soil due to decomposition. CMEmitSoilDcmp = DcmpFracActv * ActvCMLast	t / ha
CMEmitPrdDcmp	Carbon mass emitted by products due to decomposition. CMEmitPrdDcmp = DcmpFracFuel * FuelCMLast + DcmpFracPapr * PaprCMLast + DcmpFracPack * PackCMLast + DcmpFracFurn * FurnCMLast + DcmpFracFibr * FibrCMLast + DcmpFracCons * ConsCMLast + DcmpFracResi * ResiCMLast	t / ha
CMEmitTreeFire	Carbon mass emitted by trees due to burning. CMEmitTreeFire = StemMDecBurnAtm * CFracStem + BranMDecBurnAtm * CFracBran + BarkMDecBurnAtm * CFracBark + LeafMDecBurnAtm * CFracLeaf	t / ha
CMEmitDebrFire	Carbon mass enitted by debris due to burning. CMEmitDebrFire = DeFDcyCMDecBurn * FracGasDeFDcyBurn + ReFDcyCMDecBurn * FracGasReFDcyBurn + DeCDcyCMDecBurn * FracGasDeCDcyBurn + ReCDcyCMDecBurn * FracGasReCDcyBurn + DeLLitCMDecBurn * FracGasDeLLitBurn + ReLLitCMDecBurn * FracGasReLLitBurn + DeBLitCMDecBurn * FracGasDeBLitBurn + ReBLitCMDecBurn * FracGasReBLitBurn + DeDwdCMDecBurn * FracGasDeDwdBurn + ReDwdCMDecBurn * FracGasReDwdBurn	t / ha
CMRemvStd	Total, net carbon mass removed by the stand (does not include carbon emitted by products not the products). CMRemvStd = CMRemvTreeGrth – CMEmitDebrDcmp – CMEmitSoilDcmp – CMEmitTreeFire – CMEmitDebrFire	t / ha
CMRemvStdPrd	Total, net carbon mass removed by the stand and the products, which is the total net carbon removed from the atmosphere as a result of the stand - this row. CMRemvStdPrd = CMRemvStd – CMEmitPrdDcmp	t / ha
CMRemvToDate	Total, net carbon mass removed by the stand and the products (removed from the atmosphere) - to date, from beginning of simulated period. CMRemvToDate = (value from previous row) + CMRemvStdPrd	t / ha

Aggregates

Name	Calculated As…	Units
StemCM	Carbon mass of stems. StemCM = CFracStem * StemM	t / ha
StdCM	Carbon mass of stand. StdCM = TreeCM + DebrCM + SoilCM	t / ha
StdPrdCM	Carbon mass of stand and products. StdPrdCM = StdCM + PrdCM	t / ha
FracCMTotalInPrd	Fraction of carbon mass in stand and products that is in products FracCMTotalInPrd = PrdCM / StdPrdCM	-

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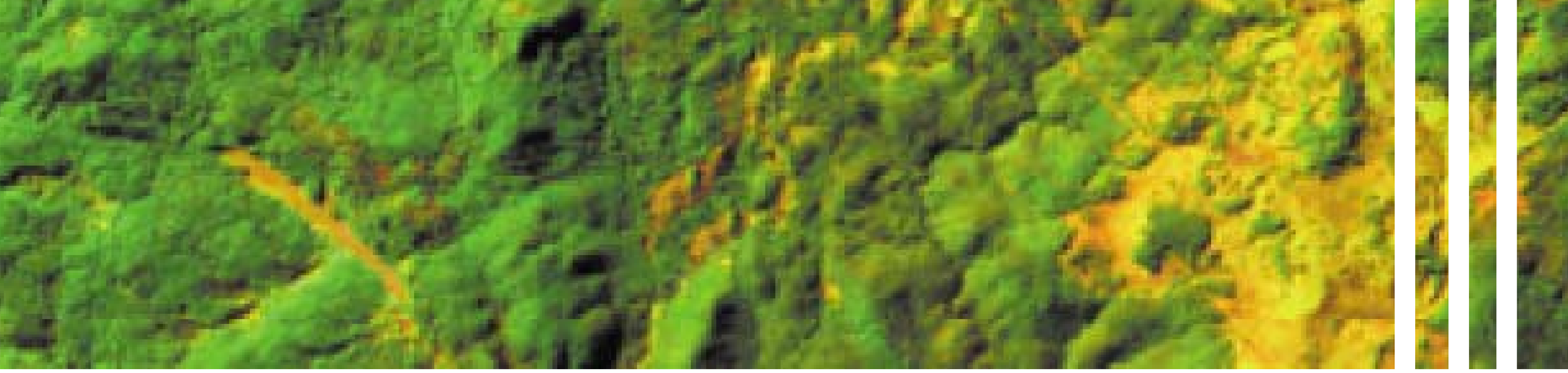

The National Carbon Accounting System provides a complete accounting and forecasting capability for human-induced sources and sinks of greenhouse gas emissions from Australian land based systems. It will provide a basis for assessing Australia's progress towards meeting its international emissions commitments.

technical report no. 26 Carbon Accounting Model for Forests (*CAMFor*) User Manual - Version 3.35