



The Carbon Farmer Model

Volume Two: User Manual

**A report for the Rural Industries
Research
and Development Corporation**

by *Hassall & Associates*



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The Carbon Farmer Model

Version 1.2

User Manual



Carbon Farmer

Version 1.2

Software that helps users investigate the potential for storing carbon in plantations of trees and entering into a carbon trading market.

Scenarios tailored to local circumstances and to particular tree crops indicate whether the economic benefits of carbon farming outweigh the costs, or, if not, how much circumstances would have to change for the net benefits to be positive.

Review Scenarios

Create Scenario

Compare Scenarios

Delete Scenarios

Introductory Help

The menu on the right mouse button offers help for this area

Hassall & Associates has prepared this model in good faith according to information available at the time. The assumptions, operating context and individual circumstances can vary dramatically and change without notice. Hassall & Associates accepts no responsibility for the use of this model and recommends that all users check their individual results with their advisers.

Foreword

In recent years there has been increasing international concern about the level of atmospheric gases that may increase the greenhouse effect, particularly carbon dioxide (CO₂). CO₂ is absorbed in the production of biomass, and so there is the possibility that emissions may be offset by storing CO₂ ('sequestering' it) in various biological 'sinks'. Many jurisdictions, including Australia, are contemplating markets for rights in sequestered carbon. In these markets, industries and other institutions may offset their emissions of CO₂ by buying rights to the carbon absorbed in the production of biomass, chiefly timber in plantations.

"Carbon farming" is the cultivation of trees in order to sequester carbon and then to obtain tradable rights in that carbon. These rights can then be sold to emitters of CO₂ and other interested parties.

The "Carbon Farmer Model" has been developed to assist advisers and farmers to decide whether it is worth engaging in carbon farming. It does this by allowing them to explore the physical and financial consequences of different assumptions about the productivity and management of plantations, the costs of cultivation and administration, and the price for which the sequestered carbon (as well as the timber itself) may eventually be traded.

The specific project objectives are to:

- Develop a working model (the "Carbon Farmer Model") that can assist its users decide whether it is worth engaging in carbon farming;
- Train groups of personnel in the fields of forestry and agroforestry in the latest information concerning carbon farming and equip them with a copy of the Carbon Farmer Model.

Volume One of this report contains the report on the project, including the consultation undertaken as part of the model development. Volume Two contains the User Manual that supports the Carbon Farmer Model.

This project was funded by the Joint Venture Agroforestry Program (JVAP). The JVAP is supported by three R&D Corporations — Rural Industries, Land & Water Australia and Forest and Wood Products. These Corporations are funded principally by the Federal Government.

This report, a new addition to RIRDC's diverse range of over 450 research publications, forms part of our Agroforestry and Farm Forestry R&D program, which aims to integrate sustainable and productive agroforestry within Australian farming systems.

Most of our publications are available for viewing, downloading or purchasing online through our website:

- downloads at www.rirc.gov.au/reports/Index.htm
- purchases at www.rirc.gov.au/pub/cat/contents.html

Peter Core

Managing Director

Rural Industries Research and Development Corporation

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Disclaimer:

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1. Introduction to the Carbon Farmer Model

The *Carbon Farmer Model* has been developed to enable people to investigate possible financial returns from storing carbon in trees.

This section provides the context for the model, explains the reasoning behind its design and then outlines a way to use the model.

Background

In recent years there has been increasing international concern about the level of atmospheric gases that may increase the greenhouse effect, particularly carbon dioxide (CO₂). These gases have been linked to global warming, which will have both good and bad consequences for Australian agriculture.

To combat these changes, the United Nations has been working toward a reduction in greenhouse gas emissions. The main action to date is agreement by most of the developed nations to the Kyoto Protocol. Within the Kyoto Protocol, countries are assigned levels of emissions that will be permitted in the first commitment period (2008 – 2012), based on their emissions in 1990. For Australia the level is 108% of its 1990 emissions. The Kyoto Protocol has still to be ratified by the Australian Government. The Kyoto Protocol allows developed countries to use international emissions trading to assist in meeting their emission commitments. The rules and guidelines for international emissions trading have yet to be negotiated.

The Kyoto Protocol recognises emissions from land use change and forestry activities. CO₂ is absorbed in the production of biomass, and so there is the possibility that emissions may be offset by storing CO₂ ('sequestering' it) in various biological 'sinks'. Many jurisdictions, including Australia, are contemplating markets for rights in sequestered carbon, sometimes called 'carbon credits'. In these markets, industries and other institutions may offset their emissions of CO₂ by buying rights to the carbon absorbed by the production of biomass, chiefly timber in plantations.

"Carbon farming" is the cultivation of trees in order to sequester carbon and then to obtain tradeable rights in that carbon. These rights can then be sold to emitters of CO₂ and other interested parties such as governments. Some additional references for the background to, and likely arrangements for, carbon farming are given in Appendix 1: References about Carbon Farming

Carbon farming provides an additional benefit to planting trees through an extra income source for sequestering carbon, but also incurs some additional costs. It is important to quantify these benefits and costs to see if the activity is worthwhile.

Whilst the basic idea of buying and selling the value of carbon 'locked up' in plantations has wide acceptance, there are still many sources of uncertainty. These include:-

1. Many aspects of the Kyoto Protocol that govern legislation remain to be negotiated.
2. The prices that will be paid for permits to emit CO₂, and even the mechanisms which will determine these prices, are a long way from being settled.
3. Every individual user will have uncertainties about the rate of growth of trees, establishment costs and the like.
4. The calculation of carbon quantities from field data and theoretical models. (The basis of the calculations used here is described in Appendix 4: Keeping Track of Carbon).

A model can help deal with the sources of uncertainty by allowing “what-if” questions to be asked and rapidly calculating the impacts of varying prices, etc. A model is especially useful when the costs (e.g. tree establishment) and benefits (e.g. harvest, and payment for carbon stored) of different actions occur at different times and the levels of these are linked to physical parameters like tree growth. The next section introduces the model.

The Carbon Farmer Model

The Carbon Farmer Model is designed to assist its users decide whether it is worth engaging in carbon farming. It does this by allowing them to explore the physical and financial consequences of different assumptions about many sources of uncertainty. It is anticipated that it will be of use primarily for advisers to farmers, individual farmers and other institutions contemplating offsetting tree-growing expenses by engaging in carbon farming.

The user (the true “carbon farmer”) is expected to be contemplating either the establishment and registration of a new tree plantation, or the registration of an existing plantation, for purposes of carbon farming. It is expected that only plantations established after 1990 will be eligible for registration, on predominantly cleared land that has been subject to a non-forest land use since 1990.

In these situations, there are some basic questions the carbon farmer will need answered.

1. What will trees produce (under local conditions) in terms of usable timber and sequestered carbon?
2. What will be the costs of establishing and maintaining a plantation and engaging in the market for sequestered carbon? It is to be expected that the plantations will have to be registered, and that there will also have to be independent verification of the carbon sequestered.

3. What returns will there be for the timber (if it is sold) and for the sequestered carbon?
4. What other benefits may arise from planting trees? Other benefits may include shelter, landscape, biodiversity and soil and water protection. These benefits are often difficult to quantify.
5. What else would be done with the piece of land in question if it were not planted to trees?

The Carbon Farmer Model responds to these issues by calculating benefits and costs based on the values of parameters like the price of timber and the growth rates of trees. The user supplies estimates of some of these parameters; in some cases suggested values are offered. The Carbon Farmer Model is generally designed to complement other tools available.

The Carbon Farmer Model is not a “carbon accounting” package, in that it does not simulate or trace the movement of carbon among various ecological pools. Instead it makes some simple assumptions about the growth of biomass and the proportion of that biomass that will be carbon. It then concentrates on the financial implications of the storage and release of that carbon, and the sale of timber. Appendix 4: Keeping Track of Carbon expands on the simple assumptions that are made.

Should users decide to go ahead with growing trees for timber and/or carbon, more detailed and site-specific carbon predictions can be made by using carbon accounting tools [see the Australian Greenhouse Office website: www.greenhouse.gov.au/ncas]. Site-specific modelling of projected growth and timber yields is also recommended.

At present, there are a number of schemes that are being offered to farmers and landholders by carbon ‘brokers’. Carbon brokers liaise between potential buyers and sellers of stored carbon. There can be a number of advantages in joining these schemes, as they can help to minimise fixed costs and risks by sharing these across a pool of carbon contributed by many landholders. Thus, they can offer economies of scale that may not be available for a small grower selling onto the open market. Each scheme will need to be reviewed on its individual merits. The model is not designed to review the variety of schemes available and assistance from your advisers is recommended.

The Carbon Farmer Model can also provide responses to broader policy questions such as “what are suitable incentives to promote tree planting in a certain region?” These types of uses are incidental rather than the main focus of the model, which is aimed at the decision point of whether a farmer or landholder should consider carbon farming, based on an economic analysis.

The Manual

This manual refers to the Carbon Farmer Model software, version 1.2

Section 2 describes the most basic and general features of the software that the user will need to know. Section 3 describes the options that the user encounters when opening the Carbon Farmer Model for the first time. Section 4 describes the layout of the central feature of the Carbon Farmer, the Scenario worksheet.

Section 5 is the heart of the manual. In it, detailed explanations are given of the assumptions about carbon farming that are covered by the Carbon Farmer, what they mean, and how to choose and introduce assumptions.

Sections 6, 7 and 8 deal with the various displays that show the user the consequences of those assumptions, in terms of the physical and financial projections that can be made about the performance of carbon farming.

Section 9 explains how to create multiple scenarios in which the effects of different sets of assumptions can be explored. Section 10 describes the options offered for comparing the results of multiple scenarios.

Section 11 and Section 12 offer some more advanced possibilities for users who wish to do some of their own modelling.

The rest of this Section explains the reasoning behind the design of the Carbon Farmer, and then outlines a strategy for the use of the Carbon Farmer.

1.1 General Concepts Used in the Model

In addition to the meaning of the individual parameters such as “carbon price” (the price for trading carbon stored in trees), the user of the Carbon Farmer Model will need to be familiar with three main concepts – the Scenario, the Tree Model and the Enterprise.

1. The Scenario

Within the Carbon Farmer Model, a set of values for all the pieces of information that are needed to evaluate the prospects for carbon farming is termed a “Scenario”. The user builds up a Scenario by entering these values in a worksheet.

Different Scenarios can be created and stored for different sets of assumptions that suit different situations or to explore different options, for example, to compare the effect of using a 30 year rotation for a plantation rather than a 25 year rotation.

2. The Tree Model

Within the general idea of a Scenario as a set of assumptions about the value of parameters, there is one subset of assumptions that is of special importance. This subset is knowledge of the growth and productivity of trees.

The Carbon Farmer Model offers seventeen “Tree Models” based on specialist research; chosen to cover a wide range of possible situations. Each of these Tree Models predicts the biomass, usable timber and sequestered carbon of a particular type of plantation under particular environmental conditions. The user is able to specify a rotation period and thinning schedules to fit particular circumstances.

Each Scenario works with only one Tree Model at a time, but a different Tree Model may be quickly selected. When a new model is selected, all costs and benefits are recalculated.

Users can also construct their own Tree Models to fit their circumstances.

3. The Enterprise

The Carbon Farmer Model uses what it calls Enterprises to model the economic consequences of uses for a piece of land *other* than tree-planting. Ultimately, it is the comparison of the results of the best *other* land use with those of carbon farming that determine whether carbon farming is economically worthwhile.

Enterprises are like Tree Models, but are generally less detailed. An Enterprise consists of a projection of gross margins and fixed costs from a number of activities (for example, different crops in a rotation). A basic Enterprise model is included with the Carbon Farmer, and this may be modified to suit the user’s knowledge of the previous and current uses of an area.

Each Carbon Farmer Model Scenario will have, at any one time, one current Enterprise being used as a yardstick of carbon farming. Other enterprises can be quickly selected or developed.

1.2 A Suggested Strategy for using the Carbon Farmer Model

Given the basic concepts of Scenario, Tree Model and Enterprise, it is possible to lay out a strategy for using the Carbon Farmer.

1. Seek out information that allows a Scenario to be built up. This will include such items as the latest data on the likely price for which sequestered carbon will be sold, the local value of timber, information about the costs and returns of alternative Enterprises, and so on. Section 5 supplies a detailed list.
2. Fill out a Carbon Farmer Model Scenario worksheet with this basic information. Section 4 explains how to navigate around such a worksheet.
3. Choose one of the possible Tree Models for the area. Again, see Section 5.1.
4. Make some assumptions about the choices available to each carbon farmer, such as when to establish a plantation, when to end the rotation of trees (which might be 'never' if the trees are being thought of as landcare plantings) and what discount rate to apply to future costs and benefits.
5. View the projected results of these assumptions.
6. Fine-tune the Scenario's assumptions (e.g. it may be unwise to thin a plantation during a period when it is being monitored for carbon sequestration).
7. Create a new Scenario and vary some of the key assumptions (e.g. different tree growth rates, the possibility of lower timber prices, etc).
8. Compare the different Scenario results.

The flowchart in Figure 1 on the next page expands on this simple sequence.

The next section introduces some basic facts about the software, before the more detailed information about how to explore the system (in Section 3) and about how to follow the steps in the strategy (in Section 5).

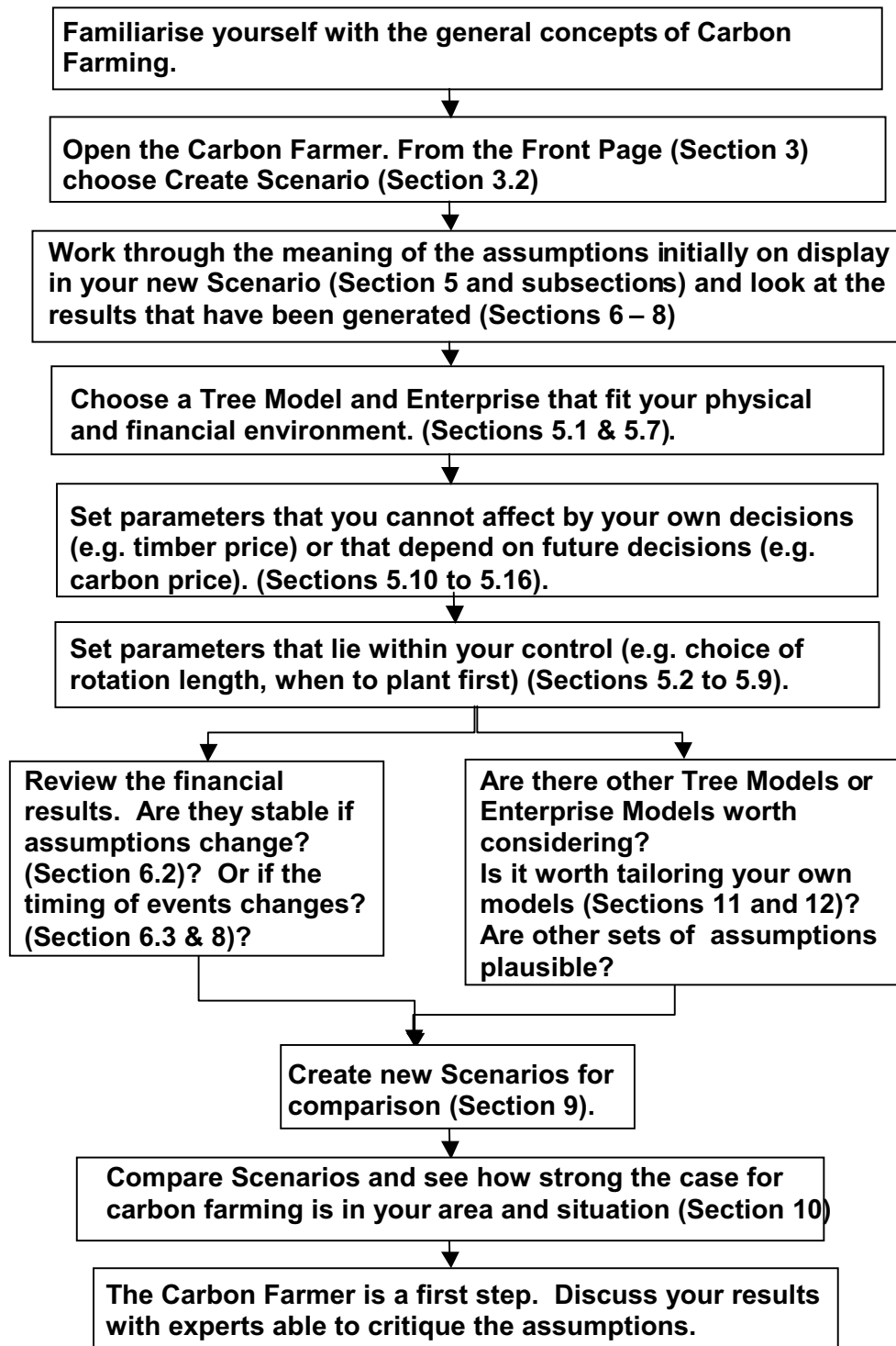


Figure 1. A suggested strategy for using the Carbon Farmer Model

2. The Software

Software specifications

The Carbon Farmer Model version 1.2 is a Microsoft Excel Workbook that is written in Excel 97, using some Visual Basic procedures, and the Goal-Seek tool. It will not run under Excel 95. It assumes only basic familiarity with spreadsheets (scrolling, selecting sheets, entering data in cells). More expert users will be able to tailor the worksheets to their own purposes.

The worksheets are protected, to prevent users damaging the system by accident, but none of the protection is passworded, and it can be removed (Tools menu, Protection option) by anyone wishing to make changes. In addition, the structure of the whole workbook is protected to prevent accidental deletion of data necessary to the functioning of the Carbon Farmer. This protection too may be removed.

As the Carbon Farmer Model contains Visual Basic macros, when the file is opened Excel will show a warning dialog box. This asks whether the user wishes to disable or enable macros. In order to use the Carbon Farmer Model the "enable macros" option must be chosen.

The safety of the macros in the Carbon Farmer Model has been checked with Norton AntiVirus, using definitions current at 23 March 2001. The user should check the Workbook with a virus checker current at the time of receipt.

Help

A number of "Help" buttons are positioned at various points in the Carbon Farmer Model software. A mouse-click on one of these will take you to the relevant part of Section 14 Introductory Help, containing material designed to answer the most immediate questions of the new user, and links to the rest of this manual.

In some areas of the worksheets, the cell menu (the menu from the right mouse button) has been augmented to give context-sensitive help that takes you to the appropriate section of this manual – a caption on the screen ...

The menu on the right mouse button offers help for this area

...identifies these areas. .

The different worksheets

There are a number of separate worksheets always present in the Carbon Farmer Model workbook.

1. When the Carbon Farmer Model is first opened, the particular worksheet called the Front Page is automatically activated. From here, Scenarios can be created, compared and deleted.
2. The Scenario worksheets themselves. Each Carbon Farmer Model Scenario occupies a separate Excel spreadsheet. There is always at least one Scenario worksheet – the “Default Scenario”: this is protected from the deletion routine just mentioned.

NOTE. A Scenario worksheet is not a Microsoft Excel Scenario Report

3. The worksheet of Tree Models. All the models of tree growth and productivity are stored in a special format on the Tree Models worksheet.
4. The worksheet of Enterprise models.
5. The worksheet on which Scenario comparisons may be displayed
6. A worksheet of suggested parameter values.

Subsequent sections of this manual, beginning with Section 4, explain in detail how to work with each of these worksheets. .

Navigating

On most of the Carbon Farmer Model worksheets there are control buttons that move the user to other areas of the current worksheet or to other worksheets. Movement by scrolling and selection of the sheet tabs at the bottom of the window may be carried out in the normal Excel fashion. However, use of the control buttons has an advantage. In a number of cases use of the buttons changes the zoom factor of the window so that a reasonable amount of the destination is visible. This zoom factor can be overridden by using the Zoom box on the Standard toolbar. Alternatively, the menu on the right mouse-button may be used to “Turn auto-zoom off”, in which case use of the control buttons does not change the current zoom level. (If auto-zoom is OFF, the same menu offers “Turn auto-zoom on”).

Moving between worksheets by selecting the sheet tabs **DOES NOT** activate this re-sizing of the window.

Colour coding and protection of worksheets

NOTE that a consistent colour coding is used on all the Carbon Farmer Model worksheets;

1. A light green background denotes labels and headings and general open space. The user is not expected even to want to change most of these cells, and they are protected. Tree Models and Enterprises included with the Carbon Farmer Model are among these areas backgrounded in green. Before altering cells on either of the Model worksheets, users should read Sections 11 and 12, where the process of editing models is explained.
2. A white (no colour) background shows the results of Carbon Farmer Model calculations. These areas are also protected. They include the areas where Tree Model and Enterprise forecasts are displayed. Generally, users should not change these except with considerable caution and after backing up the workbook.
3. A light yellow background denotes cells that are not locked. These are the cells in which the user may type. Cells where parameter values are set and other assumptions are varied are yellow. So also are cells in the Tree Models and Enterprises worksheets that correspond to models that users themselves add to the Carbon Farmer Model.

3. The Front Page

When the Carbon Farmer Model workbook is opened, a worksheet named the “Front Page” is automatically displayed (even if the workbook was saved with a different worksheet visible). This worksheet is a base from which the user can create and delete Scenarios, and access a comparison of their outcomes: these functions are accessed by clicking on the buttons to the right of the window displaying the Front Page.

The page automatically resizes to fit the settings on your computer, while this (and other internal operations) are going on there are three to four flashes and a small delay.

3.1 The “Review Scenarios” option

The “Review Scenarios” button offers a dialog box in which the names of existing Scenario worksheets are listed. Clicking the OK button in this dialog box displays the worksheet containing the selected Scenario. One of the choices here is always “Default Scenario” – this displays the basic Scenario issued with the Carbon Farmer.

NOTE. It may be better to keep only one Excel window open at a time, rather than comparing Scenarios by swapping or tiling windows. On some systems, opening more than one window can result in running out of computer memory.

3.2 The “Create Scenario” option

This choice causes a copy of the Default Scenario to be made, and stored in the workbook under a name that the user specifies by typing in a dialog box. (This name cannot be a Scenario name that is already in use.) Once the new name is selected by clicking the OK button of the dialog box, the new Scenario is created (which may take a few seconds) and displayed.

3.3 The “Compare Scenarios” option

The “Compare Scenarios” button immediately displays a worksheet that contains a comparison of the most important results for all the Scenarios in the workbook. More detail of this worksheet is given in Section 10.

3.4 Deleting Scenarios

Finally on the Front Page, the “Delete Scenario” button offers a dialog box with a list of the existing Scenario worksheets **except** the Default Scenario. **Any** user may delete any of the **other** Scenarios, and these will be **completely** lost from the version of the Carbon Farmer Model workbook that is currently in memory.

4. The Scenario Worksheet

Each Carbon Farmer Model Scenario is stored on a separate Excel worksheet, containing the assumptions made in that Scenario, and the results of those assumptions.

Each Scenario worksheet is divided into four main areas.

1. The Assumptions area, where parameter values are varied, and the choice of Tree Models and Enterprises made.
2. The Summary area, where selected results are tabulated
3. The Time Sequences area where comprehensive results are tabulated
4. The Charts area which displays the main time sequences graphically.

The relative position of these areas on the worksheet may be seen by zooming the window to a factor of about 10%, at which value the Excel Name of each area, if not the individual cells, should be visible.

Building up a Scenario is done in the Assumptions area. The other three areas allow inspection of the results. Brief descriptions of each area are given below, before the detailed information about setting assumptions in Section 5.

4.1 The Assumptions Area

When a Scenario worksheet is first activated by using one of the Carbon Farmer Model's own navigation buttons, such as the "Review Scenarios" button on the Front Page worksheet, the window opens on the Assumptions area of the Scenario worksheet, which is at the top left corner of the worksheet, and sets the zoom factor of the window to show most of that area of the worksheet. (Activating worksheets by use of the sheet tabs **DOES NOT** automatically select the Assumptions area, and the user must navigate up and to the left to find it.)

In the Assumptions area are specified the parameters that describe the particular Scenario. The names and values of the parameters are listed on the left-hand side of the screen. More detail about editing and interpreting them is given in Section 5. Some of the results are shown in a small chart headed "Options Compared", which is described below.

At the top right of the area are buttons for creating a copy of the Scenario (see Section 9), copying the current Tree Model, and copying the current Enterprise (usually copying is done

as a prelude to creating new models using the old ones as patterns – see Section 11 and Section 12).

Just below the Help button on the right are buttons to select the other areas of the *current* worksheet. (In these areas there are buttons that return the user to the Assumptions area.)

Also in the Assumptions area, on the lower right hand side, are buttons to activate *other* worksheets; the Front Page (Section 3), the Scenario Comparisons worksheet (Section 10), the Tree Models worksheet and the Enterprise worksheet. In the latter two cases, the cells on those worksheets that contain the name of the current Tree models and Enterprise of the Scenario will be selected when the worksheet is displayed.

“Quick Feedback” on the effects of assumptions

In the lower middle of the Assumptions area, there is a small chart titled “Options Compared”. This chart shows the Net Present Values* of;

1. Timber production alone.
2. Carbon farming alone.
3. Timber production plus carbon farming combined.
4. $(=3 - 2)$ – i.e. the marginal effect of carbon farming on timber production.
5. The comparison enterprise that might be carried on if trees were not planted on a given area.

All these results are automatically recalculated according to the current values of the assumptions.

To see a more detailed picture of the results it is necessary to click on the buttons labelled “Go To Summary”, “Go To Time Sequences” or “Go To Charts”. Clicking on these causes a different area of the Scenario worksheet to be displayed. The following sections explain these areas.

*Net Present Values (NPV's) are defined in Appendix 3: Net Present Values. They are used in the Carbon Farmer Model as a sensible single number for evaluating the financial success of a whole sequence of costs and benefits.

4.2 The Summary Area

When the “Go To Summary” button is clicked, the active window selects an area on the Scenario Worksheet to the right of and below the Assumptions area. This area shows a tabulation of Net Present Values of timber, carbon farming and the alternative enterprise. There is also a tabulation that shows how robust these results are, by showing how much some of the important parameters would have to change for the Net Present Values to be driven to zero. More detailed information on this area is given in Section 6.

4.3 The Time Sequences Area

In the case of the “Go To Time Sequences” button, the selection in the window moves further down and to the right of the Summary area. The Time Sequences area shows the complete outputs of Tree Models, Enterprises, and the Carbon Farmer Model’s cost and benefit calculations, all using the current values of the assumptions. More detailed information on this area is given in Section 7.

The best way to understand the layout of the Time Sequences area is to divide it into three blocks of rows. In the top block, the physical products from the trees are calculated for each year. Second, benefits and costs are attributed. Thirdly the benefits and costs of the enterprise model are calculated.

NOTE that the initial zoom factor for this area is set to a relatively large value to make the first sets of numbers in the top left of the area more legible. If the display is too large on your system to give an impression of the overall layout of this area it may be overridden by use of the zoom box on the standard toolbar.

4.4 The Charts Area

The Charts area shows the main financial and biophysical variables as charts. These charts are initially shown at a rather small scale, as their most valuable function is to detect long term interactions between the rotations scheduled for the “carbon crop” and the timing of the “commitment periods” at which the level of sequestered carbon will be assessed. More detailed information on this area is given in Section 8.

5. Setting the Assumptions of a Scenario

Overview

The user of the Carbon Farmer Model is thought of as someone who looks at the benefits and costs of carbon farming in terms of streams of dollar values, positive and negative, which arise from various sources over a long period of time. Some of these values are annual amounts, others arise in particular years only. Some are proportional to the area considered, others (like registration costs) may not be. Again, some depend on the productivity of trees, and others do not. To bring all these values to a single number when assessing a scenario, the Carbon Farmer Model discounts the streams of benefits and costs to the present year, as a Present Value (this requires the user to choose a discount rate for future values), and then adds and subtracts the Present Values to create a Net Present Value. (For more on Net Present Values see Appendix 3: Net Present Values.)

In determining these values, the user first selects the kind of tree crop to be modelled, and then describes his or her expectations about a list of possible costs and benefits, some of which are unavoidable, and some of which may be disregarded for particular purposes. The Assumptions area of a Scenario worksheet is the place where it is decided which costs and benefits shall be considered, and what parameters values shall apply to them – usually in the form of an annual dollar amount. Once the description of a user's assumptions is complete, calculation of the Scenario's Net Present Values is automatic.

In each subsection below, an assumption is discussed, and the mechanism of making a choice about that assumption within the Carbon Farmer Model is described. There are two groups of assumptions – the Main Assumptions, which are at the top left of the area and are usually visible, and the Additional Assumptions, only the heading for which is usually visible. As their name suggests, the latter are not expected to be of as much interest to the user as the Main Assumptions.

In some cases a bolded heading at the end of a subsection indicates a **SUGGESTED VALUE** with which to start the analysis.

Resetting parameter values

If the "Reset" button at the foot of the list of parameter values is clicked, the *bottom seven parameter values only* in the "Main Assumptions" area will be reset to the values from the "Suggested values" worksheet, which are the "**SUGGESTED VALUES**" given below. (Other parameters, such as the choice of Tree Model, and the area to be planted, do not have 'suggested values' to reset.)

5.1 Choosing a Tree Model

The user needs to choose an appropriate model of tree development and CO₂ sequestration, that is, a Tree Model. Each Tree Model is stored as a number of rows in a separate worksheet ("Tree Models"), from where it is copied to the Scenario worksheet when it is chosen.

The first row of data in each Tree Model is a series of values of tonnes of biomass per hectare, the second is a series of values of tonnes of carbon sequestered per hectare, and the third is a series of values of cubic metres of timber per hectare. Each column of numbers in these three rows corresponds to a year after plantation establishment, starting at zero and going to 73. 74 simulated years covers the possibility that plantations planted from 1990 onwards can be simulated from establishment through to 2063. 1990 is the starting point because carbon sequestered in plantations pre-dating 1990 is not expected to be eligible for carbon credits. The models stop at 2063 because timber production after 2063 is unlikely to have an impact on a current financial evaluation, and 2062 is the end of a possible "commitment period" for carbon accounting (see below): the 2063 year is needed for comparisons with 2062.

The values in the cells of a Tree Model may be simply numbers copied from an external source, or they may be calculations performed by formulae in the cells. Such calculations will in turn depend on biophysical parameters: some of these, relating to the ratios of biomass to carbon content and similar matters are listed at the front of the model in labelled cells. Other parameters such as the parameters that govern growth of biomass with time are stored on a fourth row in the model. A more detailed description of these model parameters may be found in Section 11.1

However arrived at, the values of biomass, carbon and timber, and any underlying parameters are intended to predict the growth of trees of (i) a particular species under (ii) particular conditions. It is up to the user to choose a suitable Tree Model to suit the circumstances at hand.

5.1.1 The Carbon Farmer Model's Own Tree Models

The Carbon Farmer Model comes with a stock of 17 Tree Models that may be of use either directly or as a basis for a model that better suits local circumstances. These models can be inspected on the Tree Models worksheet.

Table 1. The Inbuilt Tree Models

Model Name	Approximate annual rainfall needed*	Equivalent Mean Annual Increment (m³ timber/yr)**
EO: extremely fast growing plantation Eucalypts, intensively managed	>1,000mm	17
E1: very high productivity native forest Eucalypts and moderate productivity plantations	>800mm	13.5
E2: high productivity native forest Eucalypts and low intensity plantations	>800mm	10
E3: moderate productivity native forest Eucalypts	600-800mm	7
E4: low productivity native forest Eucalypts	400-600mm	4
E5: very low productivity native forest Eucalypts	<400mm	2
P1: high productivity pine plantations	>1,000mm	17
P2: moderate productivity pine plantations	800-1000mm	13
P3: low productivity pine plantations.	<800mm	8.5
Basic MAI (E0)	N/A	17
Oil Mallee	N/A	N/A
Pinus pinaster	N/A	N/A
E. globulus (Gippsland data)	600-1220	23.9
E. nitens (Gippsland data)	600-1220	16.0
E. viminalis (Gippsland data)	600-1220	23.1
Eucalyptus salignae group (Gippsland data)	600-1220	21.8
E. globulus (S.A. data)	630-930	16.8

Notes:

*The effect of rainfall on productivity is highly variable and there are a range of climatic factors, such as latitude, radiation, humidity, winds, temperature and evaporation. The production from trees growing in a 800mm rainfall in favourable conditions, for example, may do as well as other trees in a 1200mm environment. In addition, there are site specific factors such as soil properties, groundwater quality and management factors that mean that different production can be achieved than that suggested in Table 1. Consult with your adviser to determine the likely range of conditions and expected production.

**The equivalent MAI figures in the right hand column of the table correspond to average simulated growth 2009 2030, and are not true for all years.

Figure 2 shows the behaviour of these models through time.

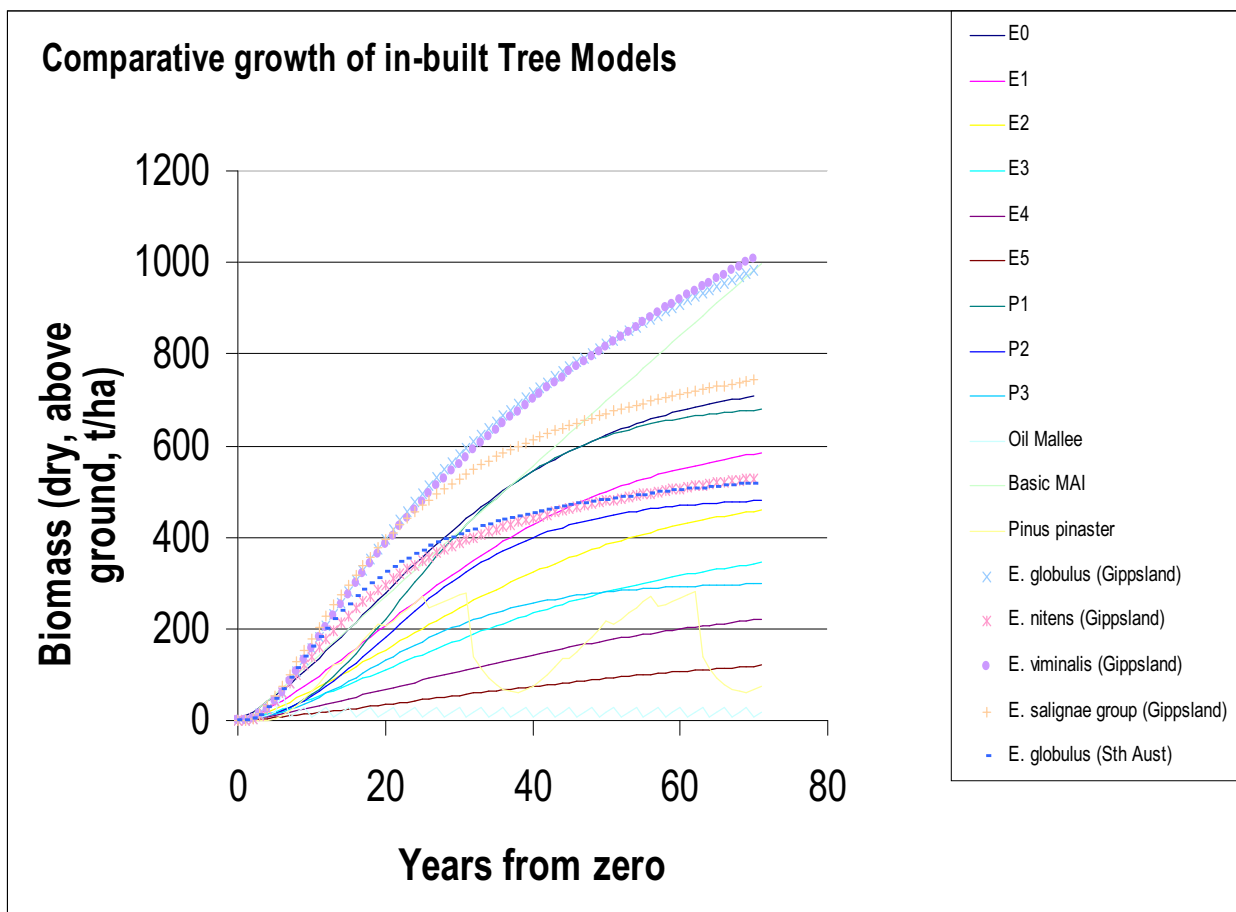


Figure 2. Biomass performance of Tree Models

The circumstances for the different Tree Models

The Carbon Farmer Model's in-built tree models cover five rather different suites of circumstances.

1. The first 6 models represent the growth of Eucalypt plantations in a range of environments, from exceptionally favourable (the first model) to relatively unfavourable. The models use a general classification in terms of productivity to capture a large range of potential parameters like species, rainfall, intensity of management, soil and site conditions, etc.

Each of these models is based on the fitting of a curve to data selected by the designers of the Carbon Farmer Model. The curve that is used is the Gompertz function (see [Appendix 2 – The Gompertz Equation](#)). In each case, the curve predicts dry, above-ground biomass in a given year, this value is converted to values of usable timber and sequestered carbon (above and below-ground). [Appendix 4 – Keeping Track of Carbon](#) describes the procedure in more detail.

2. The next 3 models represent pine plantations in a similar range of environments, also using the Gompertz function to model growth.
3. The tenth model is an exceedingly simple one which models linear increase in timber with time, using a growth rate (Mean Annual Increment or MAI) value that reaches the same timber volume at age 30 as the most favourably situated Eucalypt in the first group of models (after this, it overpredicts, which will not be a significant problem except for very long rotations).

All the first ten models simulate uninterrupted growth, on which the user imposes rotations and thinning periods (this is termed a “free” model – see Section 11.1). How rotations and thinnings are imposed is described below in Sections 5.4 and 5.5.

4. The eleventh model represents the growth and repeated harvesting (thinning) of an Oil Mallee crop. This model differs from the others in that the rotation is a very long one and it is the biomass rather than the timber as such that is the product.
5. The twelfth model represents the growth of *Pinus pinaster* under a rotation of 30 years.

These last two models are termed “frozen” models (by contrast with “free”) because the user may not vary the rotation and thinning periods. Instead, standard rotations and thinning intervals are loaded in by the Carbon Farmer Model when the user selects these models as part of a Scenario.

6. The 13th to 17th models are based on curves fitted to data from a number of Australian sources by Wong *et al* (2000)¹. In the first four cases, the data comes from tree-growth experiments in Gippsland: the first three of these refer to the separate species named in the Table and the fourth to pooled data from three species (E. botryoides, E. grandis and E. saligna). The fifth model refers to data for E. globulus from South Australia.

These are 'free' models that depend on one parameter, the "site index" – the height of the tree at age 10 years – rather than the rainfall classes of the first group of models. The user may select a model from this group according to species and then alter the single site-index parameter (see Section 11.2 for methods) to reflect local knowledge. Note that the predictions of these models are being made for time periods that greatly exceed the times covered in the original data and the work of Wong *et al*.² This should be borne in mind when long rotations are being simulated.

Figure 2 comes from a chart on the Tree Models worksheet. It may be accessed quickly from any of the worksheets by selecting the Name TreeGraphs in the Name box at the top left of the window. New models created by users will not be added automatically to this chart, but it can be edited in the usual way.

The names of some of these Tree Models are a clue to the type of environment that they are intended to suit. Others must be adapted before they will be of use, and in these cases the user may need to know something about the parameters involved. It may be necessary to review Section 11 on the editing of Tree Models (and refer to local knowledge of plantation performance) to produce a version of a model that applies to a particular environment.

5.1.2 How to Choose An In-built Tree Model

The user chooses a particular Tree Model by making a choice from the drop-down list of names in Cell B3, using Table 1 as a guide. It is possible to create new models, or variations on existing ones by following the rules given in Section 11. Once these new models have been created, they can be accessed via the same drop-down list as the in-built models.

When the user selects a particular Tree Model, the values in the necessary rows and columns are copied from the "Tree Models" worksheet and inserted into the appropriate rows and columns of the Scenario Worksheet in the "Time Sequences" range. The cells

¹ Wong, J, Baker, T, Duncan, M, McGuire, D and Bulman, P. (2000). Forecasting growth of key agroforestry species in south-eastern Australia. RIRDC Publication No 00/68

² To create these models, the formulae that Wong *et al* (2000) derived for basal area and height (as functions of site index and time) were substituted into their formulae for timber volume to create a function $V = f(SI, t)$ which Wong *et al* did not directly estimate. This timber volume is then converted to dry above-ground biomass using the same ratios as the other models, and this biomass value is used as the model variable.

containing formulae for costs and benefits (which may be seen in the Time Sequences area) read these inserted values as inputs.

NOTE that it is only *values* (in the Excel sense), i.e. *numbers*, that are inserted. Any *formulae* calculating tree growth (again in the Excel sense) exist only on the "Tree Models" worksheet.

NOTE also that changes made on the Tree Models worksheet have no effect on the results shown in any Scenario worksheet until the changed model is selected in the Assumptions area. If such a change is made to the current Tree Model, the effect will not be seen until a different model is selected in the Assumptions and then the changed model is re-selected.

5.2 When to Plant

Under the Kyoto Protocol, the sequestering of CO₂ in trees can only be counted as an offset to emissions if the trees were planted in 1990 or later. The effect of sequestration will, however, only be measured in terms of the amount of carbon stored within a number of "commitment periods", the first of which begins at the beginning of 2008 and ends at the end of 2012. Thus no credit will be given for carbon that has accumulated before 2008. Definitions of eligible activities have not been agreed upon at the international level.

Other things being equal, the carbon farmer will want the trees to be growing as fast as possible in the period 2008-2012 inclusive, as the carbon credit will be equivalent to the difference between the amount stored at the start and end of the period. If there are subsequent commitment periods, the growth of the trees in those periods may need to be considered. One possibility is to plant trees at such a time that they will be growing at their peak rate in the relevant years. The timing of thinning and harvesting operations around the first commitment period will be important in determining whether there is an overall carbon loss or gain from the site during that period.

To set the date of planting, the user makes a selection from the drop-down box in Cell B4. The range is from 1990 to 2010, by single years.

When the user chooses a year, the Carbon Farmer Model inserts 63 columns of the chosen Tree Model's predictions of tree growth into the Scenario worksheet in rows 70 to 72, starting in column AE. (This is towards the top of the Time Sequences area.) If a year before 2000 is chosen, the Carbon Farmer Model copies in the years of the tree model that would be expected to occur from the year 2000 and subsequent years up to the end of 2063. 2062 is chosen because (a) effects of choices at such a distance from the present are small (b) it is the end of what may be a commitment period for carbon trading (see below, Section 5.3). (The year 2063 is needed for comparisons with 2062.) If a year after 2000 is chosen, the

first few columns are filled with zeroes and the Tree Model values are inserted with the necessary offset to the right.

When to start counting returns?

Specifying a planting date introduces a subsidiary question. What happens on the area in question before the trees are planted? There are two points of view about this. One is that the object of the analysis is to reveal the value of carbon farming itself, whenever it begins. In this case, the value of whatever is done earlier is irrelevant. On the other hand, one may wish to select the best use of a piece of land. In this case, the value of use is the value of whatever occurs between now and the time that trees are planted, plus the discounted value of trees once they are planted.

The Carbon Farmer Model is presently set up to take the former point of view. *Neither* the Enterprise *nor* the plantation is taken to return *any* value in the years between now (2000) and tree planting. To change this, the user may go to the Additional assumptions area of a particular Scenario and change B23 (among the Additional Assumptions) from FALSE to TRUE. If this is done, NPV results will assume that “carbon farming” consists of the Enterprise from year 2000 until the year before the trees are planted, followed by the Tree Model results starting from year of planting.

Calculations for the Enterprise itself, on the other hand, always run from 2000 to 2062.

5.3 How Far Ahead To Look? Commitment periods

A commitment period is a span of years over which the parties to the Kyoto Protocol are required to report the net change in greenhouse gas emissions by sources and removals by sinks, measured as changes in carbon stocks. Commitment periods are central for the purposes of calculating the returns for carbon farming.

So far only one commitment period, that from 2008 to 2012, is a relatively assured prospect. In the life-time of trees, however, five years is not a long prospect. The user may, therefore choose an assumption about how many commitment periods there will be. The maximum number of periods considered by the Carbon Farmer Model is eleven, which takes the period for analysis to the end of 2062. There is not an option to choose a different length of commitment period other than five years.

The number of commitment periods to be assumed is set by using the drop -down list in Cell B5, which offers whole numbers from 1 to 11.

Formulae in the Times Sequences area of the Scenario Worksheet that calculate costs and benefits of carbon farming include 'IF' statements for the years corresponding to the ends of

commitment periods. These statements test for whether a benefit is to be calculated over that period (i.e. whether that commitment period has been selected).

5.4 Rotations

While ordinary forestry practice in a given environment may suggest a particular rotation length, the user may have considerable freedom of choice. Is it intended that the trees be harvested at all? If for example their main use is actually as an environmental planting they might be retained indefinitely.

The user determines the length of the rotation by entering a number in Cell B6. This number must be between 2 and 100 (100 being effectively “forever”).

The Carbon Farmer Model simulates rotations of tree crops by restarting the tree growth from its year 1 value in the year after a rotation ends, and continuing this pattern to simulated year 2063. The first rotation is measured from the year of establishment (not year 2000). At the end of each rotation period, all of the timber is removed and sold for the value set in Cell B11 in the Assumptions (see Section 5.10).

NOTE that one possibility for future legislation is that the carbon removed during harvesting may be taken as being released, and the carbon farmer may have to pay for its release (see Section 5.12 below, which outlines the different options).

NOTE also that for some models the rotation is already specified in the model. In these cases the cell will reset itself whatever the user types. See Section 11.1.

5.5 Thinning

Three kinds of thinning are currently possible in the Carbon Farmer: “First”, “Second” and “All later”, all of which apply to every rotation. At each thinning in each rotation, a specified percentage of the timber is removed, and is assumed to be sold for a price that the user specifies, which may be zero. This price needs to be a net price, with costs deducted from gross receipts. To create a “non-thinning”, set the percentage of timber removed to zero.

NOTE that one possibility for future legislation is that the carbon removed during thinning may be taken as being released to the atmosphere, and the carbon farmer may have to pay for its release (see Section 5.12 below, which outlines the different options).

Thinning in a commitment period will probably also reduce the amount of carbon measured as being sequestered over that period.

The user sets a thinning policy by filling out the three rows of the table in Cells E6 to G8.

The first of these three rows corresponds to the first thinning in a rotation.

In the left hand column, a year for the thinning event can be chosen. The number (N) here can be read as “the first thinning will first take place in the Nth year of the rotation”. Numbers greater than (the rotation length –1) cannot be entered in this cell.

The corresponding cell in the middle column allows specification of thinning intensity, in terms of the percentage of timber that will be removed.

Finally, in the right-hand column, the user must fill in a number representing the price of the thinnings. If this is zero, there will be no economic returns, but carbon losses will still be calculated, and simulated timber ‘removed’.

The second row corresponds to the second thinning in a rotation. Here the number (N) in the left hand column is to be read as “the second thinning will occur in the Nth year after the start of the rotation”: the other two columns have the same meanings as the corresponding ones in the first row.

The third row corresponds to all subsequent thinnings, as for example where coppicing is being practiced. Here (N) is to be read as meaning “thinning will occur in every Nth year after the second thinning” but the other columns of the table have the same meaning as before.

NOTE that for some models the thinning is already specified in the model. In these cases the cell will reset itself whatever the user types. See Section 11.1.

In order to simplify investigations of the effects of thinning, Cell D5 contains a toggle button which determines whether or not the thinning policy has any effect on the results or not. When the button is ‘depressed’ and reads “Thinnings Active”, the thinning policy described in the table is ‘put into effect’. When the button reads “Thinnings Inactive”, calculations are carried out as though the Percent Thinning is zero in every case.

To simulate the effects of thinning in a way that is compatible with even very simple Tree Models, the Carbon Farmer Model restarts the Tree Model from the last year that has the biomass $\leq$ (current biomass minus the specified thinning). This simulation of thinning leads to some inaccuracies, since real trees will never come back exactly to the history of growth of an un-thinned stand, as the simulated trees do.

NOTE that a severe thinning that leads to a biomass less than the biomass of year 1 of uninterrupted growth will result in restarting of growth from year 0, which will be treated as re-establishment after a rotation, and will attract a new set of establishment costs.

We have not at this stage a general **SUGGESTED VALUE** for thinnings, as in some cases they will have essentially no value.

For the special case of the Pinus Pinaster model a **SUGGESTED VALUE** for the first thinning would be \$14.50 \$/ m³ and for the second (repeated) thinning \$20 / m³.

For the other special case of Oil Mallee production, the **SUGGESTED COMMON VALUE** of all thinnings is \$15/t. (NOTE that with Oil Mallees the product is t of biomass not m³ of wood.)

These **SUGGESTED VALUES** are not reset by the Reset button.

As with all suggested parameter values, use the model to determine how sensitive the results are to the parameter.

5.6 Choosing an Enterprise

The choice of an Enterprise is a simpler version of the choices relating to Tree Models. It is simpler because no elements of timing, or long-term harvesting apply. An 'Enterprise' is simply a number of rows in the worksheet, each cell of which lists the gross margins or the fixed costs of a year of, for example, running a given number of sheep per hectare. The Enterprise always runs from 2000 to 2062 but only the years within the Planning Horizon (see below) count in the calculation of NPV's.

The user chooses an Enterprise by making a selection from the drop-down list in Cell B7. As with Tree Models, new Enterprises can be created by the user, and, when completed according to the rules of Section 12, can also be accessed from the drop-down list.

Also as with Tree Models, the Carbon Farmer Model applies an Enterprise to a Scenario by inserting the relevant values from another worksheet (in this case the "Enterprises" worksheet) and pasting them in the lowest rows (116 downwards) of the Time Sequences area of the Scenario worksheet.

Unlike the Tree Models that come with the Carbon Farmer, the Enterprises that are included are no more than a sketch of what the user may choose to do. It is assumed that users will be familiar with alternatives to carbon farming, even if they are not familiar with carbon farming itself!

5.7 Planning Horizons

The planning horizon is the length of time from the year 2000 to be considered in the Carbon Farmer Model's financial analyses. Benefits and costs occurring after the planning horizon are not included in calculations of Net Present Value and Internal Rates of Return. (Outputs, benefits and costs for each year are still calculated and plotted.)

If the value in Cell B8 of the Assumptions area is set to N, then benefits for the year 2000 and N -1 subsequent years only are included in financial calculations.

NOTE that the planning horizon is set independently of the rotation period and the establishment of a plantation. Costs incurred before year 2000 also fall outside the scope of financial calculations.

5.8 Area to be Planted (ha)

The Tree Models and Enterprise Models return their values in terms of dollars per hectare and physical quantities per hectare. On the other hand, some set-up costs are fixed costs, whatever the area. To value an entire carbon farming scheme it is therefore necessary to specify the area of the intended plantation. Cell B9 takes the net area intended, in units of hectares. The net area must take into account firebreaks, buffer strips, watercourses and roads and is, in effect, the planted area.

5.9 Establishment Costs (\$/ha)

These are the costs of actually creating a plantation – such as clearing, initial fertilisation and planting – without reference to whether carbon farming is ever carried out. They are not intended to cover subsequent costs such as later fertilising, roading, and management in general. The establishment costs are treated as occurring in the year of planting, if that year is later than or equal to the present one. If the year of planting is before 2000, no costs are incurred, whatever cost estimate is typed in Cell B10.

NOTE that these costs are per-hectare costs.

These costs are added into financial result for timber, and timber+carbon, but not carbon alone. Users can unprotect the worksheet and alter the formulae in row 91 if they wish to introduce a non-recurrent cost.

A SUGGESTED establishment cost is \$2,000/ha, although the range could be between \$800 and \$3,000/ha. In the case of Oil Mallee a reasonable value is \$1,500/ha, and a value for Pinus Pinaster is \$1,000/ha.

As with all suggested parameter values, use the model to determine how sensitive the results are to the parameter.

5.10 Timber Stumpage Value (\$/m³)

This is the selling price to be expected when trees are harvested at the end of the rotation. Technically speaking, the value to be used is the stumpage value of standing trees not adjusted for inflation (\$/m³).

There are three timber prices that are often used: stumpage (trees standing), along roadside (cut down but not transported) and mill door (harvested and delivered). The user must ensure that they are using stumpage for the value in Cell B11. This has the effect of ensuring that transport and harvest costs are taken into account in the net price received.

(Alternatively, users may alter the formulae in row 91 of the Time Sequences to include transport or harvest costs (see Section 5.9). This row is intended for costs like transport and harvesting that are not part of carbon production, but in this version of the Carbon Farmer Model it is set up for recurrent costs only.)

NOTE that transport costs are often a major determinant of the profitability of timber farming. They are a function of the distance that the timber product has to be transported. This complexity is the reason that they are not explicitly included in this version of the Carbon Farmer.

In this version of the Carbon Farmer, only one timber product is shown. In fact, there may be many timber products and classes of sawlogs, each attracting different prices. Hence, the value of timber will need to be a weighted average, according to the timber mix.

A SUGGESTED VALUE is \$30/m³, although obviously this will vary according to type and mix of product, intensity of management (like pruning), distance to mill and a range of other factors.

For the special case of Pinus Pinaster, a **SUGGESTED VALUE** is \$24 / m³, which is a weighted average over a number of different products.

For the special case of Oil Mallees, a **SUGGESTED VALUE** is \$15 /t biomass, which is net of transport costs (see the next section) and is the same as the thinnings value described above. (NOTE that with Oil Mallees the 'timber' product is t of biomass not m³ of wood.)

As with all suggested parameter values, use the model to determine how sensitive the results are to the parameter.

How to include non-timber benefits from trees

Specifying a timber price introduces a subsidiary question. What are the other benefits from planting trees, apart from timber or carbon? These benefits might include: shelter, biodiversity, soil and water management. Such benefits are not only of many different kinds but hard to quantify, and the Carbon Farmer Model does not attempt to calculate any of them.

Instead, the Carbon Farmer Model allows an additional annual benefit not linked to the carbon or timber calculations to be incorporated. The user may go to the Assumptions area of a particular Scenario and insert a figure for the annual benefit into Cell B19 (among the Additional Assumptions). This will be treated for the purposes of NPV's as a benefit that is received each year from the first planting of trees.

Users who wish to develop their own formulae for benefits, or insert numerical estimates that vary with the age of the trees may insert them manually in row 86, in the Time Sequences area.

5.11 Carbon Farming Set-up Costs (\$)

In effect, selling a carbon offset is a legal agreement like selling a house. Once a decision is made to go with carbon farming, various costs of registration, solicitor's fees and so forth will be incurred. In the Carbon Farmer, these costs are treated as occurring in 2008, at the beginning of the first (default) commitment period, and then **recurring** at the start of all subsequent commitment periods. The amount, however, is available to be changed by the user according to the particular time and place. In practice, it might be hoped that later periods would be less expensive to administer than the first, and this may be reflected in the number that the user chooses.

The set-up costs are treated in the Carbon Farmer Model as *independent* of the area planted. (Cell B12).

A SUGGESTED VALUE for this parameter is \$2,500. As with all suggested parameter values, use the model to determine how sensitive the results are to the parameter.

Using a broker or joining a carbon pool may help to reduce these set-up costs.

5.12 Carbon Price (\$/tC)

This is the price of the carbon sequestered in the trees, the value that will be used in counting the carbon credits that will accrue after commitment periods. It is applied to the difference between the carbon found to be present when measurements are made in the first year and that found in the last year of the commitment period. The carbon benefit is treated in the Carbon Farmer Model as being obtained at the end of the commitment period, after any verification procedures. The carbon price is quoted in tonnes carbon. Another unit that is used is tonnes carbon dioxide equivalent – to convert, multiply by 3.67.

The price of carbon will be market based and can go up or down according to how the market operates. This implies there is substantial risk involved. We have only included one price for carbon, in the absence of better information to the contrary. Future versions of the Carbon Farmer Model may investigate other options.

A SUGGESTED VALUE is \$10/tonne carbon. As with all suggested parameter values, use the model to determine how sensitive the results are to the parameter (Cell B13).

The Carbon Farmer Model incorporates a working assumption that the carbon credit is “in perpetuity” or lasts forever. This may make carbon farming unattractive, because trees do not last forever. A concept of a “tonne/year” may be a more attractive option for carbon farming. Later versions of the Carbon Farmer Model might include the capacity to work with alternative definitions.

Buying back carbon

One of the most controversial issues in carbon farming is what should happen when carbon is released or when (which is not usually the same thing) the trees containing the carbon are harvested. It is considered quite likely that carbon farming legislation will require the carbon farmer to buy back the carbon sequestered, if the trees in a plantation are cut down, burnt or otherwise destroyed. Evidently, this may have a major impact on the profitability of carbon farming, even though it will usually only come into effect at the time of the end of a timber rotation.

If the checkbox in cell C13 is ticked, the Carbon Farmer Model assumes that a buyback will be enforced on both harvest and destruction of trees, and also on thinnings carried out during the course of silviculture.

NOTE that thinning or harvesting during a commitment period may *also* reduce the amount of carbon apparently sequestered between the beginning and the end of that period, leading to a loss of carbon benefit.

5.13 Monitoring (\$/ha)

Treated realistically, monitoring may be quite complex. While the main measurements to be made would be those at the start and at the end of commitment periods, (these measurements being needed to establish that claimed amounts of carbon had in fact been sequestered), other events such as fire and thinning might need to be documented. Here it is assumed that validation of commitment periods attracts costs of the amount specified in Cell B14, and that the costs are proportional to the area planted. Inspection of the Time Sequences will show that these costs are actually incurred at the start and the end of commitment periods.

A SUGGESTED VALUE is \$10/ha. As with all suggested parameter values, use the model to determine how sensitive the results are to the parameter.

5.14 Land Rental (\$/ha)

This cost is intended to cover the point that land will still incur costs whether carbon farming is carried out or not. Alternatively, the user may need to lease land, at commercial rates, to undertake the timber or carbon farming.

The user is able to include or discard this assumption by checking the box in cell C15, next to the rental value cell. If land rental is included, the net value of carbon farming and timber production will have this rental subtracted in every year *after the establishment of the plantation*. For comparison of timber and carbon farming with the alternative enterprise, rental should be omitted.

A SUGGESTED VALUE is \$100/ha, or 5% of the cost of the land. As with all suggested parameter values, use the model to determine how sensitive the results are to the parameter.

5.15 Discount Rate (%)

When determining the Net Present Value, the discount rate is the actual rate that is used to convert future values into today's values. The discount rate can also be based on "opportunity cost", that is, what the money would be worth for other purposes.

The discount rate can include a "risk" component. Thus a higher risk situation probably calls for a higher discount rate to be used.

The discount rate may also be used as an informal way of changing the emphasis given to future events, such as the end of timber rotations. A larger discount rate will suppress the effect of future rotations on NPVs.

A SUGGESTED VALUE is 7%, which is also the discount rate used by some government agencies. As with all suggested parameter values, use the model to determine how sensitive the results are to the parameter (Cell B16).

5.16 Other ‘Additional Assumptions’

The Additional Assumptions heading covers five subsidiary assumptions, two of which (“Other plantation benefits” (Section 5.2), and whether Enterprise benefits are received from the planted area before tree-planting (Section 5.10)) have already been mentioned. In addition, there are three categories of cost which the Carbon Farmer Model does not consider in detail, but which the user may introduce in a simplified way. These are named in cells A20:A22 as;

1. Maintenance & management costs (after establishment) (\$/ha),
2. Other timber costs not contributing to carbon sequestration, e.g. transport (\$/ha), and
3. Other carbon costs not contributing to timber production e.g. carbon insurance (\$/ha).

They correspond to rows 90, 91 and 95 in the Time Sequences.

Despite these differing names, values that are entered in cells B20:B22 will all be treated by the Carbon Farmer Model in exactly the same way: as annual costs that begin to be incurred in the year of planting. Note that all these items are proportional to the area planted.

Additional Assumptions are not covered by the Refresh Sensitivities, or Scenario Comparison routines, and are not affected by the Reset button in the Assumptions area.

6. Reading the Summary of Outputs

If the button labelled "Go To Summary" is clicked, area of the Scenario worksheet that is selected changes to display a table. This table contains three types of results.

1. The Net Present Values* that are the “bottom line” of the whole carbon farming exercise.
2. The sensitivities of the Net Present Values to changes in parameter values.
3. One limited type of advice – the best year to establish a plantation, from the point of view of each category of Net Present Value.

*Net Present Values (NPV) are defined in Appendix 3: Net Present Values.

6.1 Net Present Values

These results in the first row of the table are the Net Present Values (NPVs) of various combinations of farming for forestry only, for carbon only and so on. (Net Present Values are defined in Appendix 3: Net Present Values.)

These numbers are the ones plotted in the Options Compared chart in the Assumptions area. As such, they represent the nearest thing that the Carbon Farmer Model offers as a “bottom line” for carbon farming. These results depend particularly on the choice of discount rate (Cell B16), but also on the other parameters.

NOTE that these NPVs are calculated for the year 2000, using costs and benefits up to the Planning Horizon (or year 2062, whichever is the less) only.

The most difficult feature of these results to comprehend is usually the behaviour of the number called “carbon margin”. This is defined as the NPV of carbon farming plus timber minus the NPV of timber alone. It is the additional benefit (or cost) achieved by undertaking carbon farming as well as ordinary tree farming.

The puzzle may be to explain how a negative ‘carbon only’ farm can have a positive carbon margin. The basic reason that this occurs is usually that carbon farming builds on the back of tree farming by sharing some of the same establishment costs – notably planting the trees. Careful scrutiny of the rows in the Time Sequences area will eventually make such results more plausible to the user (or reveal faults in the Carbon Farmer).

6.2 Sensitivities

Below the Net Present Values in the Summary table is a table that shows how sensitive the NPVs are to changes made in the assumptions in Cells B9 to B16 of the Assumptions area. (Each of these sensitivity values is calculated leaving all the *other* parameters at their assumed values.)

In each cell of this part of the table appears the value that the parameter named in the left hand column would have to take, in order for the NPV at the top of the column to change from its value under the current assumption to a value of zero. For example, the value in Cell P31 shows what area would have to be planted for the Enterprise to break even in the long term (at the assumed discount rate etc).

Most of these numbers are calculated by the Excel Goal Seek routine. If the routine cannot find a number, then a “-“ is inserted in the table. This may occur, for example, if the NPV remains positive no matter what the value of a parameter.

The last row of this part of the table is different. The discount rate that sets NPV to zero is the same as the Internal Rates of Return (IRR). The value in the cell is that given by the Excel IRR routine. In some cases no sensible IRR can be calculated for numerical reasons. In this case, the cell in the table is given the value “Not computable”. In other cases, no variation of discount rate can serve to bring the activity to break-even point, as in the case of an enterprise which is profitable in every individual year. In this case, the cell in the table is given the value “Not defined”.

NOTE that these IRRs, like the NPVs are calculated for the year 2000, using costs and benefits up to the Planning Horizon (or year 2062, whichever is the less) only.

Interpretation of the results is not always straightforward, especially when there are apparently nonsensical negative table entries, but these usually do mean something that is relevant to carbon farming decisions.

For example, a negative value in Row Cell M31 indicates that the break-even area to plant is negative. This means that at least some per-area costs have to be removed or even turned into benefits (e.g. by subsidies) before ‘carbon only’ farming becomes a profitable exercise.

For another example, a negative value in a cell in row 34 would mean that paying people to set up carbon farms may be an appropriate policy option; other costs are apparently exceeding benefits, and the only way to redress this by varying set up costs is not merely by reducing them to zero, but by converting them to a subsidy.

It is usually worth looking at the results for the “Carbon Margin”. Since carbon farming to some extent rides on the back of timber production there is often a synergy between the two, and this synergy usually shows up in a carbon margin that is positive over a wide range of parameter values.

NOTE also that while the NPVs and IRRs are recalculated automatically every time an assumption is changed, the other sensitivities are not. The Carbon Farmer Model uses the Excel Goal Seek add-in to calculate the sensitivities. This has not been automated to occur every time the Summary area is displayed because it is a relatively slow process. To see the effects of a change in assumptions, click the button labelled "Refresh Sensitivities".

Failure of the Goal Seek routine to converge is indicated by a "-" in the table. This may be either a Goal Seek problem or a Carbon Farmer Model problem, but usually means that the parameter being changed has no effect on the NPV being investigated.

Sometimes the Goal Seek will fail leaving one parameter set to an absurd value. In these cases, re-entering the correct value in the Assumptions area should free the system up again.

Alternatively the failure of the table to update may mean the Goal Seek add in has not been installed: in this case, see the Excel on line help or manual.

6.3 Optimal Planting Dates

The last two rows of the Summary Table contain a rather different type of entry to those above. As was indicated in the section on Carbon Farming strategy, the main free choice left to the carbon farmer is when to plant. The dilemma is that, while planting early brings the revenue from selling timber forward, planting too early may mean that the timber is not absorbing CO₂ at its highest rate during commitment periods. The numbers in these rows are intended to offer guidance here.

When the “Refresh Sensitivities” button is clicked, the Carbon Farmer Model selects all planting dates from 2000 to 2008 in turn (keeping all other assumptions at their assumed values) and records which planting date maximises the NPV of timber, of carbon alone and so forth. The optimal planting dates (from each point of view) and the corresponding Net Present Values are then tabulated.

NOTE that this simple optimisation does *not* go into the complexities of adjusting rotation and thinning to fit around commitment dates, which may affect the decision on when to plant. Some trial and error, coupled with inspection of the charts of results may be needed to clarify these issues.

7. Reading the Detailed Time Sequences

Because of the size of the Time Sequences area, when it is selected by the use of control buttons the window is automatically split and its panes frozen. The headings labelling the main categories of costs and benefits occupy the left hand (frozen) side of the window, and the dates of simulated results occupy the (frozen) top of the window.

When a return to other parts of the Scenario worksheet is triggered by using the control buttons in this area, the split is automatically removed.

The scrolling section of the window has three main sub-areas. The top sub-area shows the physical products of the plantation – timber, carbon and biomass. In the middle are the dollar costs and benefits of the plantation. At the bottom is the Enterprise results (which are all in dollars). This structure reflects the fact that the Enterprise may have a flexible number of rows, depending on the interests of the user (See Section 12), while the first two areas are of fixed size. Column AD of the results (the second column of the scrolling region) is reserved for the formula calculating the NPV of each row of results.

The first area contains (rows 70-72) the projections of tree growth according to the current Tree Model. It also contains some derived quantities in rows 73 –77; thinnings amounts and changes in carbon from year to year. Also included (row 76) is the price for a particular year's thinnings, which is inserted by the Carbon farmer for use in formulae below.

The second area (rows 82-113) is the one where most of the detailed financial calculations that are the heart of the Carbon Farmer Model take place. If this manual leaves open questions about how individual costs or benefits are calculated, or what year or event they are assigned to, inspection of these rows gives the definitive source of the numbers in tables and charts.

Rows 115 onwards show financial projections for the current Enterprise model, in the same format as they are shown on the Enterprises worksheet.

Below the results for the Enterprise is the source of the Internal Rate of Return results that may be seen in the Summary table.

8. Charts, Physical and Economic

As an intermediate degree of condensation between the Time Sequences layout and the Summary layout, the charts in the Charts area are offered. These charts show the physical and financial data from the Time Sequences area. The data that they show may be altered by the user, by altering their source data (see the Excel help), under the usual condition of un-protecting the Scenario Worksheet.

All the charts share a common feature – a row of between 2 and 12 “X”s across the middle. These symbols represent the start and end of the commitment periods selected by Cell B5 in the Assumptions area – two symbols in the case of one period and five in the case of four, and so on.

In the bottom left chart, the physical level of sequestered carbon is the black trace, and standing timber the green one. This chart is a useful check to show the interactions of rotation and thinning. Apart from serving as a check that these are occurring when they are supposed to, they allow observation of the general behaviour of the Tree Model.

The top left chart simply illustrates the peaks in benefits and troughs in costs for the timber production itself. Peaks occur when rotations end, or thinnings are sold. Troughs occur when plantations must be established at the start of a new rotation. The value of this chart is as a signal of whether the sizes of peaks and troughs are realistic. Any problems may have to be followed through first the Assumptions area, and later the rows in the Time Sequences area that list the benefits and costs of timber itself

In the top right chart the net benefits of carbon farming alone are shown as a dark blue trace. In the bottom right chart, the Enterprise Model’s output is shown in violet.

Typically the carbon net-benefit trace is one of a series of brief peaks occurring at the end of commitment periods (the X’s indicate the boundaries of commitment periods), with sharp troughs at the time of establishment, thinnings and timber harvesting. (Troughs only occur for thinning and rotation ends if the “buy back carbon” check box in the Assumptions area has been checked: see below for more on this.)

Careful reading of this chart can help in the ‘debugging’ of a carbon farming strategy. A general maxim seems to be that complicated patterns of thinning (and short rotations) interact with commitment periods in a very complex way.

Thinning, or turning over a rotation, in the middle of a commitment period may wipe out the apparent sequestering of carbon in that period, or convert it into a loss, since the amount of

carbon at the end of the period may not recover to the level at the beginning. These losses, absolute or relative, have to be set against the returns from harvesting timber.

On the other hand, thinning near the start of a commitment period may increase the rate of sequestration during the period, and increase the returns of carbon farming, especially if “buying back carbon” is not being enforced.

The chaotic nature of the patterns which sometimes appear in this chart suggest the vulnerability of short-rotation carbon farming to unexpected events, and a need for close examination of the Time Sequences to find out exactly when each event should be timed to occur.

In addition, where buying back of carbon releases is enforced (and where thinnings or harvest count as releases), thinning and harvesting tend to make big negative impacts on the value of carbon farming. From the point of view of silviculture, a short rotation brings timber sales closer to the present, and increases NPV. From the point of view of carbon farming, the same rotation brings closer the day at which a carbon release may have to be repurchased, or (perhaps) new set-up costs must be incurred, and therefore reduces NPV.

9. Cloning a Scenario

It is probably unwise to alter the Default Scenario unless only one Scenario is needed. If one is planning to investigate alternative Scenarios, the safer course of action is either to "Create Scenario" from the control button on the Front Page, or to use the "Clone Scenario as ..." control button at the upper right of the Assumptions area (of whatever Scenario is most like the new Scenario to be explored).

(Both "Create Scenario" and "Clone Scenario" create a new Scenario worksheet, but "Create Scenario" always copies the Default Scenario, while "Clone Scenario" copies the currently selected Scenario.)

When the "Clone Scenario " button is clicked, a dialog box is presented on which the user is given a list of all existing Scenario names, and invited to type a new one. Duplicates are not allowed, but the selection of an existing name off the list puts the name into the text box at the bottom of the dialog box, so that it may be used as a basis for the new name.

When the OK button of the dialog box is clicked, a complete copy of the current Scenario worksheet is created, under the new name that was chosen, and inserted to the right of the Front Page worksheet. This new worksheet is then selected automatically. On later occasions it can be accessed either by direct clicking on the sheet tabs at the bottom of the window, or by returning to the Front Page and picking it off the list offered by the "Review Scenarios" button.

When first created, the new Scenario has all parameters set to the values that the copied Scenario was using at the time, but no later changes on the old Scenario affect the new Scenario, nor do any changes subsequently made on the new Scenario affect its parent.

10. Scenario Comparisons

While most of the effort in using the Carbon Farmer Model will probably go into the refinement of individual Scenarios, the time will come when what is needed is a comparison of different Scenarios: Is it better to plant in 2000 or in 2004? How big a difference does it make if a different Tree Model is used?

The worksheet named “Scenario Comparisons” is the place to answer these questions, without having to resort to pencil and paper. It contains a table in which every row corresponds to a Scenario and every column after the first corresponds to an important parameter or output value. In the first column, the names of the all the Scenarios appear. These names have been formatted as hyperlinks so that a click on them takes the user back to the worksheet of that particular Scenario.

There is only one operation that the user can carry out on the Scenario Comparisons worksheet. The table can be updated by clicking on the Refresh Comparisons button. This will introduce all the latest values from all the Scenario sheets.

NOTE that updating does not occur except when this button is clicked, so data from deleted Scenarios and obsolete assumptions will persist in the table until the user takes action.

NOTE that the worksheet is protected, but that, as usual, this protection is not passworded. Any further analysis on the results in the table that is entered in columns A to AB and rows 1 to 200 will be overwritten every time the table is refreshed.

The scenario comparison can also be used as a “pool manager” tool, where the cumulative results of different plots (different species, different ages, different costs) can be calculated, by putting an Excel “Sum” formula at the bottom of a column. (Though such formulae will be overwritten when the table is refreshed.)

This feature may be a useful tool to facilitate access by smaller growers into carbon farming. It is quite obvious that high set-up costs will need to be defrayed over a large area and small growers may have to join forces, perhaps through the services of a pool manager.

11. Saving and Altering Tree Models

A new Tree Model may be created by copying a model from the list of models in the Tree Models worksheet and pasting it to the bottom of the worksheet's current list of models. Once there, outside the protected (green) area of that worksheet, the new model may be edited.

However, the recommended way to create a new Tree Model is to use the "Save Tree Model as ..." button on a Scenario worksheet. Using this option has two advantages. One is that the spacing of models on the Models worksheet is automatically preserved. More important is that the new model is given a unique name. Duplicate names are likely to cause the Carbon Farmer Model's Visual Basic code to misbehave.

The procedure for editing a new model is the most complex part of the Carbon Farmer. The next sections describe how the different models are stored, and how they must be laid out in order to function properly.

A couple of simple examples are given in Section 11.2.

11.1 Types of Tree Models

Tree Models considered from the point of view of layout and programming are of two main kinds.

- 1) "free" models
 - a) models which use cell formulae
 - b) models which simply use data values
- 2) "frozen" models (in the current version of the Carbon Farmer Model these all use data rather than actual cell formulae)

The difference between "free" and "frozen" models is that "frozen" models have a sequence of rotations and thinnings "built in", while "free" models can have rotations and thinnings set by the user.

A "frozen" model consists of an array of numbers representing the biomass, carbon and timber in each year, with the values given for a 'thinning' year being the values before the thinning, and the values in the next years after a thinning (or a rotation) being the values that

would be reached after the thinning took place. An example of a “frozen” model among the built-in Tree Models that come with the Carbon Farmer Model is the “Oil Mallee” model.

“Free” models, in contrast, consists of an array of the values of biomass etc that the crop would naturally take from years 1 to N, if no thinnings were performed, and no new rotations were begun. These values may be simple numerical lists, or they may be calculated by cell formulae. Free models use the instructions typed into the rotation and thinning cells of the Assumptions area to calculate the expected values in years before and after thinning (see Section 5.5). An example of a “free” model among the built-in Tree Models that come with the Carbon Farmer Model is the “E0” model.

Tree Model layout

Tree Models are assumed by the code that copies them to the Scenario worksheet to have a rather rigid layout. They occupy exactly five rows (with a sixth blank spacer row).

Column A of each model is a set of headings.

Column B of the model contains (working down through the rows); -

1. The name of the model (this cell’s contents are used by the Basic code to produce the drop-down list of model names and should not be altered).
2. Whether the model makes use of a cell formula to calculate the growth of biomass through time (in which case the cell contains the name of the formula e.g. “MAI” or “Gompertz”), or whether the model consists only of static data (in which case the cell contains the string “by data”. This cell is for the user, and is not read by the code.
3. In the case of free models, the word “free”. In the case of frozen models, the length of the rotation in years. This cell is read by the code, and should not be altered.
4. In the case of free models, the word “free”. In the case of frozen models, the details of thinning cycles, written in the format “n1(t1),n2(t2)” – this is the information used in the centre two columns of the thinning table in the Assumptions area (Section 5.5). n1 is the year of the rotation in which the first thinning is performed, and t1 is the percentage of timber removed. n2 is repetition interval for all subsequent thinnings, and t2 is the percentage of timber removed in each case. These numbers are read by the code and inserted into the thinning table, and efforts to overtype them are cancelled by the code. (The last row of the thinnings table in the Assumptions area is ignored by the Carbon Farmer Model code in the case of “frozen” models’.)
5. The number of parameters (other than interconversion factors – see below) used in any formulae of a “free” model. In the case of a frozen model, the number is 0. This cell is also a cell for your information, and its contents are not read by the code.

Columns C and D of the model contain information about how each model interconverts biomass, timber and carbon values.

Column C is a list of headings. The first four of these are intended to be read like an equation whose last term is in Column D. Thus in row 3 of the worksheet, for model E0, “total biomass = above ground [biomass] * 1.2”, with the “1.2” being found in Column D. These equations describe how the model calculates the interconversions between portions of the tree crop. In the case of E0, for example, inspection of the formulae in the range F4:F6 will show that biomass (F4) is calculated from a fundamental formula, and then total carbon and usable timber (F5 & F6) are calculated from F4 using D3:D6.

The last heading in Column C describes the parameters (if any) used in modelling biomass growth. In the case of model E0, they are “a,b,k,z for the gompertz model”. There are four of these (as announced in Cell B7), and their values will be found in Cells F7 onwards.

Column D contains the interconversion parameters just described. In cases where the “model” is actually data (like the Oil Mallee model), there may be no conversion factor applicable. In this case the cell contains the word “varies”.

Column E shows which row of the model represents which timber product.

Columns F onwards (to CA) contain the Tree Model itself

1. The first row contains year numbers from year 0. (The convention for numbering years is that values for year n represent the state of the trees at the end of year n).
2. The second row contains values for biomass (dry, above-ground biomass, t/ha) in the corresponding years.
3. The third row contains numbers for total sequestered carbon (t/ha).
4. The fourth row contains numbers for usable timber, in m³/ha.
5. The fifth row may contain parameters, if the biomass etc are to be calculated from formulae. In the case of a “frozen” model, the fifth row also includes the amounts of biomass removed in the years when the crop is thinned.

At present, all “free” models issued with the Carbon Farmer Model calculate biomass as a function of time only (using the first row of the model to give the value of “t”), and read parameters from the fifth row of the model to evaluate this function. They then use the interconversion factors at the front of the model to convert biomass to carbon and timber in the third and fourth rows. These restrictions need not apply to models constructed by users.

NOTE that the MAI model, although MAI is defined in terms of timber production, uses the MAI parameter and a conversion factor to calculate biomass first, and then re-converts this value to timber.

NOTE that when a model is saved under a new name, it is the un -delayed, un-rotated, un-thinned original version from the Tree Model worksheet that is “saved” by being copied and pasted (that is, trees planted in the current year, 2000, that are not thinned or harvested).

11.2 How to Edit a Tree Model to Produce a New One

Despite the restrictions described above, in practice certain variations on the issued models are reasonably easy to create. Here are two examples.

(A) *To create a new, free, formula based model,*

- 1) Select a model with the right formula in the Assumptions area of any Scenario.
- 2) Save it under a new name, preferably one that reflects the nature of the formula.
- 3) On the Tree Models worksheet, alter the parameters in row 5 and columns D (onward) of the *NEW* model (which will be at the bottom of the series of models, in the yellow area) to produce a model with different projections

(B) *To vary a “frozen” model by giving it a new thinning schedule (assuming that you do not actually have new data for constructing one from scratch).*

- 1) Select a suitable model in the Scenario worksheet Assumptions area.
- 2) Save it under a new name.
- 3) On the Tree Models worksheet, alter the rotation specification or (perhaps more easily, the thinning specification) in column B.
- 4) Modify one rotation (more easily, one thinning cycle) by typing in new ‘data’ beginning in column F (for a rotation).
- 5) Copy the modified cycle and paste it repeatedly to subsequent cycles.
- 6) Put an estimate of biomass removed on line 5 of the years where the new thinnings take place. (The old ones will no longer be read by the code, but should probably be removed to avoid confusion).

12. Saving and Altering Enterprises

Saving an Enterprise works the same way as for Tree Models, and should be done by the Scenario worksheet “Save ... as ... “ control button for the same reason. When the button is clicked, a copy of the Scenario’s current Enterprise is pasted to the end of the list of Enterprises, with a new and unique name chosen by the user. As with the Tree Model procedure, once saved, a new Enterprise can be edited on the unprotected area of the Enterprises worksheet. Any values (not any formulae used to generate them) that appear in the relevant rows on the Enterprises worksheet will be inserted in the Scenario worksheet when the Enterprise Model is selected via Cell B7.

Enterprise Models can be more flexible in their structure than Tree Models, because the restrictions on them are fewer, and the Carbon Farmer Model processes their numbers in a simpler way. An Enterprise Model consists of rows of data, each row being of one of two types.

1. “Gross margins”, which are per-area values (\$/ha) corresponding to some particular kind of activity, for example, grazing. These numbers are expected to be multiplied by the area defined by Cell B9 in the Assumptions as part of calculating the net benefits of an Enterprise.
2. “Fixed costs” which do not vary with area planted – machinery replacement might be an example here.

The rows from 116 to 125 on the Scenario worksheet, Columns AE onwards, are currently available for rows of this kind, and simple alterations to the formulae in rows 112 and 113 (and in the function calls in Column AD which calculate NPVs up to the Planning Horizon) would allow more rows to be used.

Enterprise layout

The format for Enterprise Models on the Enterprises worksheet consists of blocks of $N+2$ rows, where N is the number of rows of gross margins plus the number of rows of fixed costs that are to be included. The first row must contain the word “Name” in the first cell: the second cell must contain the (unique) name of the Enterprise Model, and the third cell must contain the value of N – this number is read by the code and should be kept to the correct value by the editor of any of the models. The ‘ $N+2$ ’ row is a spacer row for the sake of readability.

The first cell of each data row of the models that come with the Carbon Farmer Model contains the word “code”. This cell is not currently read by the Carbon Farmer Model

program, and may be used for any useful note – but the word in this cell must not be “Name”, as this would signal that cell 2 contains a model name.

The second cell in each data row contains a name for the particular activity within the Enterprise. This is a choice for the user, and will be inserted in the Scenario worksheet at the appropriate point in the Time Sequences, but is not otherwise used by the Carbon Farmer Model’s macros.

The third cell in each data row contains either TRUE (for a row of fixed costs) or FALSE (for a row of gross margins). This must be correctly entered for Enterprise NPVs to be correctly calculated.

Subsequent cells in the data rows must all have a value in them, even if it is only a zero, as the Excel NPV calculation depends on this. Zeros are useful or even necessary if one wishes to specify a rotation of different activities in an Enterprise. The natural way to do this is to have m years of gross margins of one activity followed by n zeros on one line, and m zeros of another activity followed by n gross margins in the next row. To maintain the distinctions between the budgets of different activities it may be helpful to have more than one row of fixed costs, also following the format of positive numbers separated by cells with zeros in them (and prefixed by TRUE in Column C).

13. Deleting Models

The recommended way of getting rid of models that are unwanted is to go to the relevant Models worksheet and delete the rows containing them. Deletion rather than a “clear contents” operation on the cells is *necessary*, otherwise the Visual Basic routines for reading and saving new models will be confused.

In the case of deleting Tree Models, it is necessary to delete the row containing the Model name and the following five lines, as all Tree Models are expected to occupy the same number of rows (including the spacer row).

When deleting Enterprises, the row containing the name *and* the succeeding N+1 rows must be deleted, where N is the number in the column headed "Rows used".

14. Introductory Help

This section contains the initial help screens that are shown when the help buttons on a worksheet are clicked. They are intended as the most focussed possible help on a particular screen for users who are relatively new to the Carbon Farmer. They are included here for ease of reference.

14.1 Introductory help on ... The Front Page

Welcome to the Carbon Farmer Model.

This worksheet of the Carbon Farmer Model workbook offers you access to the main features of the program.

Your first action will probably be to click on the 'Create Scenario' button. This will allow you to build up a scenario that suits your own circumstances.

You may also start by clicking on the 'Review Scenarios' button. This will give you a list of the scenarios that are in this example of the Carbon Farmer: initially there is only the Default Scenario. If you choose a name off this list, the worksheet that contains that Scenario will be displayed.

By clicking buttons on this worksheet you may also compare different carbon farming scenarios, and delete old ones.

For explanations of the term "Scenario" (Section 1.1) click [here](#).

For explanations of the terms "Tree Model" and "Enterprise" click [here](#).

For a fuller explanation of this worksheet click [here](#)

To go to the start of this manual click [here](#).

14.2 Introductory help on ... Assumptions area, Scenario worksheet

This area of the Scenario worksheet is where the main assumptions of the Scenario are displayed and may be changed. A small chart shows the main financial consequences of these assumptions.

Areas in yellow are areas where users can enter alternative assumptions. Green areas (headings) and white areas (results of computations) are protected against change by users.

From this area you go either to other areas on the *same* Scenario worksheet (the Time Sequences area, the Summary area, the Charts area, or to *other* worksheets (the Front Page, the Scenario Comparison worksheet, the Tree Models work sheet and the Enterprise worksheet).

Other areas on this worksheet offer buttons to bring you back to this area. To get back to this Scenario worksheet from other sheets, use the sheet tabs at the bottom of the window.

To get a more detailed explanation of the Assumptions area (Section 4.1) and its control buttons click [here](#).

To get help about particular assumptions, select any cell inside the green boundary line, click the right mouse button to get the cell menu, and select first "Help with ... Assumptions" and then the name of the parameter in question.

To go to the start of this manual click [here](#).

14.3 Introductory help on ... The Summary area, Scenario worksheet

This area of each Scenario worksheet displays the main consequences of the Scenario's assumptions.

The top row of the table contains the Net Present Values that are also displayed in the small chart in the Assumptions area of this worksheet. These values are always current.

The middle rows of the table (Sensitivities) display the values that assumptions *would have to take* for these Net Present Values to become zero.

The bottom rows of the table (Optimal Planting Dates) display the best years in which to establish a plantation, from the points of view of maximising the different Net Present Values, and also display the Net Present Values that will be achieved if those years are chosen.

Sensitivities and Optima are not automatically updated when assumptions are changed. To get updated versions, click the "Refresh Sensitivities" button.

To get a fuller description of this area (Section 6) click [here](#).

To go to the start of this manual click [here](#).

14.4 Introductory help on ... The Time Sequences area, Scenario worksheet

This area of each Scenario worksheet contains the full listing of the consequences of the Scenario's assumptions, with the production of timber, amount of carbon sequestered, and all types of costs and benefits shown for each year from 2000 AD to 2062/63 AD in columns AE:CP. (2062 is the last year for which costs and benefits are calculated, but projections of tree growth and made to 2063.)

Column AD shows the Net Present Values of each type of cost and benefit, and (in rows 127 to 131) selected overall Internal Rates of Return.

Users are not expected to alter any cells in this area directly: assumptions should only be changed in the Assumptions area.

For a more detailed explanation of this area click [here](#).

To go to the start of this manual click [here](#).

14.5 Introductory help on ... The Charts area, Scenario worksheet

This area of each Scenario worksheet contains four charts displaying the physical and financial course of the Scenario through time.

The X marks on each chart show the start and end of any commitment periods that have been assumed.

For an explanation of commitment periods click [here](#).

For a more detailed explanation of this area click [here](#).

To go to the start of this manual click [here](#).

14.6 Introductory help on ... The Tree Models worksheet

This worksheet contains the formulae and data for the models of tree growth and carbon sequestration that are used in the Scenarios.

Most of the models included in the distribution version of the Carbon Farmer Model are protected against change by users (the green area). Models created by users are below the original models in the unprotected (yellow) area. Two unprotected models are included at the top of the unprotected area as examples for experimentation by users.

Even though the yellow area is not protected, it is recommended that new models be created by using the “Save Model As ...” button in the Assumptions area of any Scenario worksheet.

To go to a particular model, double-click its name in the list box in the top row of the worksheet. To go to a description of the various models click [here](#).

To go to a description of the procedure for creating and changing models click [here](#).

To see two simple examples of ‘creating a new model’ click [here](#).

To go to the start of this manual click [here](#).

14.7 Introductory help on ... The Enterprises worksheet

This worksheet contains the formulae and data for the models of economic return by non-tree enterprises that are used in the Scenarios as a comparison for tree-farming enterprises.

Most of the models included in the distribution version of the Carbon Farmer Model are protected against change by users (the green area). Models created by users are below the original models in the unprotected (yellow) area. One unprotected model is included at the top of the unprotected area as an example for experimentation by users.

Even though the yellow area is not protected, it is recommended that new models be created by using the “Save Enterprise As ...” button in the Assumptions area of any Scenario worksheet.

To go to a particular model, double-click its name in the list box in the top row of the worksheet. To go to a description of the procedure for creating and changing Enterprise models click [here](#).

To go to the start of this manual click [here](#).

14.8 Introductory help on ... The Scenario Comparisons worksheet

This worksheet contains a table in which the assumptions and main outputs of all the Scenarios in the workbook may be displayed.

Column A lists the names of the tabulated Scenarios. Each of these names is associated with a hyperlink. Clicking on this link takes the user to that Scenario worksheet.

The information in the table is not automatically updated. To update it, click the “Refresh Comparisons” button.

For a fuller description (Section 10) click [here](#).

To go to the start of this manual click [here](#).

14.9 Introductory help on ... The Suggested values worksheet

This worksheet contains the suggested values of certain assumptions used in each Scenario, as described in the subsections of Section 5. Consequently, the entire worksheet is protected.

When the “Reset” button in the Assumptions area of any Scenario worksheet is clicked, the values on the “Suggested values” worksheet replace those on that Scenario worksheet.

To go to the start of this manual click [here](#).

Appendix 1: References about Carbon Farming

This section indicates where to start to obtain more information about carbon farming. It is not intended to be a comprehensive list.

Australian Greenhouse Office (1999a) National Emissions Trading: Establishing the Boundaries. Discussion Paper 1, AGPS, Canberra

Australian Greenhouse Office (1999b) National Emissions Trading: Issuing the Permits. Discussion Paper 2, AGPS, Canberra

Australian Greenhouse Office (1999c) National Emissions Trading: Crediting the Carbon. Discussion Paper 3, AGPS, Canberra

Australian Greenhouse Office (1999d) National Emissions Trading: Designing the Market. Discussion Paper 4, AGPS, Canberra

Borough, C. (2000) Is carbon farming worthwhile? *Australian Forest Grower* 23(1): Special Liftout No 51.

Forestry Technical Services, AACM International and Clean Commodities Inc. (1998) Greenhouse Challenge Vegetation Sinks Workbook, Australian Greenhouse Office, Canberra

Hassall & Associates (1999) Greenhouse, Carbon trading and Land Management, Occasional Paper 23/99, Land and Water Resources Research and Development Corporation, Canberra

Some useful web addresses:

www.greenhouse.gov.au/sinks [overview of the Australian government's response, discussion papers, etc]

www.aph.gov.au/house/committe/enviro/greenhse/gasrpt/contents.htm

www.ipcc.ch [see especially the Special Report on Land Use, Land Use Change and Forestry]

www.thecarbontrader.com [topical news, especially from US]

www.co2forestsinks.com.au [one of the many firms brokering carbon trades]

www.carbontrading.com.au [now outdated as the Sydney Futures Exchange has withdrawn from establishing a Futures Market in Carbon Trading]

www.anu.edu.au/Forestry/info/marketreport/ [for prices, particularly stumpage]

Appendix 2: The Gompertz Equation

The Gompertz Equation is an asymmetrical sigmoidal function that may be used simulate the time course of biomass accumulation as a forest grows. The function takes the general form:

$$W = A \cdot \exp(-b \cdot \exp(-k \cdot t)) \quad (1)$$

where

W is the biomass sequestered (m^3/ha)

t is the time (in years)

A is the asymptotic value of W

b and k are constants governing the rate of increase.

In the Carbon Farmer, a slightly modified form is used;

$$W = A \cdot \exp(-b \cdot \exp(-k \cdot t)) + z \quad (2)$$

where

z is equal to $-A \cdot \exp(-b)$.

and functions as a value shift which forces W through zero when $t = 0$.

The table below gives the parameter values that were used to model the different classes of tree productivity.

Table 2. Gompertz parameter values used in the inbuilt tree models

Parameter	A	b	k	z
E0	825	2.5	0.053	-67.72
E1	700	2.4	0.049	-64
E2	575	2.3	0.044	-58
E3	450	2.2	0.04	-50
E4	310	2.1	0.035	-38
E5	185	2	0.03	-25
P1	700	4.85	0.077	-5
P2	495	4.3	0.079	-7
P2	310	3.7	0.08	-8
P3	700	4.85	0.077	-5

Appendix 3: Net Present Values

Traditionally it is common to assess a land use in financial terms by calculating the Gross Margin of the activity, perhaps averaged over a period of years for activities involving rotations. Another way of expressing the value of an activity that is spread over a long period of time is the Internal Rate of Return (IRR).

Both of these measures have shortcomings when dealing with long-term projects. The IRR may not always exist (as with activities that are always profitable), or there may be several different IRR's. Gross Margins do not adequately compare a cost incurred now with a compensating benefit in the future.

Instead of either of these measures, the Carbon Farmer Model uses Net Present Values (NPVs) as its primary measure of the financial success of a land use. The Net Present Value is the sum of all future benefits less all future costs, expressed in today's terms. Technically, it is the discounted sum of future benefits minus the discounted sum of future costs.

Discounting takes into account the time value of money, and that one dollar received (or paid out) in ten years' time is worth less than one dollar today. When the benefits and costs arise in different years, then it is vital to put them back to a common base for comparison. Net Present Value is a convenient way to do this.

When determining the Net Present Value, the discount rate is the rate that is used to convert future dollars into today's dollars. The discount rate can be based on "opportunity cost", that is, what the money would be worth for other purposes. In this case, the discount rate becomes the interest rate which the money used in the activity being analysed would earn in an alternative use.

It is also possible to use the discount rate to express a personal preference between short-term and long-term outcomes, as well as risk: the higher the discount rate, the less importance given to the long term.

Appendix 4: Keeping Track of Carbon

The Carbon Farmer Model is a tool to show the net returns or carbon farming and to suggest whether a landholder should investigate the activity further. It is not a tool for carbon accounting, i.e. the tracking of carbon flows among different ecosystem pools.

If a proponent has decided to undertake a project that requires detailed carbon accounting, they should refer to the Greenhouse Challenge Vegetation Sinks Workbook (see the references in Appendix 1) for a description of the various pools to measure. They should also consider using a carbon accounting package like CAMFor (developed by the Australian Greenhouse Office and available on www.greenhouse.gov.au/ncas).

The Greenhouse Challenge Vegetation Sinks Workbook suggests measuring up to five “pools” of carbon: trees and roots, soil, other vegetation, litter and wood products. For simplicity, the Carbon Farmer Model uses the growth in the Trees and Roots pool only, taking into account harvesting and thinning operations. The model does not take into account the decay from harvest debris, nor does it account for loss, such as from fire. In this respect, the Carbon Farmer Model may overestimate the potential benefits from carbon sequestration. Future versions may offer a facility for including these issues. The Carbon Farmer Model also does not account for changes in soil carbon.

At present, all “free” models issued with this version of the Carbon Farmer Model (see Section 11.1) calculate biomass as a function of time only (using the first row of the model to give the value of “t”), and read parameters from the fifth row of the model to evaluate this function. They then use the interconversion factors at the front of the model to convert biomass to carbon and timber in the third and fourth rows. Thus constant ratios are assumed between above-ground and below-ground components of the crop, between biomass and usable timber, and between biomass and sequestered carbon. These restrictions need not apply to models constructed by users.

NOTE that the MAI models in the Carbon Farmer, although MAI is defined in terms of timber production, uses the MAI parameter and a conversion factor to calculate biomass first, and then re-converts this value to timber.

The situation is different with the two “frozen” Carbon Farmer tree models. In these, the only fixed ratio is that between total above-ground dry biomass and its carbon content. The other variables are directly observed, not modelled by a ratio. In the case of the oil mallee the ‘timber’ product is the biomass directly. In the case of *Pinus pinaster*, the timber production is from directly measured data, not calculated by ratio.