Farming Landscapes For The Future

Farming Landscapes for the future tool (FLFT) tutorials

User's Guide
Version 1.5

Jenny Carter
March 2013

What will your farm look like in the future?

A tool to help you develop new enterprise combinations.

CARING FOR OUR COUNTRY
wheatbelt natural resource management
CSIRO
AVONGRO Wheatbelt Tree Cropping Incorporated economic development and sustainable production

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The information presented in this software provides an indication of the likely tree and crop growth using the best information available (as of November 2012) and relative economic benefit of different farm enterprises. This information does not constitute specific financial advice. Land managers should seek appropriate financial or economic advice prior to making investment decisions.

Acknowledgements

The Farming Landscapes for the Future software was developed by CSIRO, (Charlie Hawkins, Anders Siggins, Jenny Carter, Kimberley Opie, Yvette Oliver, Andrew Moore, Keryn Paul), working in collaboration with Avongro Wheatbelt Tree Cropping and Wheatbelt Natural Resource Management. The work was performed with the financial support of the Department of Agriculture, Forestry and Fisheries, Caring for Our Country Program. We acknowledge the advice of tree growers in the Avon River Basin and on-ground logistical support from the Department of Agriculture and Food WA (DAFWA), Australian Sandalwood Network (ASN), the Wheatbelt Brushwood Growers (WBG), the Oil Mallee Association, Dr Geoff Woodall (University of WA), Tim Emmott, Graeme McConnell and Glen Brayshaw. The DAFWA provided several spatial data layers including but not limited to soils data and the DEM, while Landgate gave access to aerial photography of the Avon River Basin. Advice on modelling sandalwood growth and access to supporting data was provided by Geoff Woodall. Jon Brand from the Forest Products Commission also gave advice on modelling sandalwood growth. We would especially like to thank the farmers who were very hospitable in allowing us to measure trees and soils on their properties, and for sharing their views on tree farming.

Introduction

Farm forestry has been increasing in recent years and provides commercial and environmental benefits, such as biodiversity conservation, salinity control and protection from soil erosion. In south Western Australia, there has been a recent trend of decreasing rainfall, and this is predicted to continue into the future. Trees may perform better with decreased rainfall in comparison to shallow-rooted annual crops, due to their ability to obtain water from a greater soil volume. Perennials may also benefit from the predicted increased frequency of summer rainfall events in south Western Australia.

Despite the benefits of incorporating trees into farming landscapes, landowners may find this a difficult option to implement given the establishment cost and the prospect of delayed or reduced farm income. Therefore, the potential costs and benefits of changes in farm production need to be well considered. The Farming Landscapes for the Future software (FLFT) was developed to assist landowners in assessing the risks and benefits associated with land-use decisions. This software uses a database of predicted tree, crop and pasture production in the Avon River Basin under current and future predicted climates, and forecasts the economic implications of different scenarios. Options

include tree crops sandalwood, oil mallee, brushwood and mixed biodiversity plantings and annual crops wheat, barley, canola, oats and annual pasture for livestock. The industries around these tree crops are still developing and the potential viability of farm forestry industries is unknown, therefore economic predictions are uncertain. In addition, due to the difficulty in quantifying the potential financial gain from the environmental benefits of tree plantings, (e.g. soil conservation), this is not accounted for in this software. Profitability will depend on future developments to tree crop industries, but this software uses the best information currently available to give an indication of potential income from trees, and gives the means to rapidly compare this to the financial performance of annual crops and pasture.

Overview

A number of steps can be followed when using this software:

1. Installation
2. Opening the software
3. Include or exclude payments for carbon
4. Develop tree scenarios
5. Develop crop scenarios
6. Develop pasture scenarios.
7. Compare the economics of different scenarios.
8. Use the mapping functions to create study regions

Not all of these steps are compulsory and after installation the user can decide what to include in their analysis. The procedures for each of these steps are provided in the "Workflow" section below, and more detailed information given in the "Further information" section.

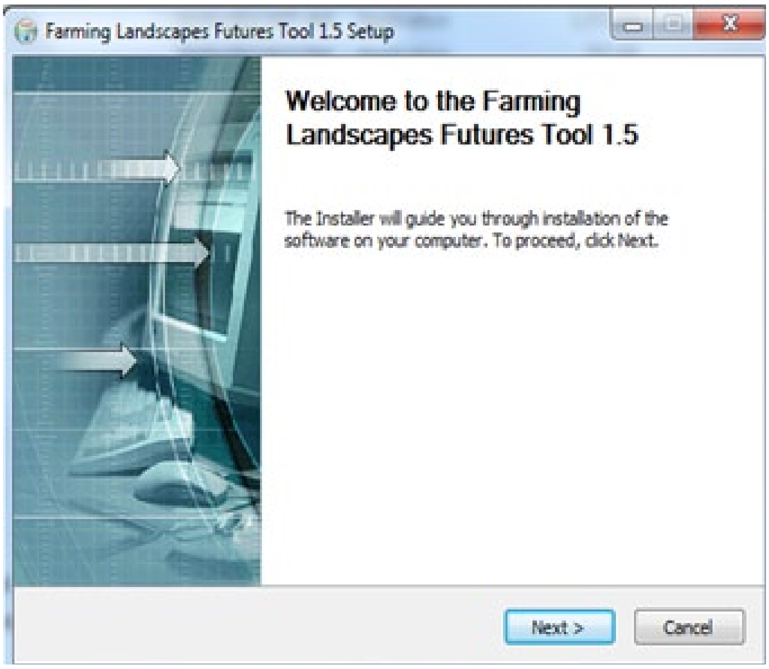
Prerequisites

- Computer with Windows XP or later operating system to install the software.
- Some knowledge of the soils in the paddock or area to be included in the analysis. You will need to choose from different soil classes such as sand, clay, loam etc. in order to obtain accurate predictions of crop and tree growth.
- You will need to choose the closest location from a choice of six in the Avon River Basin (Bencubbin, Brookton, Lake Grace, Narembeen, Northam and Wongan Hills) in order to obtain accurate climate information needed to predict crop and tree growth.
- Default costs and prices based on 2012 market information are entered automatically; these can be accepted or changed to reflect your own individual costs if you have that information available.

Workflow

1. Installation

Double click on the file FarmingLandscapesFuturesToolV1.5.exe to open and run the installation file. The software will be installed automatically, continue to click the “Next” button until the installation is complete.



You will be asked to read the License Agreement and click “I Agree” in order to install the software.

The software will install to the following folder:
C:\Program Files\CSIRO Tools\Farming Landscapes Futures Tool 1.5
If you accept this location, click on “Next”, otherwise choose a different location and then click “Next”.

You will be asked to choose a name for the software to appear in your start menu folder; you can click “Next” to accept the default or enter a different name.

At the next window, click “Next” to include a shortcut icon for the software on your desktop.

The installation window will appear, click on “Install”.

Shortly, a window will open for the installation of the MapWinGIS software, which is needed for some of the mapping features of the FLFT software.

Continue to click the “Next” button, until the installation is complete. You will also need to read and accept a license agreement for this software.

You can accept the default destination folder for the software (C:\dev\MapWinGIS), or choose a new location.

You will be asked to choose a name for the software to appear in your start menu folder; you can click “Next” to accept the default or enter a different name.

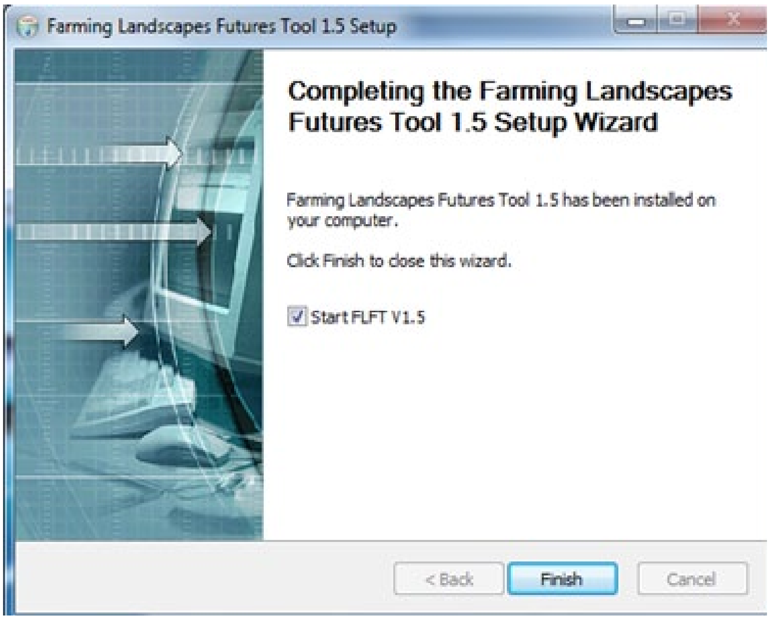
The installation window will appear, click on “Install”.

A window will open to say that MapWinGIS is now installing, this may take a few minutes.

The window below will open.

Uncheck the box “View MapWindowNotes.rtf”. If checked, a file will open in Microsoft Word with information on the MapWinGIS software; you can close this file.

After clicking “Finish”, you will now return to the FLFT setup screen.

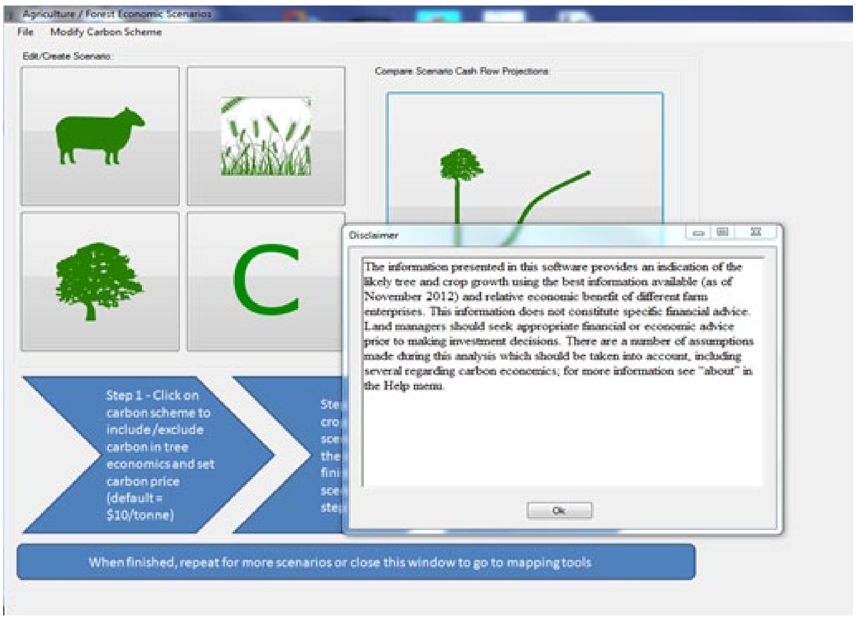


Click on “Finish” and the software will open automatically. In future, you can open the software by double clicking on the FLFT software icon located on your desktop.

2. Opening the software

After installation, double click on the FLFT program icon now located on your desktop.

If there is no icon, open the folder which you installed to during step 1 (the default will be C:\Program Files\CSIRO Tools\Farming Landscapes Futures Tool 1.5) and double click the file called FLFT v1.5.exe.



After reading the disclaimers, press ok (there are two disclaimer windows) to start your analysis.

3. Include or exclude payments for carbon

You can decide whether or not to claim carbon payments in the tree scenarios, for the carbon dioxide (CO_2) that is removed from the atmosphere and stored as carbon in trees. The default for this option is to exclude carbon payments. If carbon payments are included, the default price is $10 per tonne of CO_2 equivalent (CO_2e), but this can be changed. For more information about claiming carbon credits see the section on Carbon below.

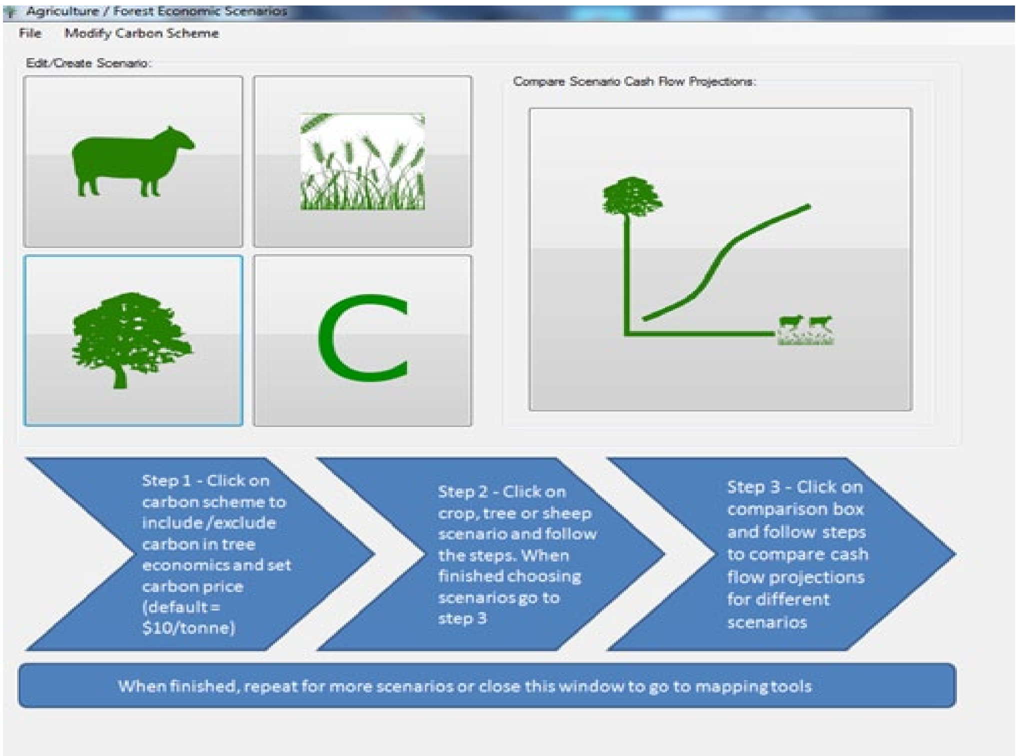
Note that carbon payments are included as an option for tree scenario economics in this software as a demonstration of the potential income that could be derived, but advice should be sought about the eligibility of your planting type before carbon projects are established.

Excluding carbon payments

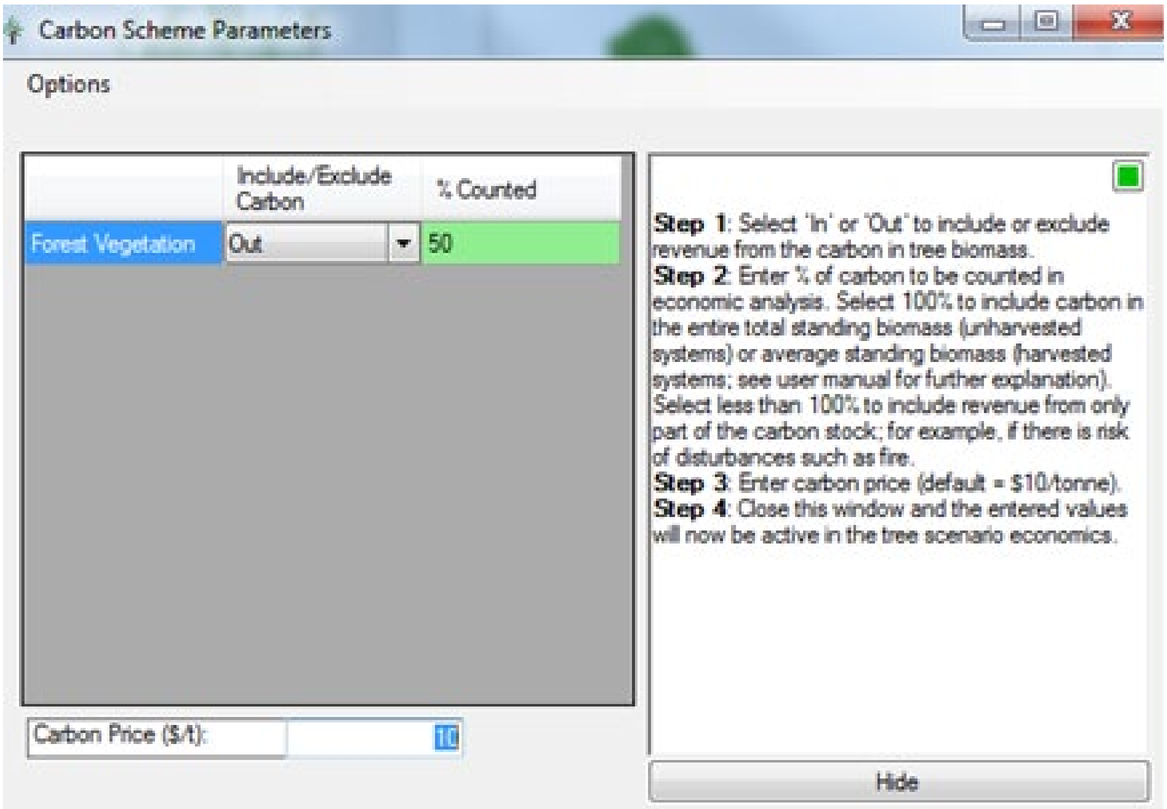
If you want to exclude carbon payments you do not need to do anything and can move on to step 4. For example, you may not wish to include carbon payments in the harvested tree systems (oil mallees, sandalwood or brushwood).

Including carbon payments

If you wish to create a scenario for trees grown only for carbon payments (environmental plantings or non-harvested oil mallees), or if you wish to include a carbon payment in addition to the wood product revenue from harvested tree systems, click on the box containing the C shown below.



The following window will now open:



Click the drop-down box under include/exclude carbon and select “In”.

- In the % counted box enter a number between 0 and 100% for the amount of carbon to be included. 100% of the carbon can be claimed, but selecting less than 100% is a way of accounting for the risk of losing part of the planting at some time in the rotation (for example, through fire or drought).
- The default price of $10 per tonne of CO2e may be accepted, or a different price entered. In July 2012 the Australian Government introduced a fixed carbon price of $23 per tonne of CO2e for three years; however from July 2015 the price will be set by the market. Future prices may also depend on which political party holds power. In 2012 the price for carbon in Europe was $10 per tonne of CO2e.
- After selecting the include/exclude, % counted and carbon price options, close the carbon window box and your selections will be now be applied in step 4, developing tree scenarios. All tree scenarios created and saved from this point will include carbon payments. If you decide at a later stage to exclude carbon payments you can go back to the carbon window to make changes, but will need to recreate and re-save your tree scenario.

Note: Default costs are entered in some of the tree economic templates (see next section) for certification of carbon projects, auditing, and brokerage or commissions fees for sale of carbon credits. However, these costs are shown to give a rough indication of potential costs only; actual costs may vary widely depending on the nature of the project, and expert advice should be sought on this.

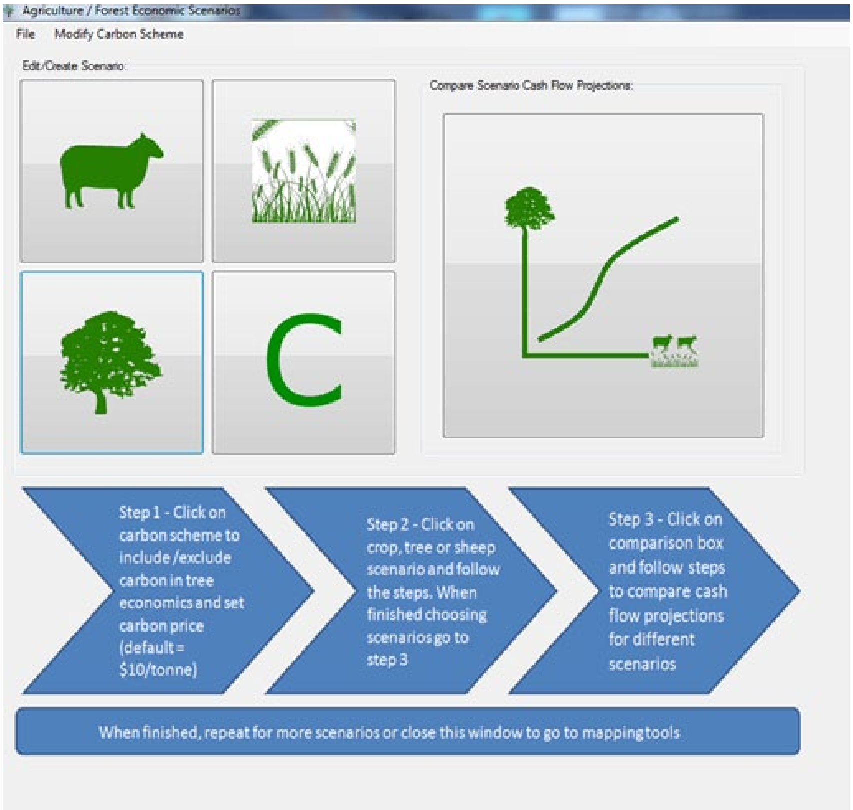
4. Develop tree scenarios

Information on the growth and potential income from several different types of tree crop is available.

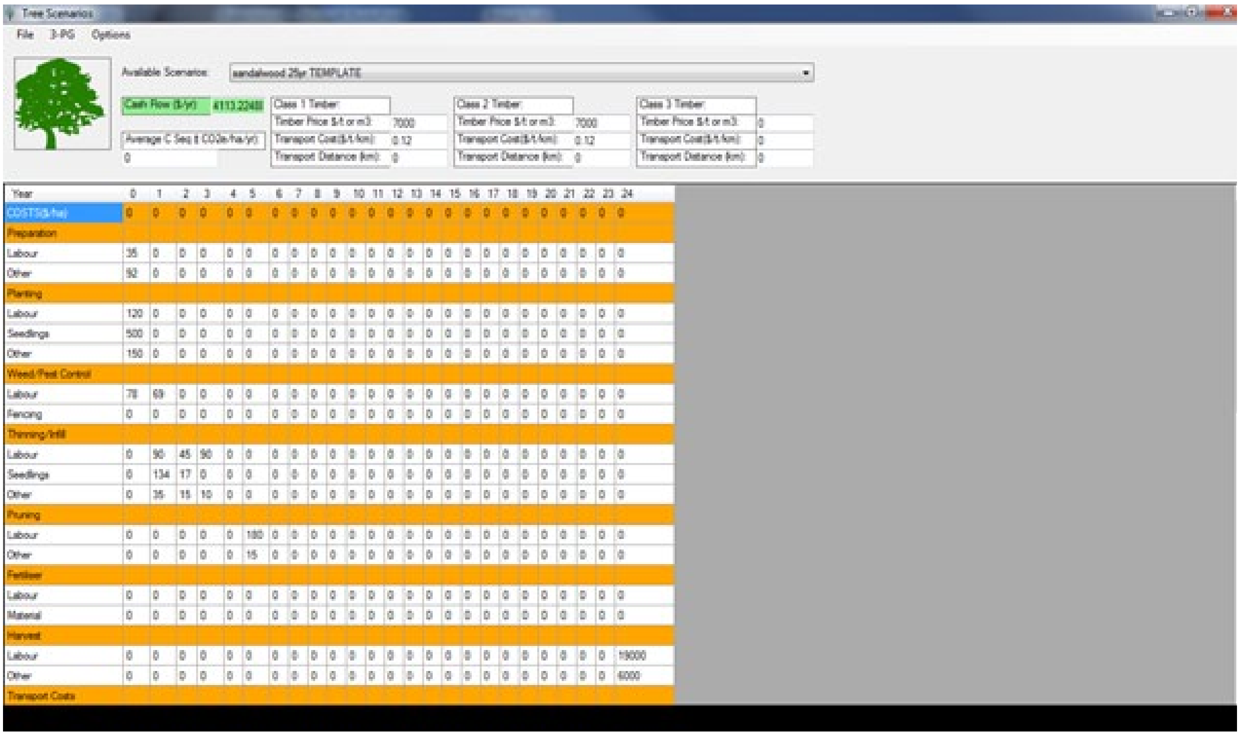
It is important to note that industries around these tree crops are still developing and the potential viability of farm forestry industries is unknown. It should be accepted that this information is uncertain and provides an indication of possible income only.

In addition, due to the difficulty in quantifying the potential financial gain from the environmental benefits of tree plantings, (e.g. soil conservation), this is not accounted for in this software.

Click on the box containing the tree shown below.



The following window will now open.



From this window you can choose templates which contain default costs and prices for the following different tree systems:

1. Mallee CO2e; oil mallees grown for carbon, not harvested
2. Mallee harvest 5 3 3 y; oil mallees harvested on a 5 + 3 + 3 year cycle
3. Mallee harvest 8 6 6 y; oil mallees harvested on a 8 + 6 + 6 year cycle
4. Mallee harvest 12 10 10 y; oil mallees harvested on a 12 + 10 + 10 year cycle
5. Environmental Planting CO2e; mixed species plantings grown for carbon, not harvested
6. Sandalwood 20 y; WA sandalwood grown with host plants, harvested after 20 years
7. Sandalwood 25 y; WA sandalwood grown with host plants, harvested after 25 years
8. Brushwood harvest 7 5 y; brushwood harvested on a 7 + 5 year cycle
9. Brushwood harvest 10 7 y; brushwood harvested on a 10 + 7 year cycle

For more information on each of these systems see the “Further information” section below.

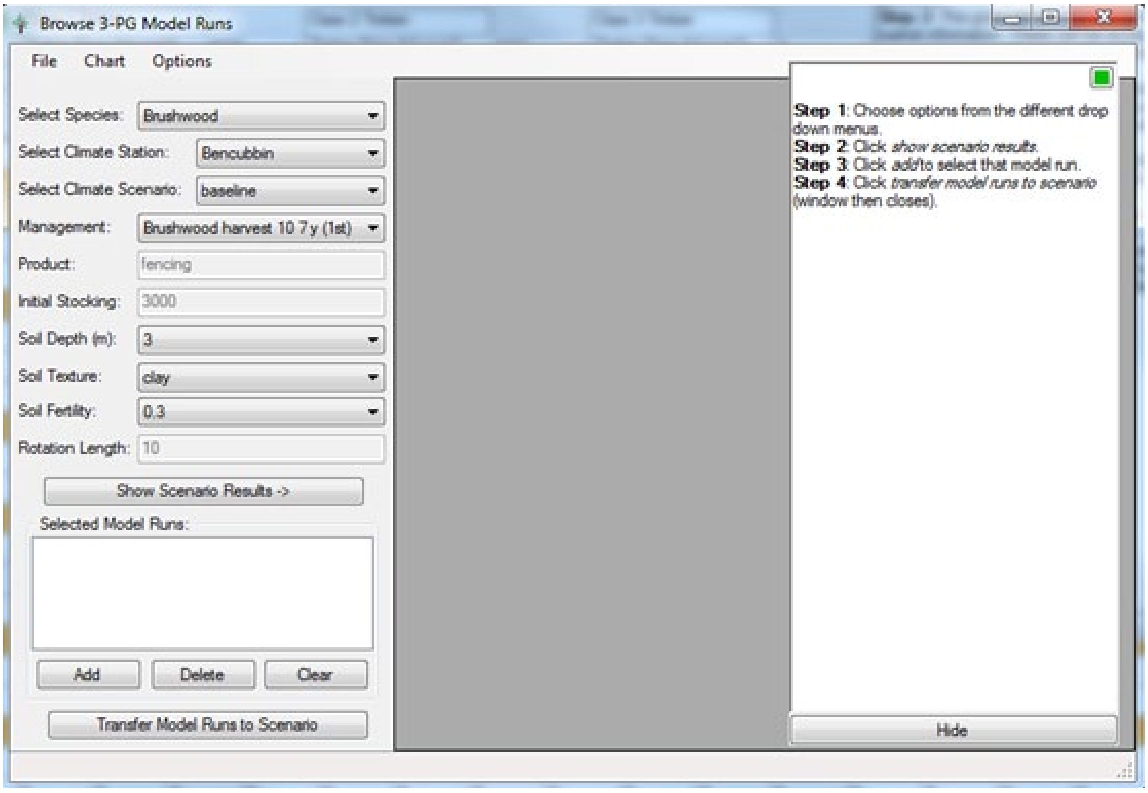
From this window you should:

- Select the template for the system which you want to develop a scenario for.
- Accept the default costs and prices (based on 2012 market information), or change as desired.
- Enter an estimated transport distance for your wood product.
- If you are including payments for carbon, you will need to enter costs associated with certification, auditing and commissions, if these are not already entered in the template you have chosen.
- Now go to the 3PG drop down menu and select “Load in 3-PG Growth Predictions” so that you can ensure you have accurate growth rates for your area’s climate and soil type.

After this step you will come back to this window.

Browse 3PG model runs

This window is where you choose from the tree growth predictions that have been produced with the model 3PG (Physiological Principles that Predict Growth). See the “Tree modelling” section for more information on how these growth predictions were made.



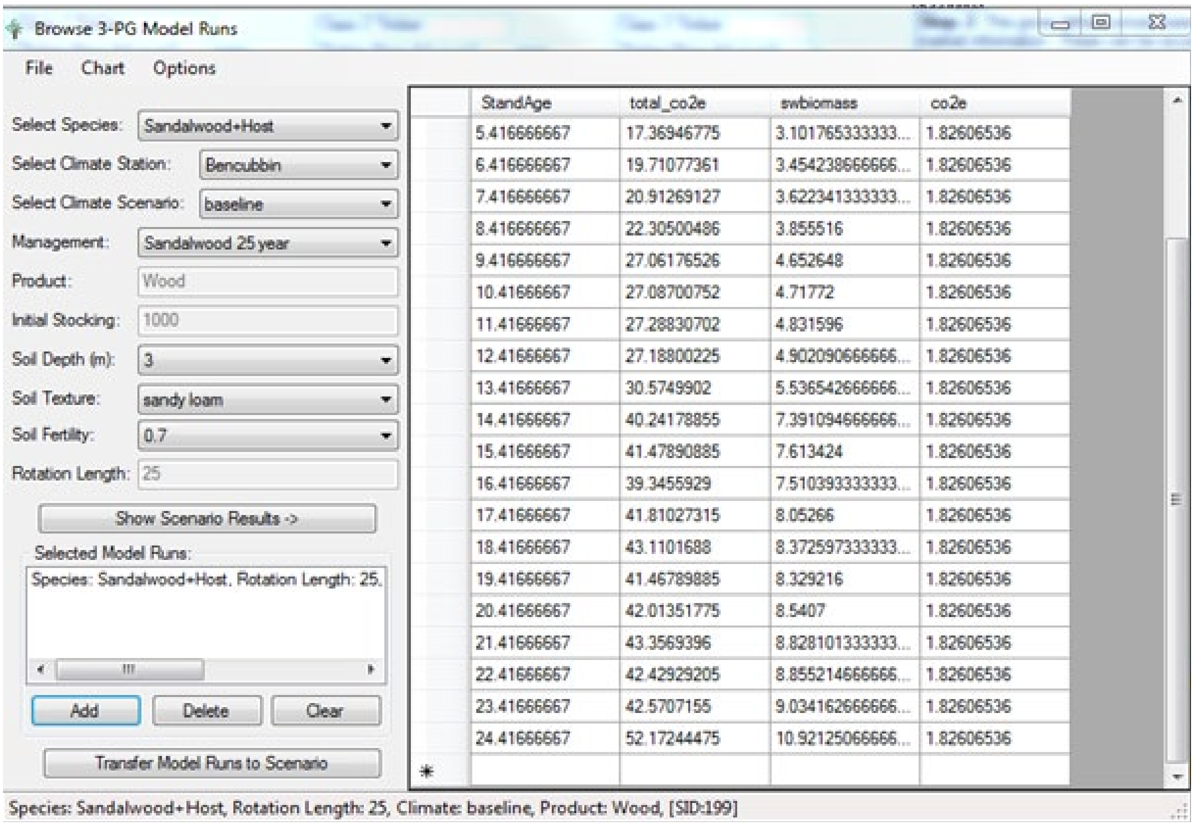
From this window you should select:

- The species you want growth for.
- The type of management you want for that species i.e. when to harvest.
- The climate station; this will select the right climate information for your location.
- If you want growth predicted for historical climate or future climates.

  "Baseline" predicts growth using climate data from 1975 – 2005

  2030 and 2070 predicts growth under what the climate is predicted to be like in the future. In the Avon region this will be generally hotter and drier, and CO_2 concentrations in the atmosphere will be higher. For more information see "Climate of the Avon River Basin".
- The soil texture; clay, clay loam, loam, sand, sandy clay, or sandy loam.
- The soil fertility; 0.7 for a relatively productive site, or 0.3 for a poor site (e.g. saline, waterlogged).

Now click on "show scenario results", and you will see the growth predictions for the selections you have made. The columns will show the age of the trees, and the wood product or carbon credits that can be claimed. For more information on these products and how they are calculated see the relevant tree scenario in the "Tree modelling" section.



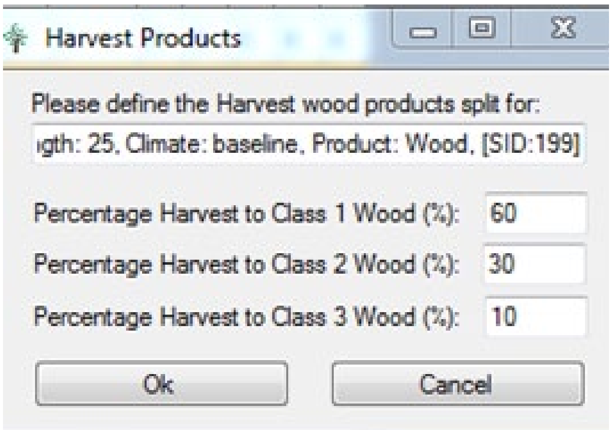
If you are happy with your choice, click "add" to select this model run. You can make more choices and add more than one model run to the "Selected Model Runs" window, e.g. if you are choosing growth for coppicing oil mallees or brushwood which have more than one harvest event.

After selecting your model runs, click "Transfer Model Runs to Scenario" and all scenarios in the window will be transferred to your economic template in the previous window.

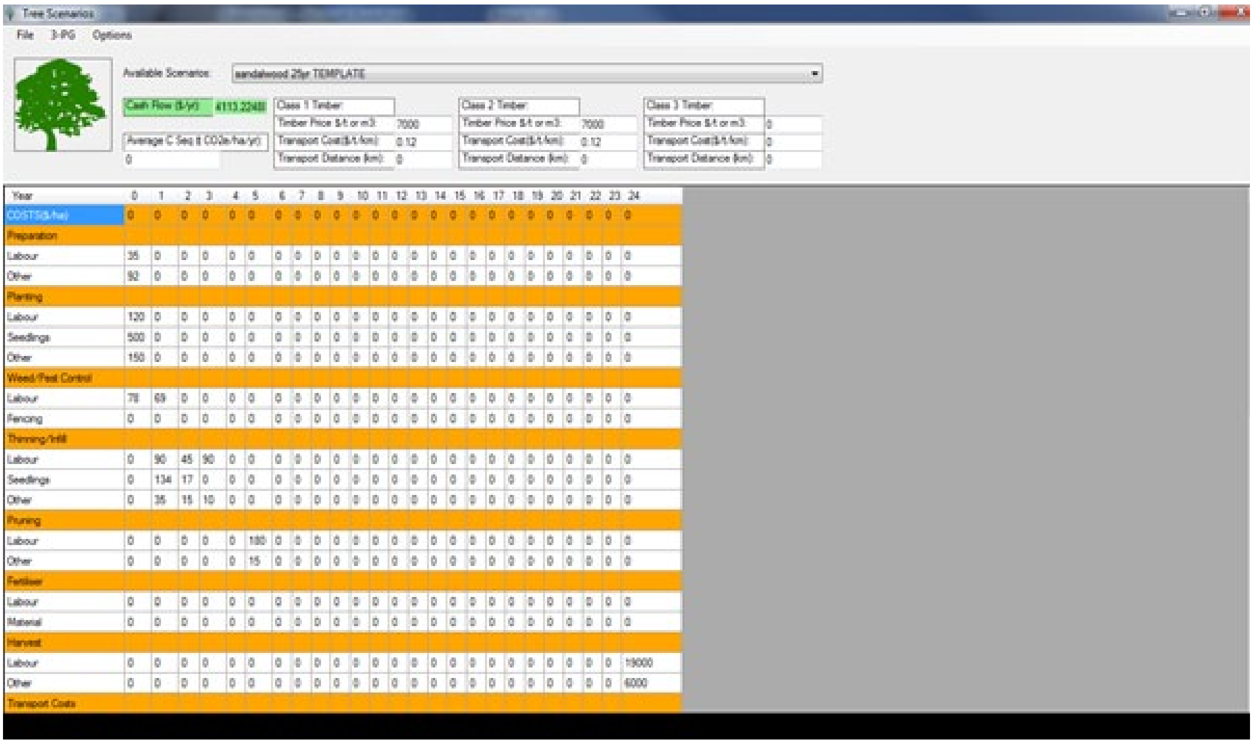




If you are choosing a sandalwood scenario, the window below will show.



Here you can select how to split your sandalwood into yield classes 1, 2 and 3. Default values are given as shown above but you may choose different values. Please see more information on these classes under the "Sandalwood" section below.

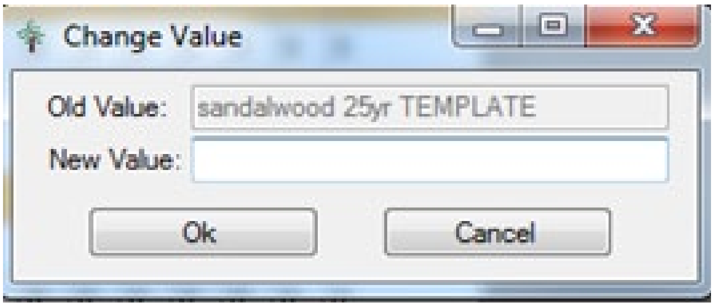


The selected yields will now be transferred to your template containing the economic information for that scenario.

Take care that you do not transfer growth data for a different species from the 3PG window to that shown in this window, as the default prices in each template are different for each species.

You may wish to add additional costs or revenues that are not covered by the headings in this sheet, by entering numbers in the "other" row. For example, nut production was not predicted for sandalwood scenarios, but you could manually enter income for the years you anticipate potentially harvesting nuts. (See more information on this in the "Sandalwood" section below).

Under the file menu save this template as a new scenario with a new name.

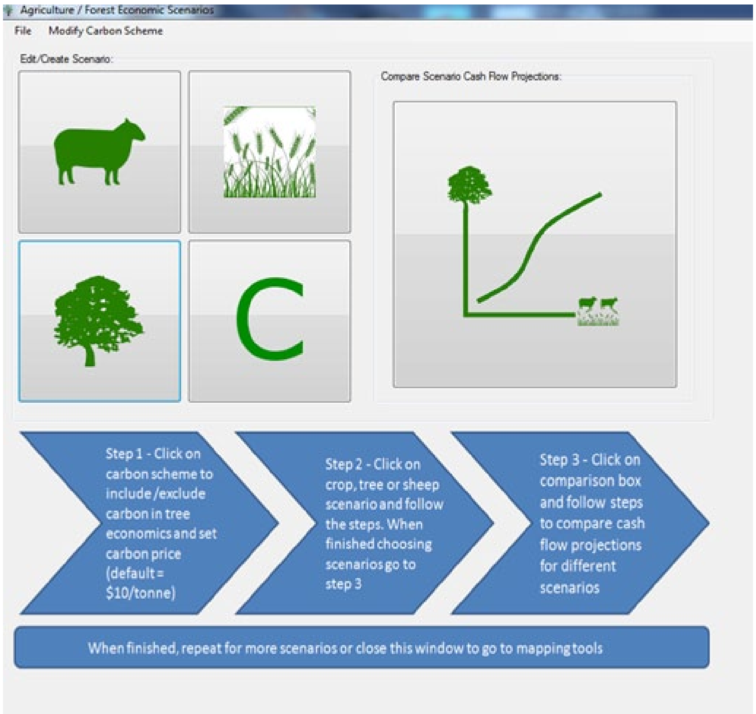


Once your new scenarios have been created, you can change the growth information contained in these and then use the “update scenario” command.

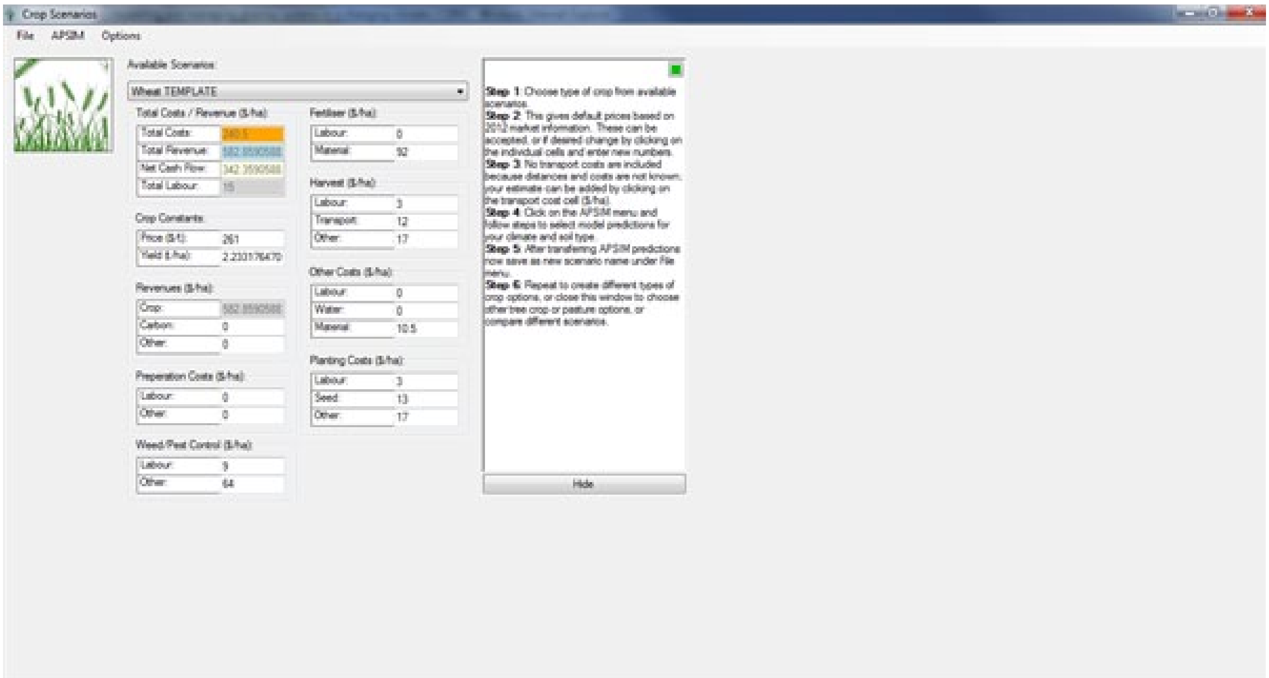
However, do not update the default templates, as the default information for prices and costs may be lost.

5. Develop crop scenarios

Click on the box containing the crop below.



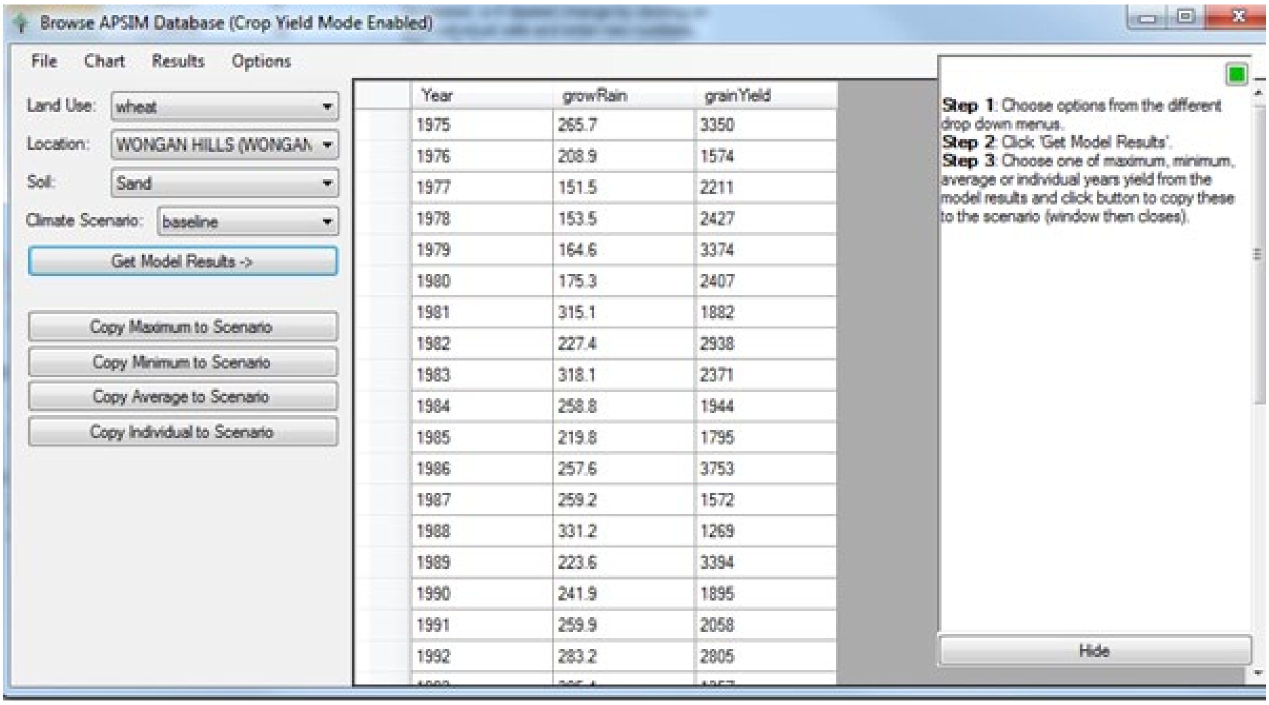
The following window will open.



From this window templates can be chosen which contain default costs and prices for the crops wheat, canola, barley, lupins and oats. For more information on how each of these was modelled see the “Crop modelling” section below.

From this window you should:

- Select the template for the crop which you want to develop a scenario for.
- Accept the default costs and prices (based on 2012 market information), or change as desired.
- Now go to the APSIM drop down menu and select “Obtain Yield from APSIM” so that you can ensure you have accurate production rates for your area’s climate and soil type.



From the APSIM window you should select:

- The crop that you want growth for.
- The location; this will select the right climate information for your location.
- The soil type; sand, shallow soil, gravel, sandy earth, shallow sandy duplex, deep sandy duplex, shallow loamy duplex, deep loamy duplex, loamy earth or clay.

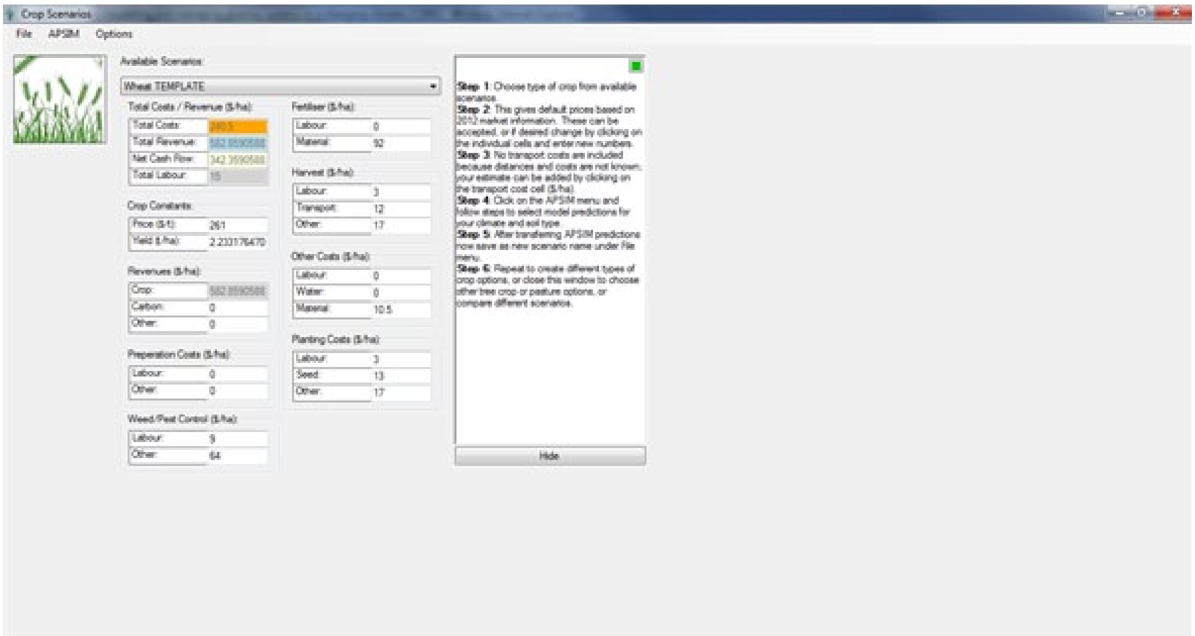
Note: the soil descriptions in the crop and pasture modelling are different to those used in the tree modelling; this is due to different types of models being used. Please choose the description that best matches the major soil type in your paddock.

- If you want growth predicted for historical climate (baseline) or future climates (2030 or 2070).

Now click on "Get Model Results", and you will see the crop growth predictions for the selections you have made. The columns will show the year, the growing season rainfall each year, and the grain yield in kg per hectare. For more information on these numbers and how they are calculated see the "Crop modelling" section.

When transferring numbers to your scenario, you may select the average production shown between 1975 and 2007 (click on "Copy Average to Scenario"), the minimum or maximum production (click on "Copy Minimum to Scenario" or "Copy Maximum to Scenario"), or production from a single year. For the latter, click on the row of the year you want to select, and then click "Copy Individual to Scenario".

You will then return to the window below:



The selected yields will now be transferred to your template containing the economic information for that scenario.

Take care that you do not transfer growth data for a different crop from the APSIM window to that shown in this window, as the default prices in each template are different for each crop.

Under the file menu save this template as a new scenario with a new name.

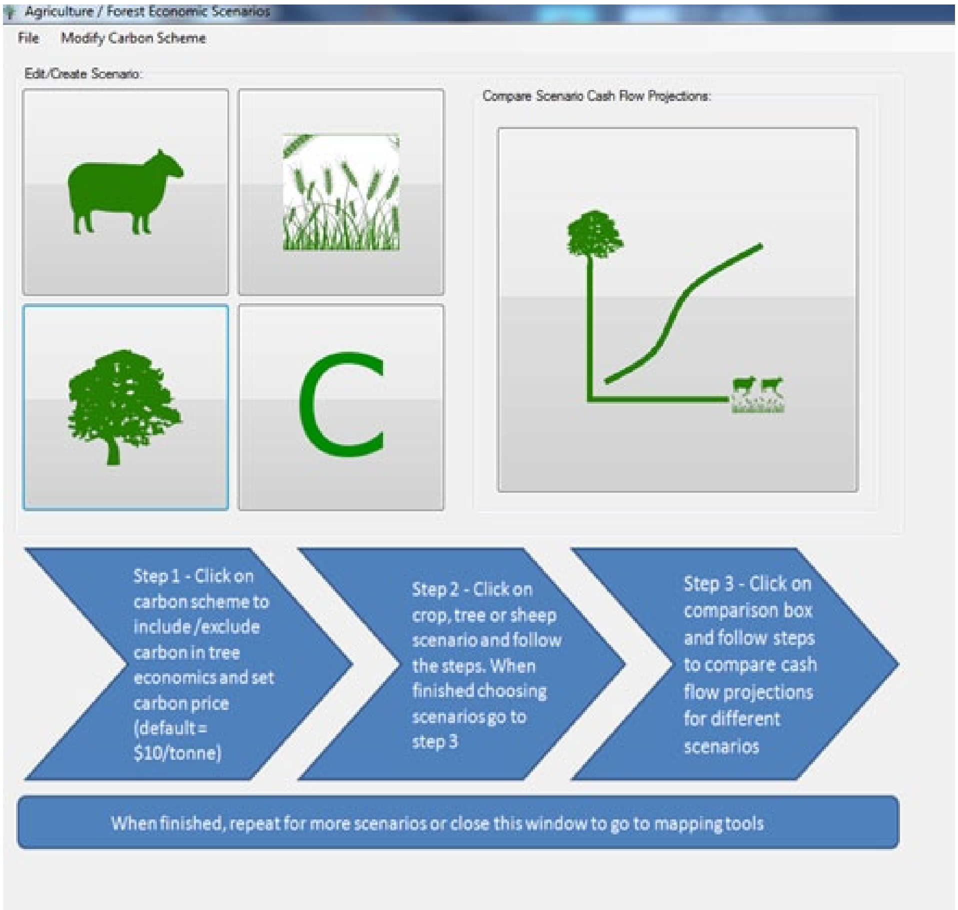
Once your new scenarios have been created, you can change the growth information contained in these and then use the “update scenario” command.

However, do not update the default templates, as the default information for prices and costs may be lost.

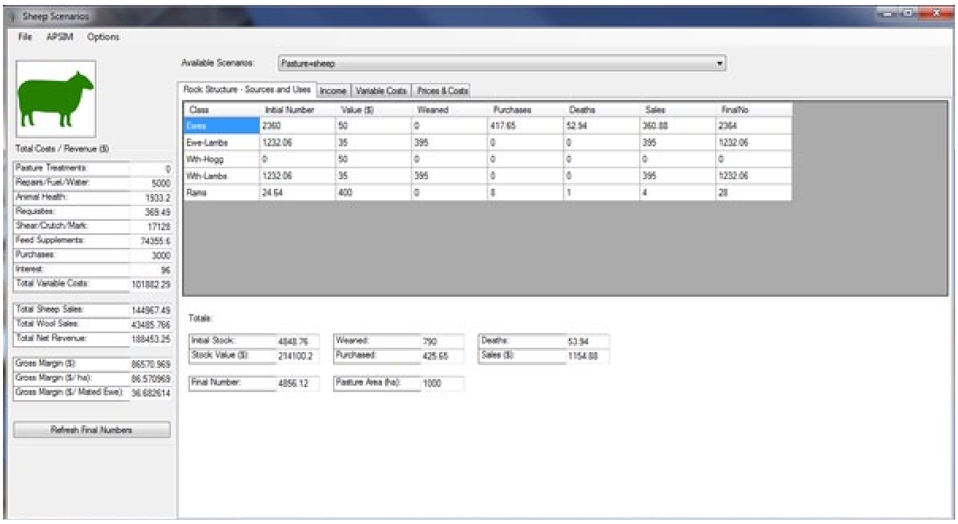
The different type of single year crop scenarios you create here can later be combined to build multiple year rotations in the “Compare Scenario Cash Flow Projections” window. You can also include pasture scenarios in these rotations; these are created as described in the following section.

6. Develop pasture scenarios

Click on the box containing the sheep below.



The following window will open.



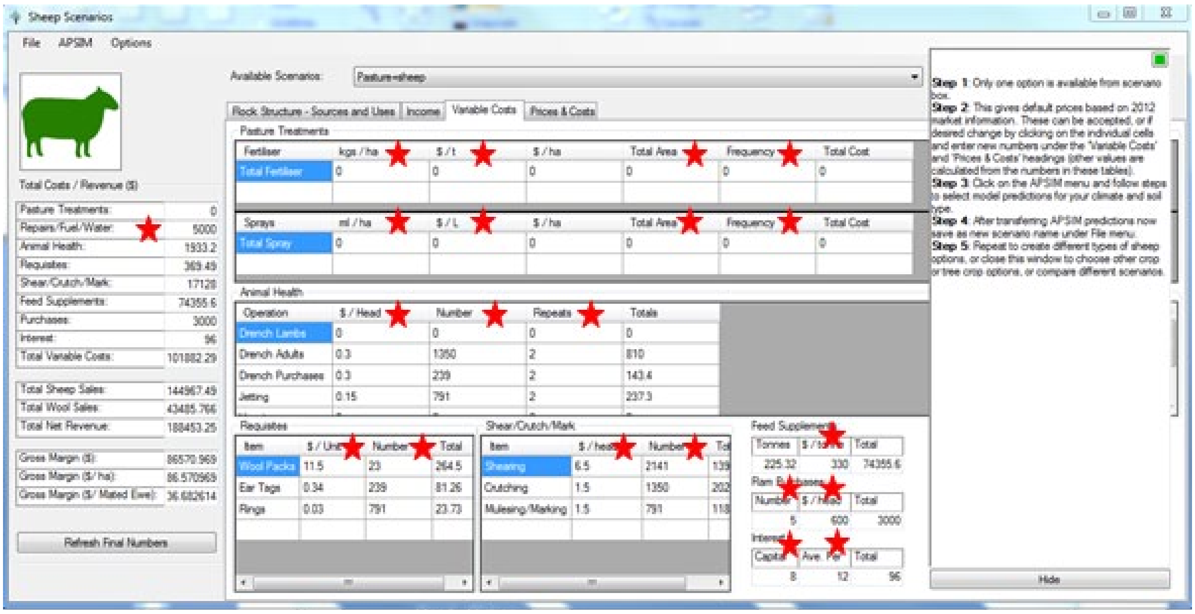
This window contains a template set up for a pasture with sheep containing some default costs and prices. You can accept the default values or change them, and then you will need to add in numbers from the APSIM menu for your location and soil type.

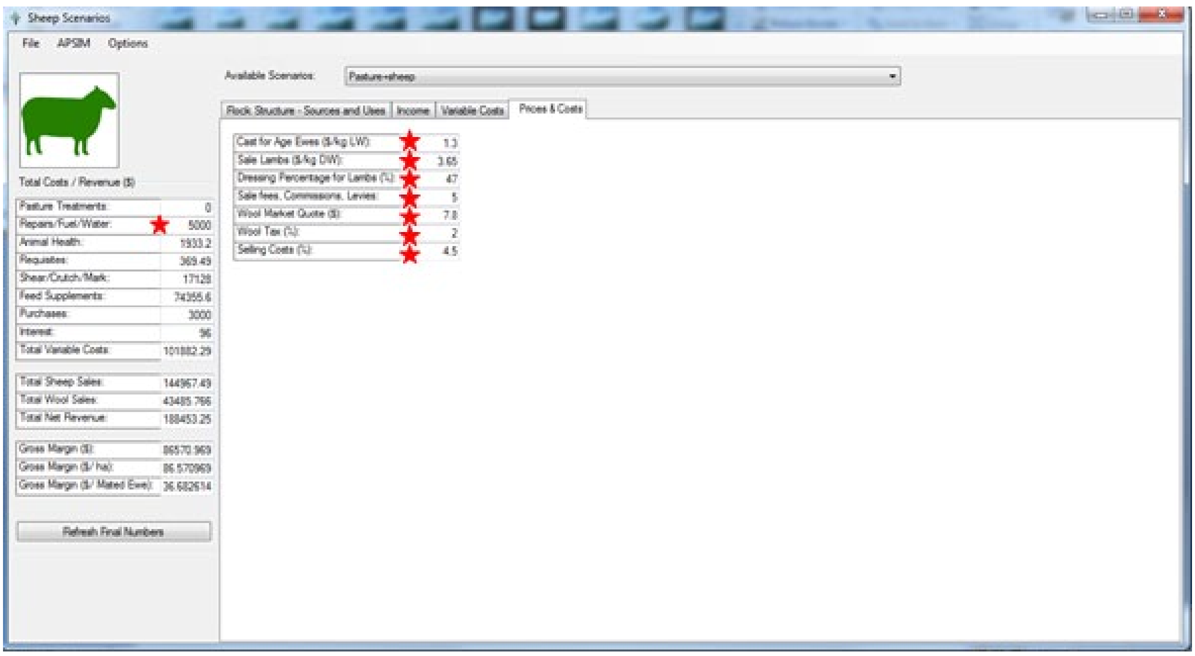
The first screen above shows the flock structure. This is predicted by the pasture model depending on what can be sustained for your climate and soil type. This will be updated when you make your selections in the APSIM window, and you do not need to change anything.

The numbers are shown for an example 1000 ha paddock. You can change this value, and change your costs accordingly. But all numbers are converted to a per hectare basis for the economic analysis so this may only be necessary if the difference in your paddock size is likely to have a large impact on your costs.

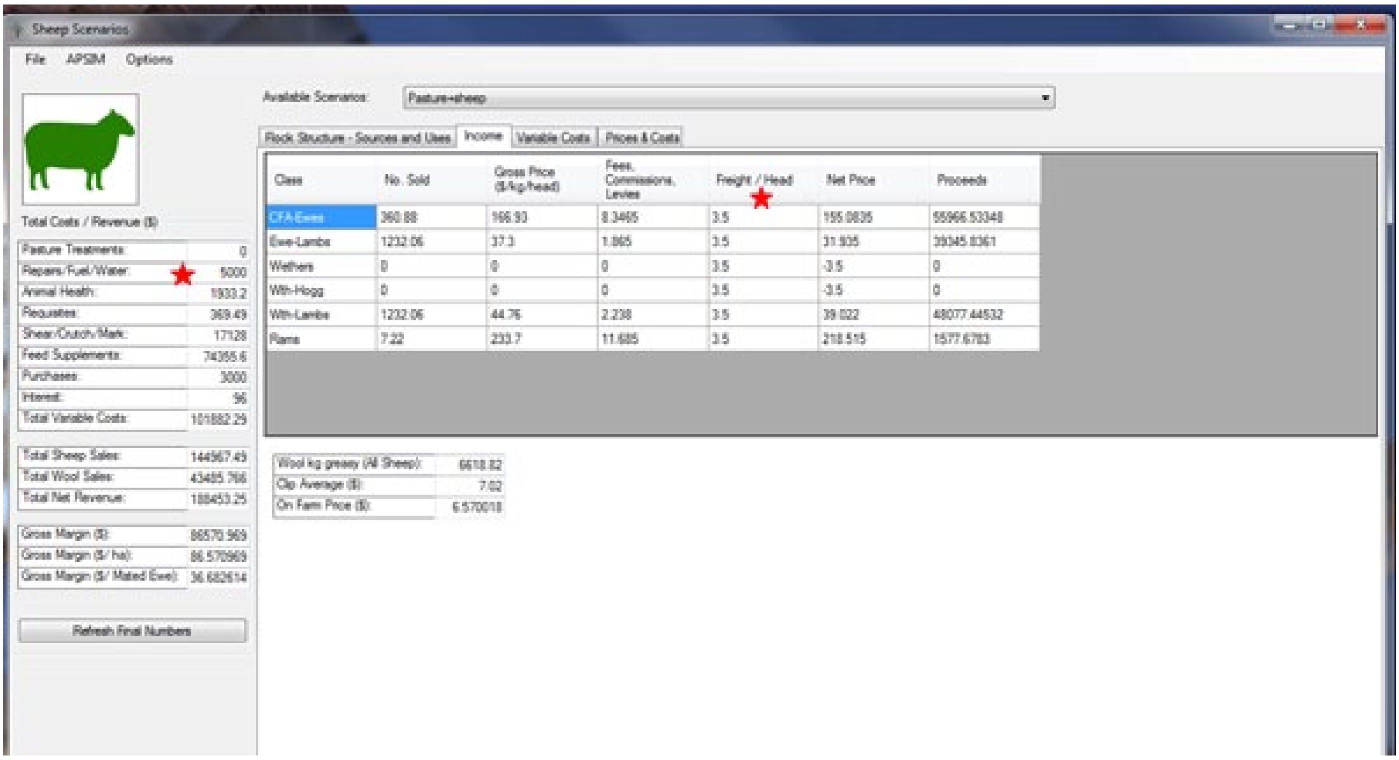
For more information on the pasture modelling and the assumptions made see the “Pasture modelling” section.

Changes to the costs can be made if desired, in the “variable costs” and “prices and costs” tabs. Values that could be changed are marked with a star in the pictures below. The other numbers come from the pasture model depending on your climate and soil, and do not need to be changed.



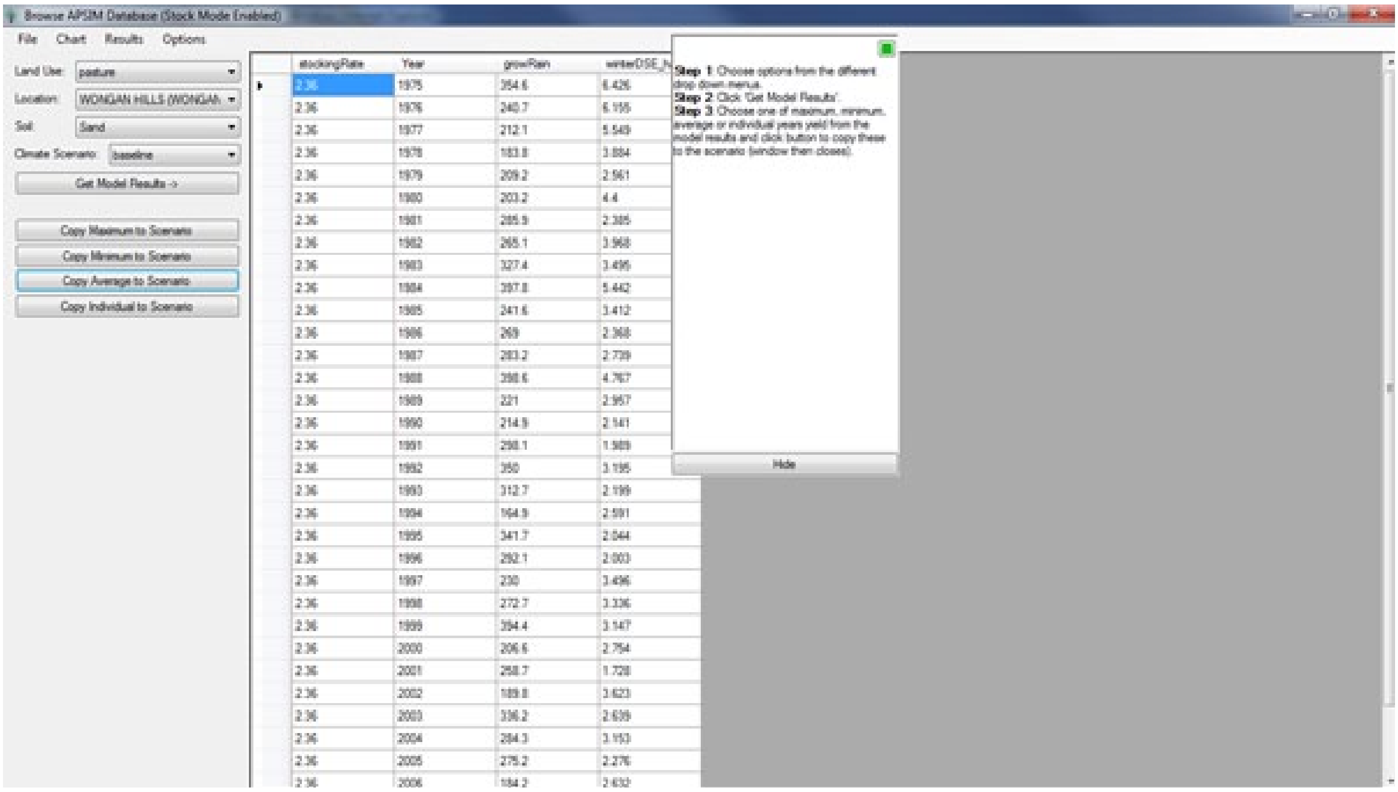


The values from these two tabs, shown above, are used to calculate the numbers in the "income" tab, shown below. In this tab, the only number you could change (and only if you do not want to accept the default), is the freight per head.



You can also enter a different value for repairs/fuel/water if you like, shown on the left hand side of the screen.

Once you have made changes to prices and costs, or decided you are happy to accept the default values, you need to open the APSIM window to choose production numbers for your location. Click on the APSIM menu and "Import APSIM scenario". The following window will open.



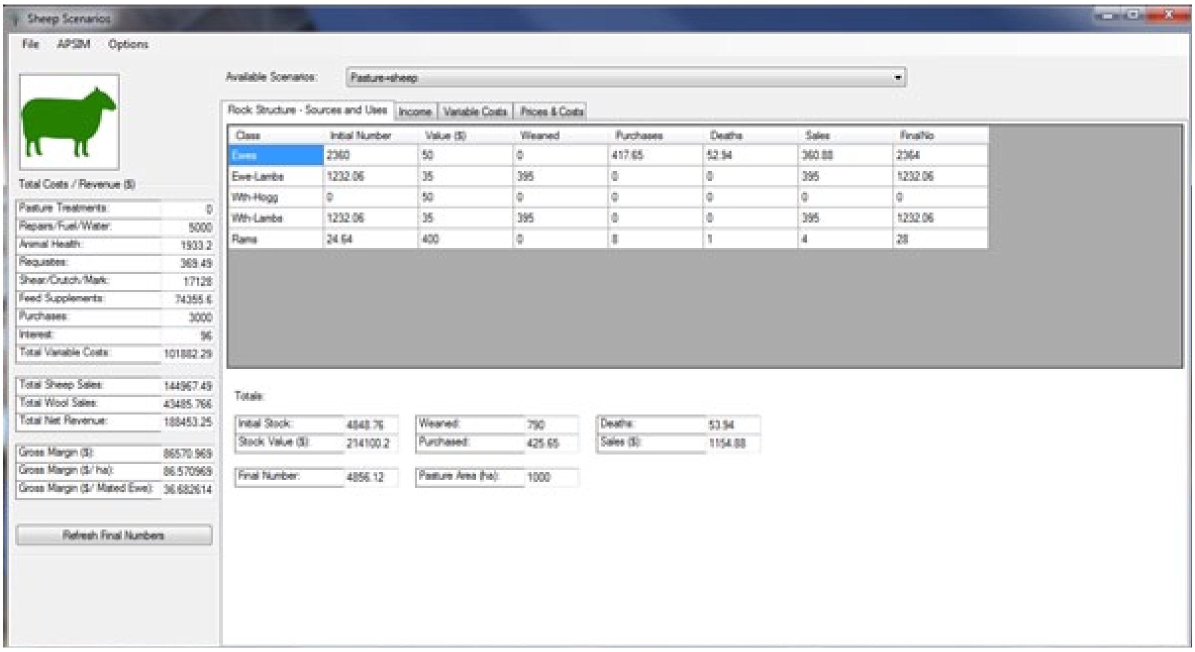
From this window you should select:

- The location; this will select the right climate information for your location.
- The soil type; sand, shallow soil, gravel, sandy earth, shallow sandy duplex, deep sandy duplex, shallow loamy duplex, deep loamy duplex, loamy earth or clay.
- If you want growth predicted for historical climate (baseline) or future climates (2030 or 2070).

Now click on "Get Model Results", and you will see the pasture growth predictions for the selections you have made. The columns will show the reference stocking rate (a number decided by what can be sustained for the average climate and soil type, see further information below), the year, the growing season rainfall each year, and the pasture production in terms of the "dry sheep equivalents" per hectare that could be maintained by this pasture growth. For more information on these numbers and how they are calculated see the "Pasture modelling" section.

When transferring numbers to your scenario, you may select the average production shown between 1975 and 2008 (click on "Copy Average to Scenario"), the minimum or maximum production (click on "Copy Minimum to Scenario" or "Copy Maximum to Scenario"), or production from a single year. For the latter, click on the row of the year you want to select, and then click "Copy Individual to Scenario".

You will then return to the window below:



Your scenario is now filled with production for your location.

Under the file menu save this as a new scenario with a new name.

Once your new scenario has been created, you can change the production information contained in these and then use the "update scenario" command.

However, do not update the default templates, as the default information for prices and costs may be lost.

You can now use the pasture scenarios you have created, along with the crop and tree scenarios, to compare profitability across multiple years, step 7.

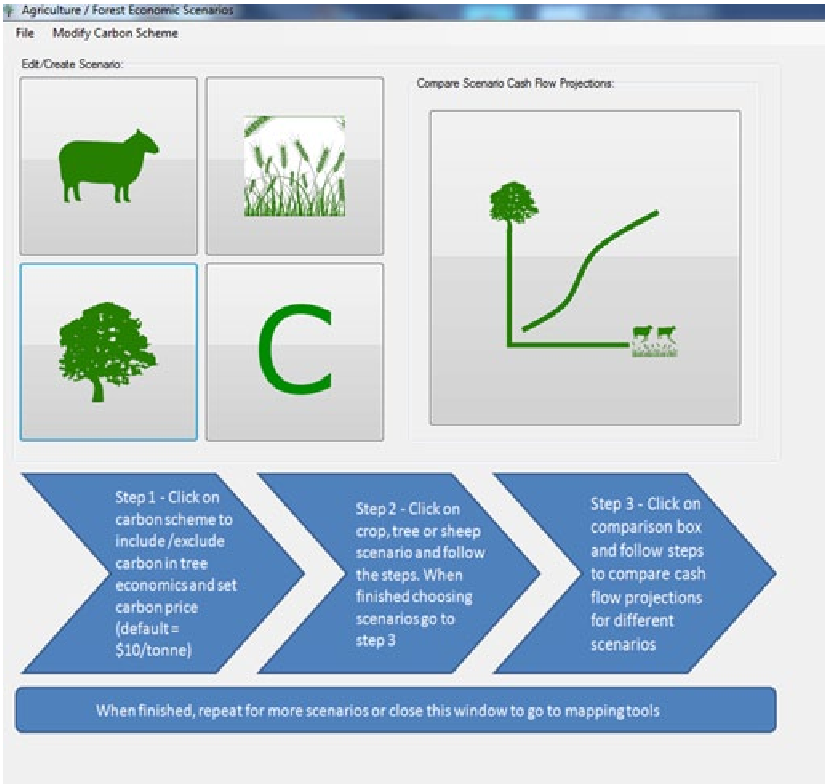




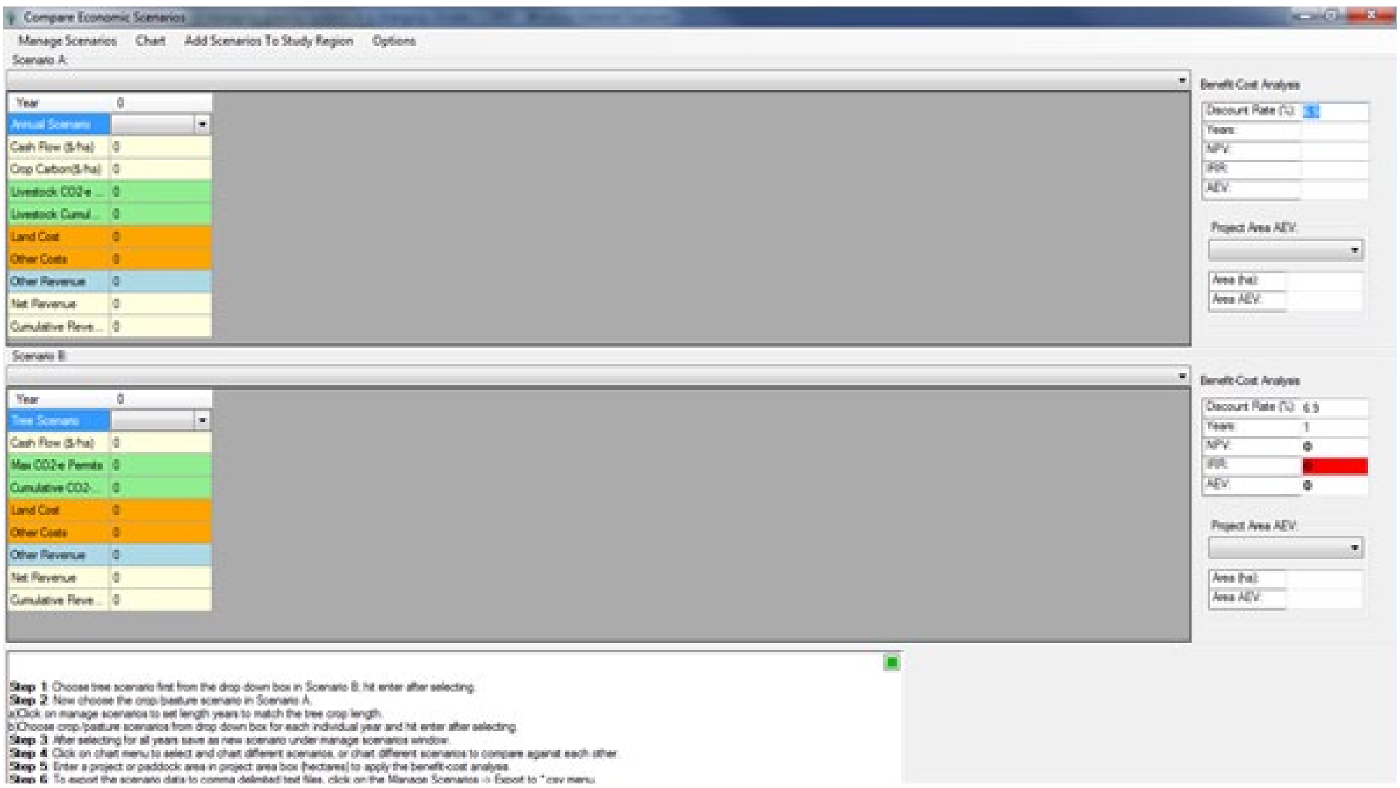
7. Compare the economics of different scenarios

You have created **multiple year** tree growth scenarios and **single year** crop and pasture growth scenarios for your area. The next step is to compare the financial performance of the different scenarios; the crop and pasture scenarios can be added together to create multiple year rotations that can be compared with the trees.

Click on the box under "Compare Scenario Cash Flow Projections".



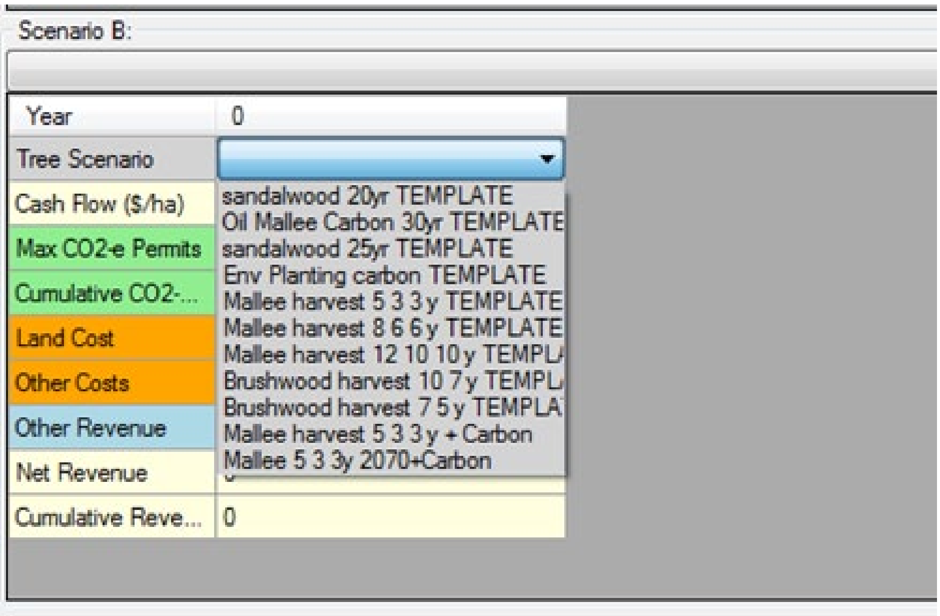
The following window will open.



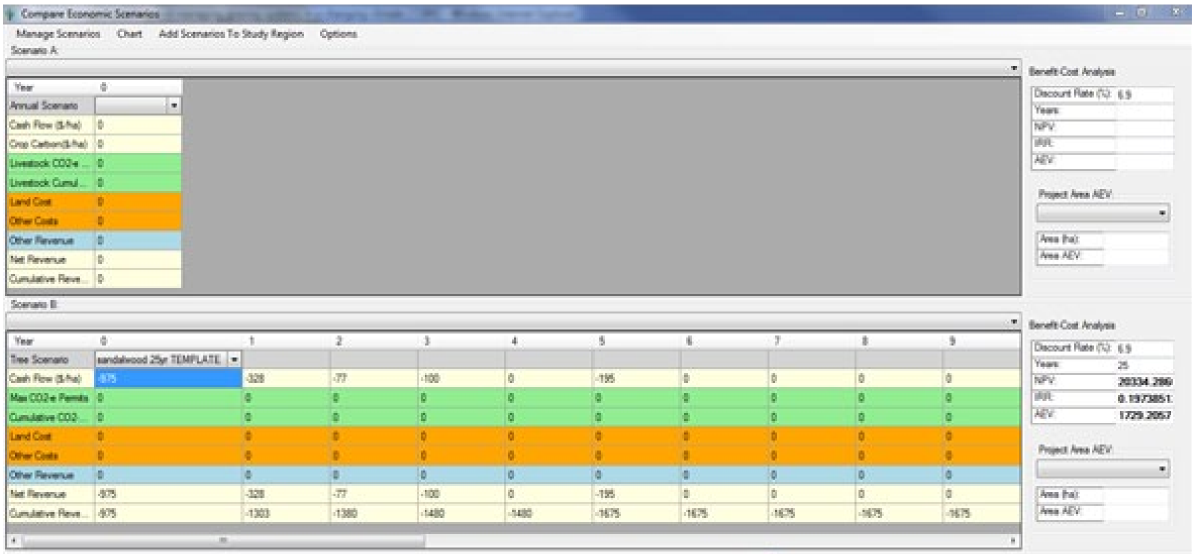
Create and compare multi-year scenarios

You can create multiple year crop and/or pasture rotations under Scenario A, and choose tree scenarios in Scenario B. It is easiest to select your tree scenario first, and then set the number of years in Scenario A to match.

Under Scenario B, click on the drop down box next to "Tree Scenario", and select one of the scenarios showing, (these are the scenarios you created in the previous steps).



After selecting, hit enter, and the revenue for this tree scenario is shown over a number of years (25 years in the sandalwood example shown here).

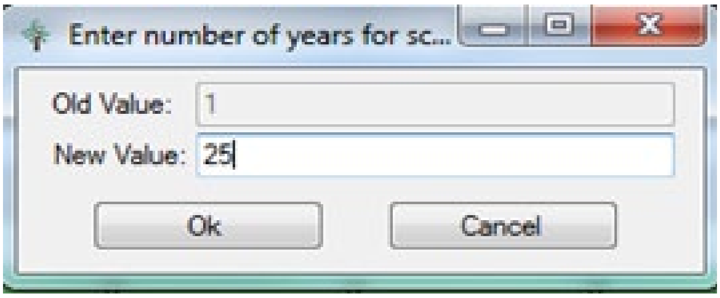


You can save this as an option available under Scenario B for later charting comparisons between the scenarios, (described in the steps below). Click on Manage Scenarios, Scenario B, Save as New Scenario and enter the name

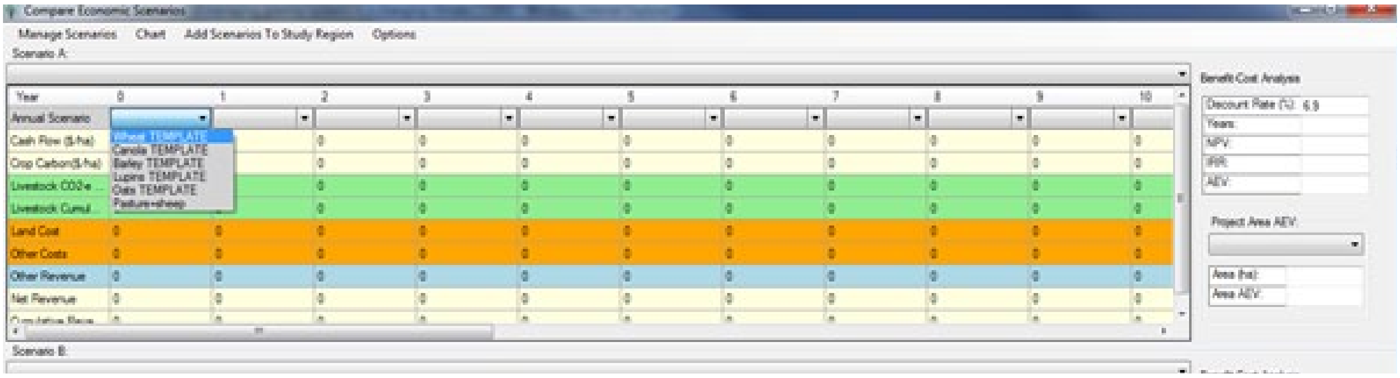




Now set the number of years in Scenario A to match your tree scenario. Click on Manage Scenarios, then Scenario A, then Set Length. Enter the desired number of years, then click Ok.

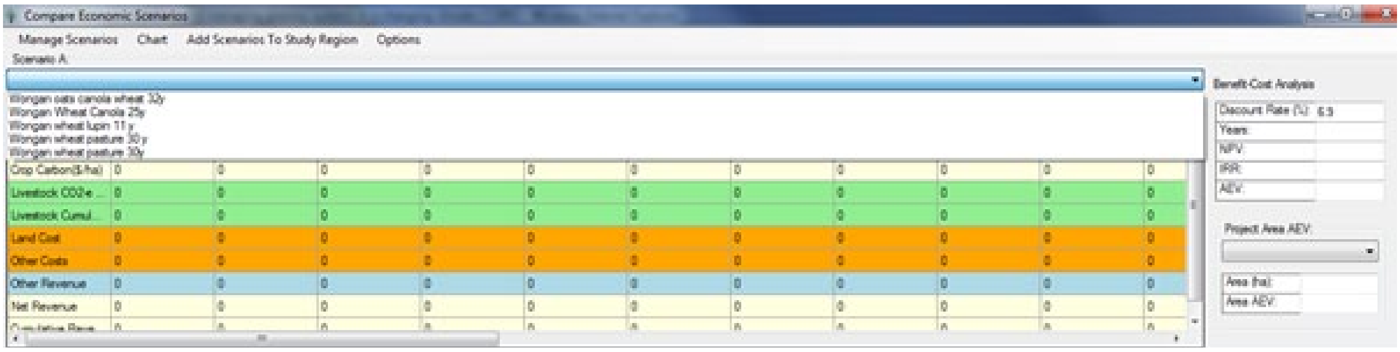


Scenario A will now show the number of years entered. For each year, click on the drop down box and select one of the crop or pasture scenarios that you created in the previous steps. Continue doing this until you have built a rotation for the number of years available.

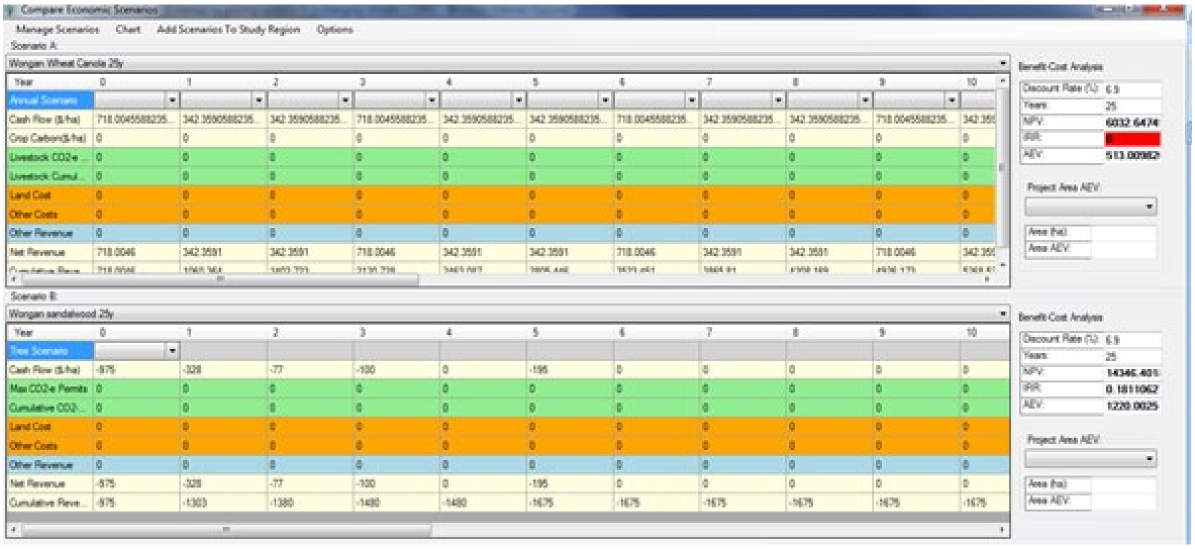


Once you have finished building your multiple year rotation, save it as a new name. Click on Manage Scenarios, Scenario A, Save as New Scenario and enter the name.

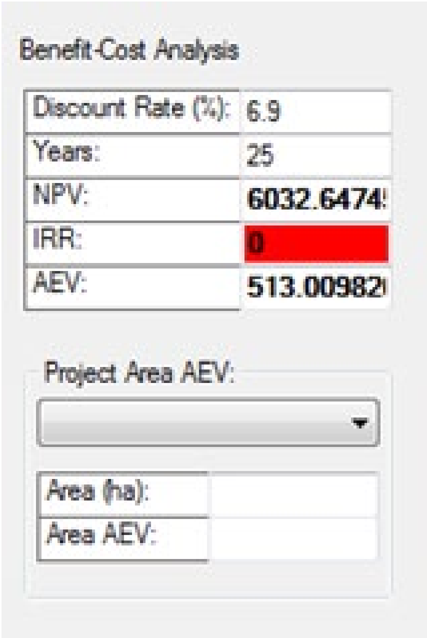
This new multiple year scenario will now appear in the drop down box at the top of the Scenario A window, as shown below.

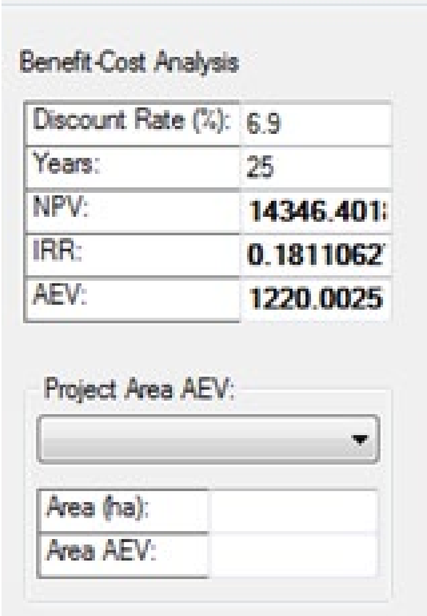


You can now compare the economics of different scenarios. In the example shown below, a rotation of one year canola with two years wheat, repeated for 25 years on a sandy soil in Wongan Hills, is compared with sandalwood grown for 25 years. The Net and Cumulative revenue is shown for each year at the bottom of Scenario A and Scenario B.



The boxes on the right hand side show the benefit-cost analysis, by converting the annual costs and revenue over the length of the scenario, to single numbers for net present value (NPV), annual equivalent value (AEV) and internal rate of return (IRR). These numbers indicate the profitability of Scenario A versus Scenario B.





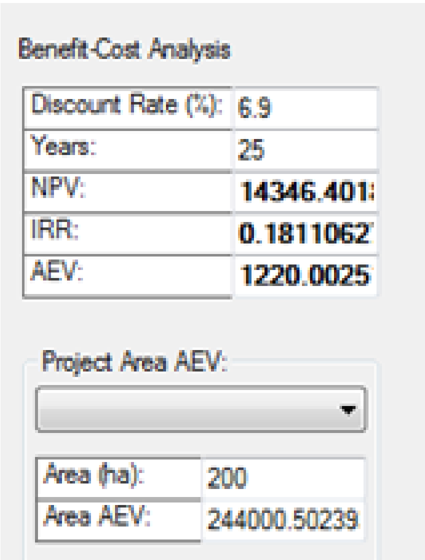
- NPV allows projects with different mixes of upfront and ongoing costs and revenues to be directly compared. It converts future costs and revenue streams into present day dollar values by discounting. The value shown is in $ per hectare.
- A discount rate is the percentage by which the value of a cash flow in a discounted cash flow valuation is reduced for each time period by which it is removed from the present.
- Note: A default discount rate of 6.9% is entered; this may be altered by the user if desired.
- NPV can be converted into an annual equivalent value (AEV), which is the average annual cash flow from the project after accounting for the discount rate. The value is in $ per hectare per year.
- Internal rate of return (IRR) is the average annual rate of return earned through the life of an investment, used to measure the profitability of an investment. The value shown is a proportional rate, multiple by 100 to compare this to the discount rate, (or comparable to an interest rate).

For more information on these measures, see the “Economics” section below.

If you wish to compare the profitability of two types of crop rotation, or two types of tree scenarios, you can change the “type” of scenario that is shown under A or B. For example, if you want to change scenario A to a tree scenario, click on Manage Scenarios, Scenario A, Change Type. A window will come up asking you to confirm that this will be changed to a tree scenario. Now Scenario A and B will both contain tree scenarios for you to select from. Similarly, you could change Scenario B to a crop type, and compare two different crop rotations in Scenario A and B.

Applying economics to a paddock area

The AEV can be calculated for an entire paddock in two different ways. Firstly, if you know the approximate area in hectares, you can enter it manually in the area box as shown below. The area AEV now shows the annual equivalent value ($) received each year for that paddock.



If the area of the paddock is not known, it can be measured with mapping functions by creating a study region. The method for creating a study region is described in the following section, step 8. To show the new study regions you have created in the mapping window (described in step 8), you will first need to close and then reopen the “Compare Economics Scenarios” and “Agriculture / Forest Economics” windows. When you return to the “Compare Economics Scenarios” window, the available study regions that have been created with the mapping functions will be shown in the drop down box under “Project Area AEV”. By selecting one of these study regions (e.g. Unnamed 1, shown below), the area of that region will be selected in the Area box, and the Area AEV ($ per year) shown for this region.

Compare scenarios in charts

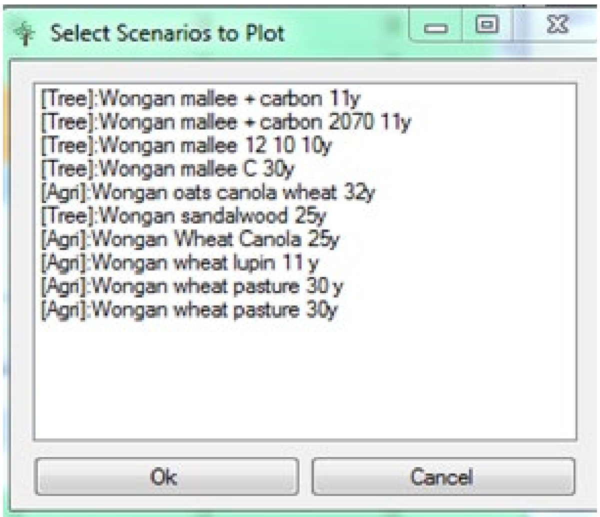




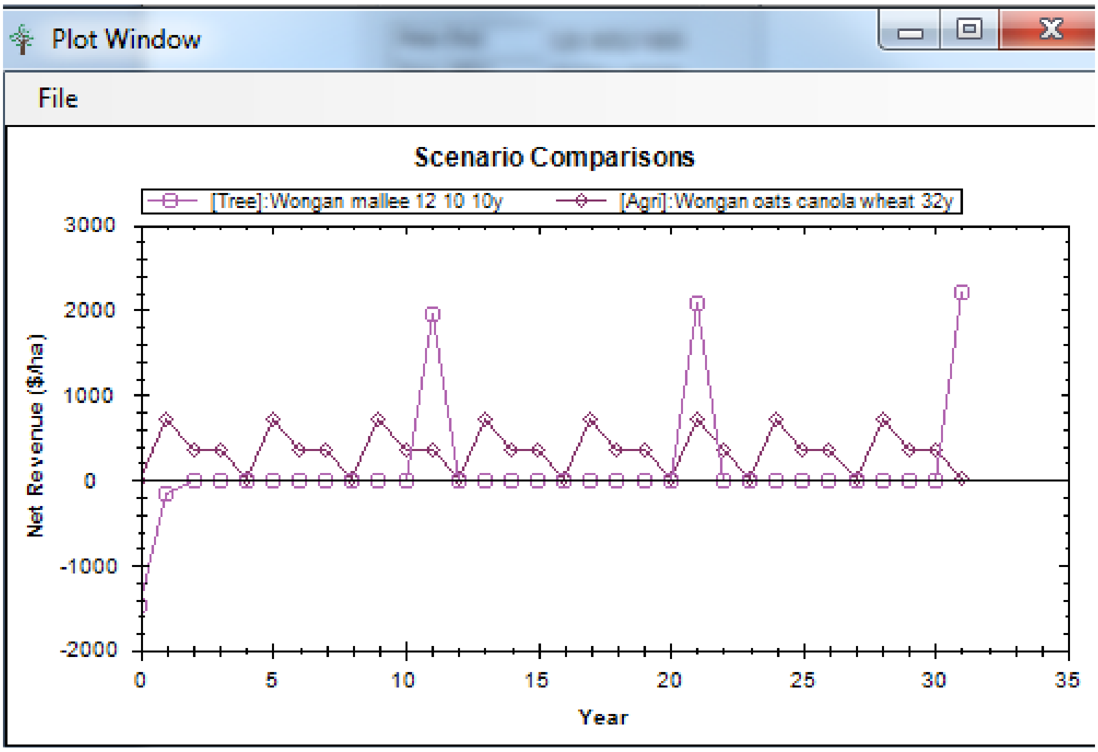
Once you have created different scenarios, you can compare them in charts, by clicking on the Chart menu.

If you wish to compare the scenarios that are currently open in Scenario A and Scenario B, click on “Scenario A vs. B Net” to compare the net revenue each year, or click on “Scenario A vs. B Cumulative” to compare the cumulative revenue i.e. the sum of each year’s net revenue for the duration of the rotation.

If you wish to compare different scenarios to those that are currently open, you can select any of the scenarios that you have created. A list will open after clicking on “Select and Chart Net” or “Select and Chart Cumulative”, as shown below.



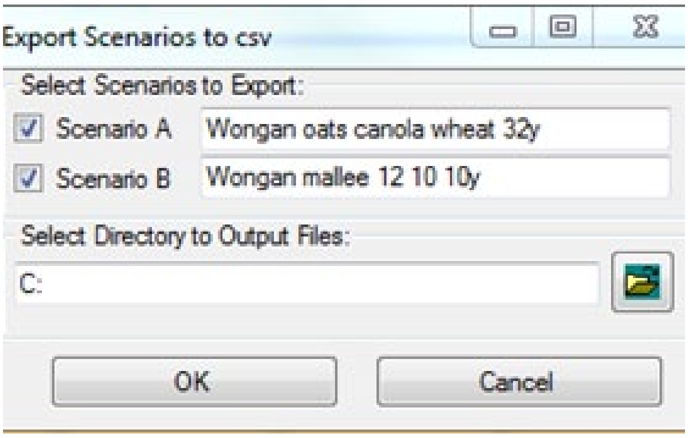
Select two scenarios to compare in your chart; click on one scenario, then hold down the control key and click on a second scenario. After clicking ok your chart will be shown. For example, the chart below compares the net revenue from oil mallees grown in a 12 + 10 + 10 year harvest rotation with a rotation of 1 year oats, 1 year canola and 2 years wheat repeated for 32 years, on a sandy soil near Wongan Hills.



If you are connected to a printer, you can print these charts by clicking File, Print.

Export your economic analysis to a spreadsheet

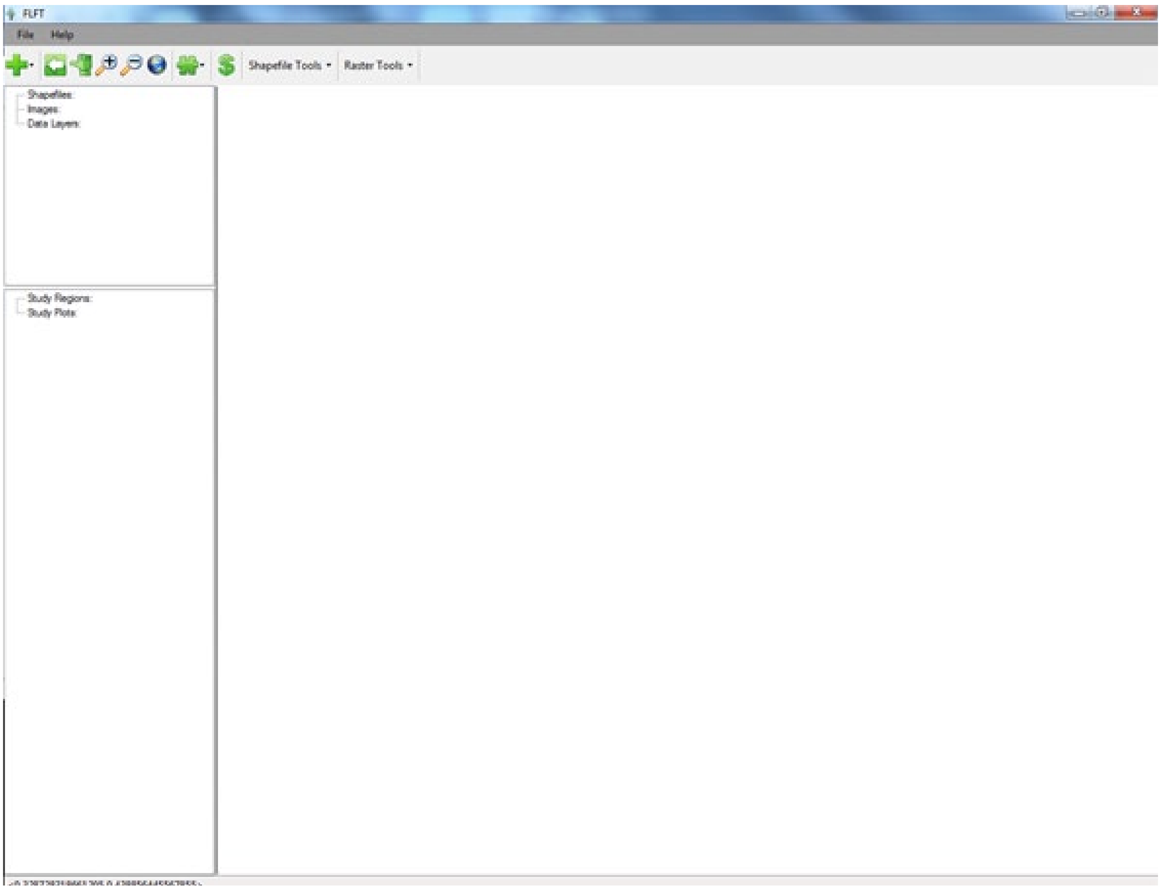
If you wish to do further analysis with the revenues produced under different multiple-year scenarios, you can export the numbers to a csv file that may, for example, be opened in Microsoft Excel.
Click on Manage Scenarios, then export to *.csv. The following window will open.



Click on one or both of Scenario A and Scenario B to select, change the file names or keep those shown if you like and then choose a directory where the files will be stored (you can either type this is in the box, or click on the file icon to browse). This will create a file for each scenario containing the cash flow and revenues for each year, as well as the information shown under the Benefit-Cost Analysis.

8. Use the mapping functions to create study regions

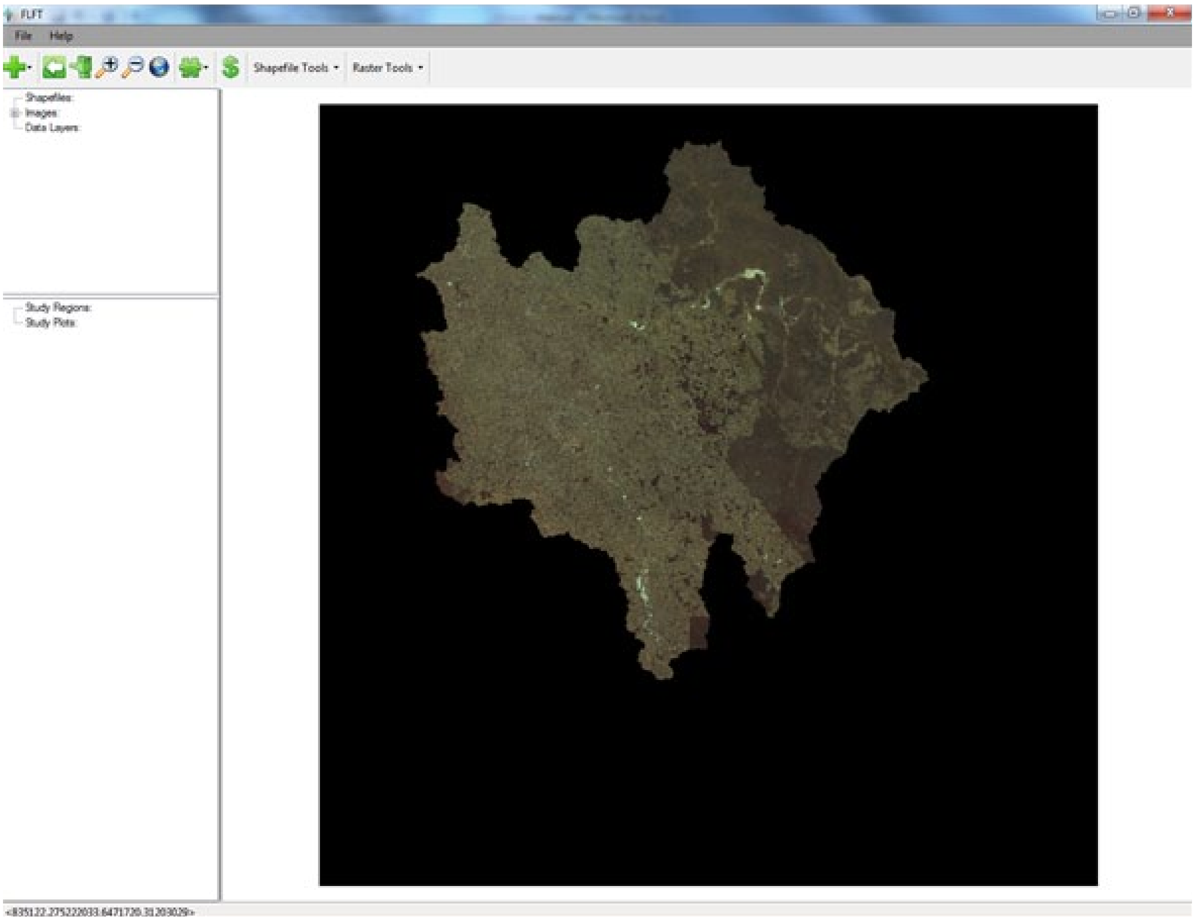
To use the mapping functions, close all other open windows until you see the following window.



From this window, open a satellite image of the Avon catchment area so that you can zoom into your paddock or area of interest.
Click on File, and Open Image Layer.

- Now you need to find the directory where you have installed this software, and then look for a folder called “catchment” under another folder “GIS_Files”. If you accepted default locations during the installation, it will probably be located at:
- C:\Program Files\CSIRO Tools\Farming Landscapes Futures Tool 1.5\GIS_Files\catchment
- Open the file called Avon_satimage321.png.

This file is large and will take a moment to load. Once loaded it will look like this:



You can zoom into your area of interest, by clicking on , then clicking and dragging the mouse to select a small area of the image. You will see this area of the map magnified.

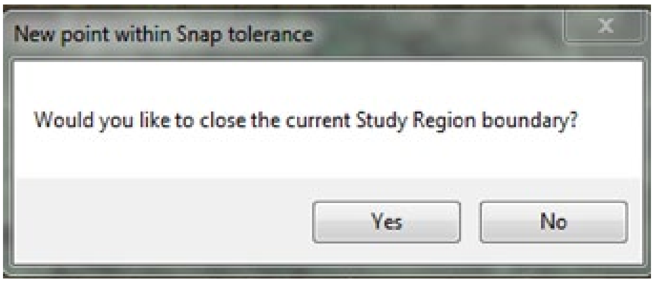
To zoom out again click on 

To move around the image click on , then click and drag the image in the direction you wish to see.
To return to the entire catchment view, click on 

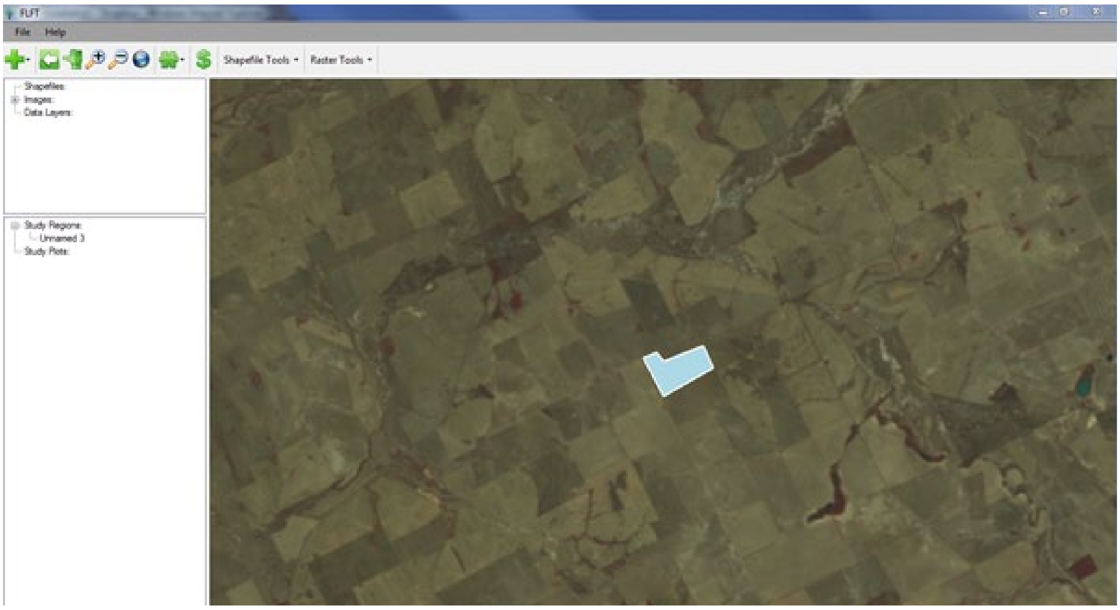
Once you can identify your paddock of interest, you can draw a line around it with the mouse to create a study region.

Click on , a menu will drop down, click on Add Study Region.

Now place your mouse over one corner of your paddock and click, place the mouse over another corner and click again; a line will be drawn between the two corners. Continue for all corners of the paddock, and when you click on the final corner you will get the following message:



Clicking yes will create a shape around your paddock, for example as shown below.



This study region will show up by clicking on the + button next to "Study Regions" on the left hand side of the screen. You can rename it by right clicking on it and clicking Rename. If you click on Toggle Shape Fill, the study region will become transparent. Now you can click on Show Region Labels, and the area contained within the study region will be shown, e.g. as shown below.

You can now use this study region in your scenario comparisons, in the “Compare Economics Scenarios” window.

To go back to the windows for creating and comparing scenarios, click on 

There are further functions available for use within the mapping window. These functions are more advanced and complicated to use. If you are interested in these functions, please contact CSIRO for more information (contact information is given at the beginning of this manual).

Further information

Climate of the Avon River Basin

The total area of Avon River Basin (ARB) is 120 000 km2, comprising three water catchments, the Avon, Yilgarn and Lockhart (Figure 1). The area has a relatively low average annual rainfall, increasing from 200 mm at the eastern edge of the basin to 450 mm in the town of Northam. The rainfall gradient then increases steeply to 750 mm at the western edge of the basin. Since 1976 there has been a trend of decreasing rainfall in the western parts of the ARB, by up to 15% (O’Connor et al. 2004).

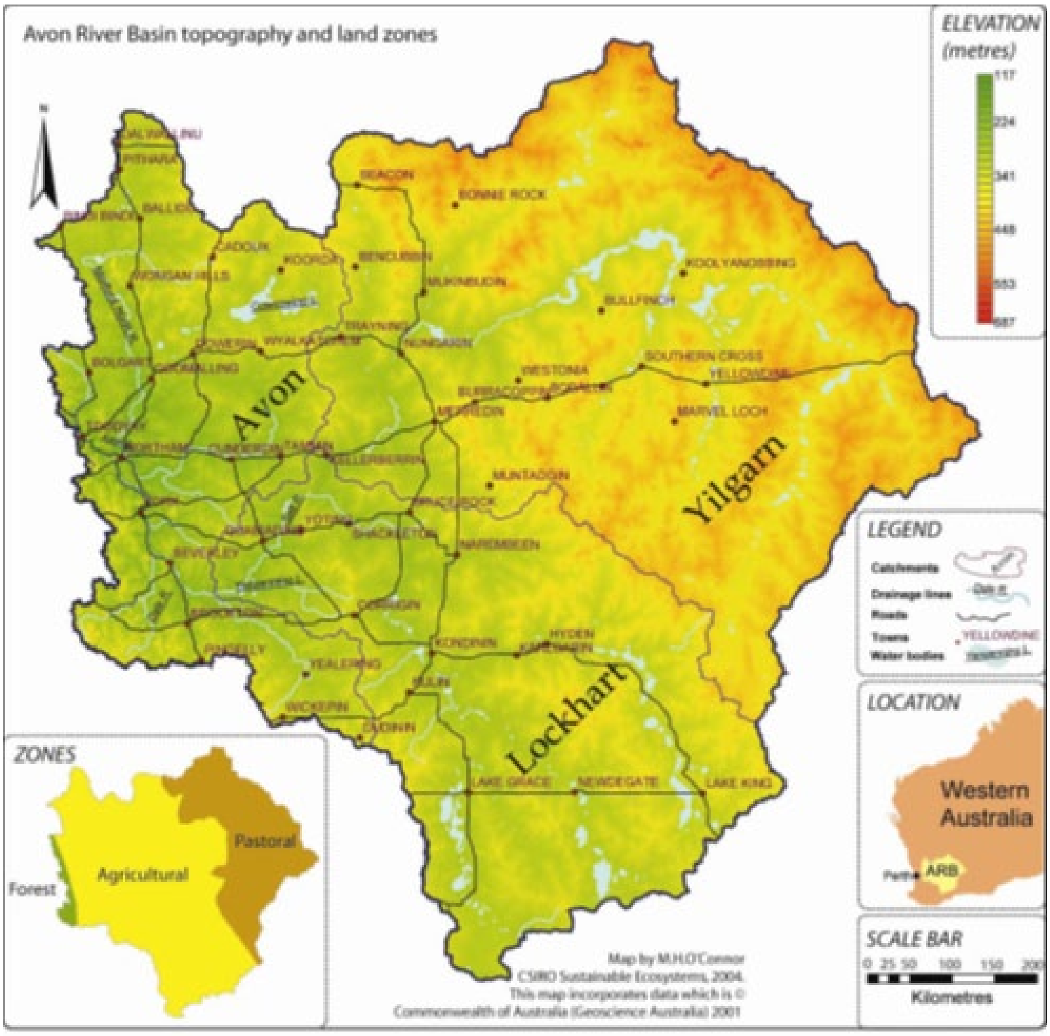


Figure 1: The Avon River Basin, Western Australia. Figure from O’Connor et al. (2004).





Climate data was used for predicting tree, crop and pasture growth in this software, from seven climate stations, chosen to cover the rainfall gradient across the ARB. These are Wongan Hills, Bencubbin, Northam, Brookton, Lake Grace, Narembeen and Southern Cross. For each site, data on rainfall, maximum and minimum temperature, frost days and solar radiation between 1975 and 2005 were attained from the 'SILO Data Drill' facility.

Tree, crop and pasture growth was also predicted for future (2030 and 2070) climates, by using the changes predicted by the climate change model CSIRO Mk3 A2 to alter the historical climate data for the 7 climate stations above. More information about climate change models can be found at http://www.csiro.au/science/Understanding-and-predicting-climate-change.html.

In the Avon River Basin, rainfall is generally predicted to decrease in 2030 and 2070, by between 5 and 30 mm per year. Rainfall is predicted to decrease in winter and spring, but there is predicted to be some increase in summer rainfall, particularly in the 2030 scenario. Maximum temperature is predicted to increase slightly at all 7 climate stations during all seasons in the 2030 climate, and increase significantly by 2070 to between 1oC and 2oC warmer than historical climate.

Atmospheric CO2 concentrations are expected to increase from approximately 390 ppm at the present, to 450 ppm in 2030 and 629 ppm in 2070. Higher atmospheric CO2 concentrations can have a positive effect on plant growth, but the effects are variable and the long term effects unknown. Due to the uncertainty predicting the effects of elevated atmospheric CO2, tree growth was predicted for future climates both with higher CO2 and with historical atmospheric CO2 concentrations. Predictions of crop and pasture growth in future climates did not take into account atmospheric CO2 increases.

Soils of the Avon River Basin

The soils in the region are predominantly deep sandy duplexes, shallow loamy duplexes, sandy earths, loamy earths, shallow sandy duplexes, ironstone gravels and deep sands. Other soils occurring less frequently are shallow sands, rocky/stony soils, cracking and non-cracking clays, shallow loams and deep loamy duplexes. Waterlogged soils occur in 5% of the ARB (O'Connor et al. 2004).

Soils within a paddock can be highly variable, and available soil maps of the ARB are at a relatively coarse scale. Therefore, rather than using soil maps to obtain soil type and predict plant growth, the users of the software are asked to enter their assessment of the soil type for the area they would like to consider. Different descriptions are used in the crop model APSIM and the tree model 3PG, as shown in Table 1, and the class that most accurately matches the dominant soil in a paddock should be chosen.

Table 1: Soil classes used for APSIM (crop and pasture) and 3PG (tree) modelling

APSIM		3-PG	
1	Sand	1	Clay
2	Shallow Soil	2	Clay loam
3	Gravel	3	Loam
4	Sandy Earth	4	Sand
5	Shallow Sandy Duplex	5	Sandy clay
6	Deep Sandy Duplex	6	Sandy loam
7	Shallow Loamy Duplex		
8	Deep Loamy Duplex		
9	Loamy Earth		
10	Clay		

Tree modelling

Growth of tree crops was predicted for the systems shown in Table 2 using the predictive model 3PG, or Physiological Principles that Predict Growth. This is a model that predicts forest stand development, as well as stem, root and foliage biomass, stand water use, and available soil water. In simplified terms, growth is predicted based on the amount of sunlight (photosynthetically active radiation) received, and modified by the temperature, rainfall and soil water availability. Therefore, information about the climate and soil type is needed. Growth is also modified by certain characteristics that are particular to different tree species; this information is collected from field studies and research experiments. Please see Appendix 1 for more information about 3PG.

Conditions for the tree scenarios shown in Table 2 were chosen based on advice received from the Oil Mallee Association, the Australian Sandalwood Network, Dr Geoff Woodall (UWA), Dr Jon Brand (FPC), and the Wheatbelt Brushwood Growers.

Table 2: Tree Scenarios

Scenario	Product	Rotation (years)	Stocking (stems per hectare)
Mallee CO2e	Carbon	30	2500
Mallee harvest 5 3 3 y	Bioenergy	5 + 3 + 3	2500
Mallee harvest 8 6 6 y	Bioenergy	8 + 6 + 6	2500
Mallee harvest 12 10 10 y	Bioenergy	12 + 10 + 10	2500
Environmental Planting CO2e	Carbon	20	1500
Sandalwood 20 y	Wood	20	1000 host
300 sandalwood			
Sandalwood 25 y	Wood	25	1000 host
300 sandalwood			
Brushwood harvest 7 5 y	fencing	7 + 5	4000
Brushwood harvest 10 7 y	fencing	10 + 7	3000

Oil mallee scenarios

Oil mallee growth is predicted based on the average of observations of the species Eucalyptus polybractea, E. loxophleba ssp. lissophloia and E. kochii, instead of distinguishing between the different species. The growth is modelled assuming seedlings are planted at 2500 stems per hectare, in two- to six-row tree belts. Note that growth of narrow belts is higher than wider belts or blocks due to greater access to water, light and nutrients on belt edges. Mallee growth was modelled here with an edge effect for 50% of the trees, which would be the case for a four-row belt. Narrower belts may have higher growth than shown and wider belts may have lower growth. The biomass (or carbon dioxide equivalents, see below) is shown in tonnes per hectare over the planted belt area only, including 1 m either side of the belt.

Mallee CO2e

Oil mallees are grown and not harvested; payments are made for the carbon dioxide that is stored in the wood, branches, leaves, bark and roots, in tonnes of carbon dioxide equivalents (CO2e), after 30 years of growth. See the section below for more information on CO2e calculations and payments.

Mallee harvest 5 3 3 y

Oil mallees are grown for 5 years and then the above-ground biomass is harvested. A market does not currently exist for oil mallees, but there is some potential for the biomass to be sold for bioenergy. As no market currently exists prices for the biomass are unknown; default prices were chosen for this software based on information contained in the Bioenergy Australia report (Stucley et al. 2012).

After the initial harvest, the mallees will re-sprout, or coppice, from the roots and lignotuber that are left behind. This regrowth will be harvested after 3 years and then again in another 3 years, to give a total rotation length of 11 years. At each harvest, payments are made for the total above-ground green biomass (tonnes per hectare, assuming 45% moisture content).

Mallee harvest 8 6 6 y

Mallees are grown as above, but harvested later; at 8 years initially, then after 6 years of coppice regrowth and again another 6 years after the second harvest (20 years total rotation length). This option might be chosen in areas where growth rate is low to allow more growth between harvests, or to reduce the frequency of harvesting costs.

Mallee harvest 12 10 10 y

As above, but with harvest made at 12 years for the first harvest, then after 10 years of coppice regrowth for the second harvest, and another 10 years of coppice regrowth for the third harvest (32 years total rotation length).

Environmental plantings CO2e

Environmental plantings refer to a mix of woody species adapted to the local area, grown for environmental benefits (e.g. biodiversity, salinity or erosion control), which may also receive a commercial payment for carbon dioxide sequestration. Growth was predicted for seedlings planted in six-row belts at 1500 stems per hectare, (i.e. edge growth enhancement for one third of trees; growth may be higher for narrower belts, or lower for wider belts). An understorey component was included (between 0.5 to 2 tonnes per hectare) which would not be credited for CO2e payments. Payments are made for the CO2e in wood, branches, leaves, bark and roots, in tonnes per hectare over the planted tree belt area only.

Sandalwood

Western Australian sandalwood (Santalum spicatum) and host growth was predicted based on observations of plantings with hosts of jam (Acacia acuminata), mulga (Acacia aneura), sheoak (Allocasuarina spp.) and biodiverse mixed species.

Because of the way the tree growth model 3PG operates, we predicted the combined growth of hosts and sandalwood as one stand of trees in a block planting. We assumed hosts were planted at 1000 stems per hectare, and the sandalwood at 300 stems per hectare. The total combined biomass was then split into sandalwood and host tree biomass based on observations of several stands across the Avon catchment. The green weight is shown, assuming 45% moisture content.

Sandalwood is split into several commercial classes, with roots, butts and Class 1 wood being the most valuable. The paper by Brand and Pronk (2011) describe these classes, and also calculated the average split between classes measured in 64 trees aged between 8-26 years, shown below:

Roots; 10 – 17%
Butts; 11 – 14%
Class 1, branches > 4 cm diameter and 30 cm length; 33 – 46%
Class 2, branches > 2 cm diameter and 15 cm length; 16-20%
Class 3, branches < 2 cm diameter; 11 – 23%

The sandalwood yield shown in the software is the green biomass for butts, roots and stems >20mm diameter. No branches, foliage or bark are included, and as such no class 3 wood is predicted. However, in the default split between classes we still included a small amount of class 3 wood to account for stems that may be shorter than the minimum required length. Therefore, the default split we used between classes is:

Class 1 plus roots and butts; 60%
Class 2; 30%
Class 3; 10%
This can be altered as required.

The value of the wood produced will depend on the oil content of the wood, and there is little knowledge of what this might be for planted sandalwood (most production of sandalwood wood in Western Australia has so for been from wild-grown trees). The default prices used in this software were based on advice received from Dr Geoff Woodall (UWA), and are for Roots, Butts, Class 1 and Class 2 wood grouped together. It is assumed that no income will be received from Class 3 wood.

Due to limitations with the model 3PG, nut production was not predicted. However, an income (and harvest costs) from nut production could be added manually in the template sheet containing economic information, by entering numbers under the “other” row, for the years you anticipate potentially harvesting nuts. For example, some growers have reported harvesting 100 kg per hectare from age 5 onwards, receiving prices between $3 - $5 per kg. For further information contact the Australian Sandalwood Network.

Brushwood

Brushwood is grown in a similar way to oil mallees, with above ground biomass re-sprouting from cut stems after periodically harvesting. Markets for brushwood biomass are not established in Western Australia, but products could include fencing or bioenergy. However, because of the uncertainty around establishment of a brushwood industry, no default prices are included and the user must decide what these should be. Two scenarios are included; an initial harvest at 7 years and a second harvest 5 years later, and an initial harvest at 10 years then a second harvest 7 years later. At each harvest, payments are made for the total above-ground green biomass (tonnes per hectare, assuming 45% moisture content).

Note: There are relatively few observations of brushwood growth, particularly for coppice growth after harvest; therefore there is significant uncertainty in the predictions of growth contained in this software.





Carbon

Carbon credits may be claimed by farmers and land managers for storing carbon or reducing greenhouse gas emissions on the land under the Government's Carbon Farming Initiative (CFI). For more information on the CFI and eligible activities see the Department of Climate Change and Energy Efficiency (DCCEE) Website: http://www.climatechange.gov.au/cfi

In this software, users can choose to claim carbon payments in the tree scenarios, for the CO2 that is removed from the atmosphere and stored as carbon in trees. Government approved methodologies exist for claiming carbon stored in environmental plantings (details are available at http://www.climatechange.gov.au/government/initiatives/carbon-farming-initiative/methodology-development/determinations/environmental-plantings.aspx) and for reforestation of land previously used for agriculture with trees that have a potential height of 2 m or more (http://www.climatechange.gov.au/government/initiatives/carbon-farming-initiative/methodology-development/determinations/reforestation%20and%20Afforestation.aspx); these may be applicable to environmental plantings or oil mallees that are not harvested.

A methodology has been proposed for harvested farm forestry plantings on agricultural land (http://www.climatechange.gov.au/government/initiatives/carbon-farming-initiative/methodology-development/proposals/farm-forestry-projects.aspx); this is currently under consideration by the DCCEE and if approved may be applicable for harvested oil mallee systems and brushwood. This could potentially also apply to harvested sandalwood systems, although may require some modification to include the carbon stored in unharvested host plants.

Note that carbon payments are included as an option for tree scenario economics in this software as a demonstration of the potential income that could be derived, but advice should be sought about the eligibility of your planting type before carbon projects are established.

The amount of carbon in trees is approximately equal to half the dry weight of above and below ground biomass; this varies slightly depending on the component (i.e. leaves vs. wood vs. bark). The equivalent amount of CO2 that has been taken out of the atmosphere by trees to produce this carbon (i.e. CO2 equivalents or CO2e) is equal to the carbon multiplied by 3.67.

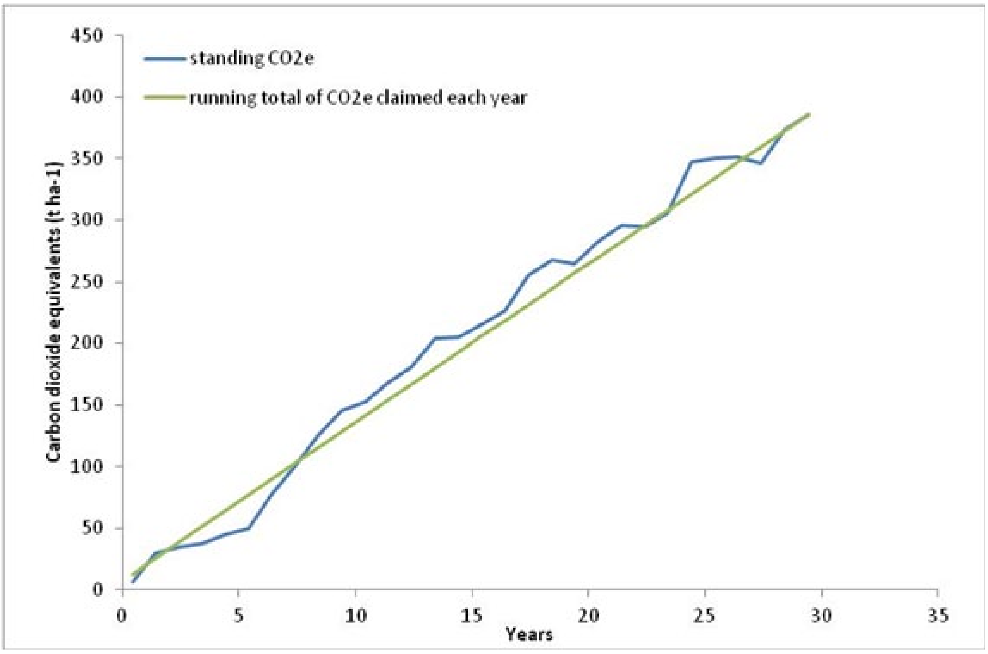


Figure 2: Example of the accumulation of carbon stock over 30 years in an unharvested oil mallee planting. A claim for CO2e is made each year for the total CO2e after 30 years divided by 30 years, to avoid the issue of negative CO2e increments in some years.

For unharvested systems (environmental plantings and oil mallees, and the host plants in the sandalwood-host system), the CO2e claimed is the amount in the final above and below ground biomass. Payments for CO2e increments are made each year by calculating the total amount of CO2e at the end of a rotation and dividing by the number of years in the rotation, as shown in Figure 2. This is to avoid issues with negative increments in CO2e in some years, due to variation in growth rates over time.

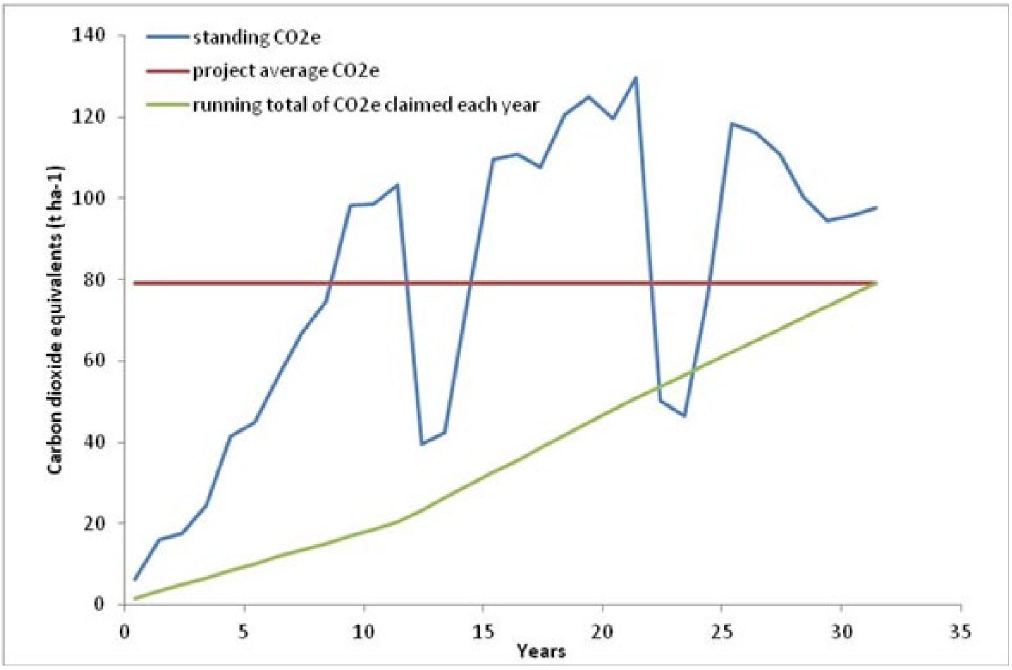


Figure 3: Example of changes to carbon stock over three rotations of a harvested oil mallee planting, and average carbon over the same time period. Carbon can be claimed at each reporting period until the amount claimed is equal to the project average carbon stock. Adapted from the methodology document of a proposed measurement-based methodology for farm forestry projects (available from http://www.climatechange.gov.au/government/initiatives/carbon-farming-initiative/methodology-development/proposals/farm-forestry-projects.aspx).

For harvested systems (harvested oil mallees, brushwood and sandalwood), the average CO2e over the rotation length can be claimed, following the proposed methodology currently under consideration. Figure 3 shows an example of the potential changes in CO2e over three rotations of a harvested and re-coppicing oil mallee planting; CO2e increases after planting as the trees grow, then decreases at harvesting with just the CO2e in roots remaining. The CO2e then increases again as the trees regrow. The average CO2e is calculated over three of these cycles, and average CO2e divided by the total number of years in the rotation is claimed each year. At the end of the rotation, the running total of CO2e that has been claimed is equal to the project average CO2e.

Carbon economics

Default costs are entered in some of the tree economic templates for certification of carbon projects, auditing, and brokerage or commission on sale of carbon credits. However, these costs are shown to give a rough indication of potential costs only; actual costs may vary widely depending on the nature of the project, and expert advice should be sought on this.

Accreditation or certification will require expert professional input and so is likely to be costly. It is difficult to estimate these costs precisely, but based on the information likely to be





required we can judge that they are likely to be in the order of $10,000 per project. Estimates of brokerage costs come in at around 20c per permit. There will also be legal and contracting costs. It should be noted that there are potential economies of scale in these costs. While brokerage costs accrue per permit, registration and accreditation costs accrue at the scale of the project or provider.

The costs in the FLFT software are on a per hectare basis; we entered some default carbon costs assuming a 100 ha project. Therefore, certification was assumed to be $100/ha. A default auditing cost of $10/ha was used. Brokerage costs were entered depending on the amount of CO2e produced, and included under “Other” costs, along with legal or contracting costs, with a default of $1/tonne of CO2e. These values are uncertain, and should be updated after seeking expert advice.

An individual landholder registering as offset providers and going through project accreditation may be unlikely to represent an efficient business model. Specialist intermediaries may be better placed to minimise the transaction costs through developing the required expertise and harnessing economies of scale. Landholders with large property holdings may be in a better position to minimise transaction costs, but they may still do better to partner with a specialist offset provider. These economies of scale also mean that small projects are always likely to prove less cost effective than larger projects.

Crop modelling

Crop growth was predicted with the model APSIM (Agricultural Production Simulator) v6 using daily historical climate data and climate forecast data for 2030 and 2070 for the seven climate stations in the Avon River Basin and soil types described above. The Avon River Basin is a mixed cropping zone with sequences based on spring wheat (Triticum aestivum L.) in rotation with barley (Hordeum vulgare L.), grain lupins (Lupinus angustifolius), canola (Brassica napus L.), oats (Avena sativa L) and annual pasture; therefore simulations of these crops were made.

Management specifications for the long-term simulations included crops sown within a sowing date window (i.e. between 1st May and 30th June) when 15 mm of rain fell over 10 days otherwise the crop is sown on the last date of the sowing window.

To remove the effect of seasonal conditions during the previous year, simulations were reset on 1st January with wheat stubble reset to 3000 kg ha-1 and 80 C:N ratio, soil water reset to wheat crop lower limit, soil profile mineral nitrogen reset to 50 kg ha-1 nitrate-N and 25 kg ha-1 ammonium-N (with them distributed down the soil profile layers as 56% in top 0-0.1m, 26% in 0.1-0.2 m, 10% in 0.2-0.3 m, 3.2% in 0.3-0.4 m and the other 6% in 0.4-1.2 m). The amount of N in the soil was based on the average from soil cores taken over 2003-2008 from the eastern wheatbelt of WA (unpublished data). The model was not configured to account for the effects of weeds, disease or waterlogging on yield potential, even though duplex soils can become waterlogged depending on rainfall and position in the landscape.

Nitrogen was applied as urea at sowing for wheat, canola, oats and barley with at the same rate for each crop regardless of soil and locations, with a top-up of urea applied 40 days after sowing based on the economical optimal rate of N period. Optimal rate of nitrogen application was calculated from the average yield for that soil and location of the 1975-2008 using standard response curves (Robertson et al. 2008; Oliver and Robertson 2009). The level of N supplied by the soil was set at 20 ppm which is similar to that measured in the 0-10 cm layer in the eastern wheatbelt (unpublished data). The model outputs include: annual rainfall, annual drainage, annual runoff, GSR, fert, days of cover <70, days of cover <90, sowing date, flowering date, maturity date, biomass at harvest, yield at harvest, water use of GSR.





Pasture modelling

In all cases, the simulated pastures were modelled as mixtures of annual grass and an annual medic. At the more westerly locations (including Brookton, Northam and Wongan Hills) subterranean clover was selected as the legume, while at the more easterly locations (including Bencubbin, Lake Grace, Narembeen and Southern Cross) annual medic was used. A reasonably high level of phosphorus fertility was assumed. It should be noted that the predicted levels of pasture and animal productivity will be highly sensitive to both the assumed level of P fertility and also the level of soil organic matter assumed for each of the standard soils, since the grass in the pasture relies on N released from the soil organic matter.

For all locations and soils, a livestock production system based on Merino ewes producing first-cross lambs was modelled. For simplicity, ewes were bought into the system. Replacement ewes were bought at 19 months of age on 31 October each year, and at the same time ewes more than seven years old were cast for age. Joining started on 1 November, with lambs being born in April and May, weaned on 15 July and sold during October and November once they were no longer gaining weight. Ewes were fed wheat to maintain their body condition once their body condition score fell below 1.5 out of 5 Scores of 2-4 for sheep are desirable (Suiter 1994).

The pasture simulations were ran at a “reference” stocking rate for each location and soil type. The reference stocking rate was found by choosing the lower of a rate that gave a long-term utilization rate (i.e. ratio of pasture consumed to pasture grown) of 0.35, or the rate that gave a high requirement for supplementary feeding (100 kg wheat ha-1 y-1 ewe-lamb unit).

Economics

Economic performance or gross margin for all farm enterprise is measured as Net Present Value (NPV, $ ha-1) and Annual Equivalent Value (AEV, $ ha-1 y-1). NPV allows projects with different mixes of upfront and ongoing costs and revenues to be directly compared. It converts future costs and revenue streams into present day dollar values by discounting. A discount rate is the percentage by which the value of a cash flow in a discounted cash flow valuation is reduced for each time period by which it is removed from the present. For example, revenue of $100 one year from now is worth $91 in today’s dollars at a discount rate of 10%. A stream of $100 payments beginning next year and continuing for 10 years has an NPV of $614. Forestry projects typically involve upfront costs with revenues delayed for some years into the future. NPV provides a useful way of expressing the expected net costs and benefits over the life of a project in a single figure which can assist landholders in making long term investment decisions (Hobbs et al. 2007). For example, a project with upfront costs of $500 and revenues of $100 y-1 for the following 10 years has an NPV of $114. It must be noted that economic performance will depend entirely on the assumptions used in the analysis.

An NPV can be converted into an annual equivalent value (AEV), which is the average annual cash flow from the project after accounting for the discount rate. The AEV allows projects of different duration to be directly compared in terms of their expected annual returns. For a 10 year project with an NPV of $114 the AEV is $18 at a 10% discount rate. Calculating the AEV ha-1 under alternative land-uses provides a useful way of comparing the expected returns of annual and multi-year crops.

Internal rate of return (IRR) is the average annual rate of return earned through the life of an investment, used to measure the profitability of an investment. It can be the effective rate of interest on a deposit or loan, or the discount rate that reduces to zero the net present value of a stream of income inflows and outflows. If the IRR is higher than the desired rate of return on investment, then the project is a desirable one.

Of course landholders do not simply make their land-use decisions based entirely on average annual returns. Many other factors are important, with variability in returns being particularly crucial. A project with a slightly higher average annual return but strong variability based on year to year climate fluctuations represents a more risky option than an alternative with lower but less variable average returns.

The discount rate is a key factor in these economic analyses. This report uses a discount rate of 6.9%, which is a fairly typical discount rate for economic analyses. In reality, discount rates will vary between enterprises and individuals. Those who are close to the limit of their borrowings and have other more profitable investment options or other priorities, (e.g. putting the kids through school), may have higher discount rates. Similarly, any who have surplus funds may apply lower discount rates. Users have the option to alter the discount rate to different values in the Farming Landscapes for the Future tool.

Limitations and assumptions of software

The information presented in this software provides an indication of the likely tree and crop growth using the best information available (as of November 2012) and relative economic benefit of different farm enterprises. This information does not constitute specific financial advice. Land managers should seek appropriate financial or economic advice prior to making investment decisions.

Modelling of tree and crop growth will be largely influenced by accurate characterisation of the local soil type.

Growth of tree crops was predicted with the model 3PG using the best available data, but the extent of this data is still relatively limited in comparison to other crops. In particular, the long term growth rates (> 20 years) of these systems in farm forestry are unknown.
The tree growth modelling did not include different spatial configurations, such as belt versus block plantings. Coppice regrowth from oil mallee systems is likely to be different to uncoppiced tree growth, but sufficient information was not available to model this differently. In addition, the sustainability of repeatedly harvesting coppice systems is unknown.

Future climate was modelled using the CSIRO Mk3 A2 scenario, and is subject to uncertainty inherent in the model and in future greenhouse gas emissions.

Predicting tree production under future climate scenarios is also subject to uncertainty in the response of vegetation to elevated atmospheric CO2 concentration. The best available knowledge from the scientific literature was used.

Predictions of crop production with the model APSIM did not account for vegetation response to elevated atmospheric CO2 concentration.

Potential viability of farm forestry industries is still unknown, and may depend on proximity of processing facilities.

This analysis does not account for changes in costs of running machinery due to changes in scale of traditional agricultural practises when allocating some land to farm forestry.

The methodology for carbon payments from harvested systems is currently not approved by the Australian





Government, although a draft methodology is under consideration as of 2012.

Eligibility requirements for carbon farming will apply, and expert advice should be sought before starting carbon project.

For more detail on approved and draft carbon farming methodologies and full eligibility requirements see http://www.climatechange.gov.au/en/government/initiatives/carbon-farming-initiative.

Emissions are not included in the carbon analysis, but assumed to be similar for agricultural and farm forestry systems.

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Appendix 1: Description of tree growth model 3PG

A full description of 3-PG has been provided by Landsberg and Waring (1997), and only a brief outline of the model is given here. 3-PG predicts forest stand development, as well as stem, root and foliage biomass pools, stand water use, and available soil water. It has five simple sub models: (1) assimilation of carbohydrates, predicted by environmental modification of light use efficiency and assuming a constant ratio of net to gross primary production; (2) distribution of biomass between foliage, roots and stems, influenced by growing conditions and tree size; (3) determination of stem number as determined by probability of death and self-thinning; (4) conversion of biomass into variables of interest to forest managers (canopy leaf area index, basal area, stem volume, average stem diameter at breast height (DBH), mean annual stem-volume increment); and (5) water balance of a single soil layer where evapo-transpiration is calculated using the Penman-Monteith equation.

Data required to run 3-PG include monthly climate data (air temperature, vapour pressure deficit, solar radiation, rainfall, and number of frost days), site factors (latitude, soil texture, maximum available soil water storage, and soil fertility rating), initial conditions of biomass and stocking rates, and management conditions (e.g. fertiliser application, irrigation and thinning). Parameters in 3-PG determining canopy structure and quantum efficiency, partitioning of biomass in stems, foliage and roots, basic wood density, litterfall and root turnover rates, and various environmental modifiers, are all likely to be species-dependent. The model runs on a monthly time-step and outputs include diameter at breast height (DBH), stem volume, leaf area index, biomass of tree components and water balance.

Impacts of climate change

More recently, Almeida et al. (2009) have further modified 3-PG to simulate the effect of elevated atmospheric CO2 on water use and growth. Numerous experimental and theoretical studies suggest light saturated assimilation rate and light use efficiency increase as atmospheric CO2 concentrations (Ca) increases, while maximum stomatal conductance declines (Ainsworth and Rogers 2007). These effects were incorporated into 3-PG through modifications of canopy quantum efficiency αC and canopy conductance gC in a manner similar to how other factors (e.g. vapour pressure deficit and soil water content) affecting growth are taken into account, i.e. through growth modifiers. A growth modifier is a function f(X) of a factor X such that f = 1 when X is not limiting growth and f declines to zero when the limitation is extreme. However, in the case of Ca, growth increases with increasing Ca while stomatal conductance declines (Constable and Friend 2000); therefore, the CO2 growth modifiers will not be bounded by 0 and 1. Separate modifiers are used for αC and gC as the effects of atmospheric CO2 on these are distinct and are described in detail by (Almeida et al. 2009). These relationships were applied to predicted data for the parameters αC and gC by utilising a detailed forest growth model CABALA (Battaglia et al. 2004) for a range of different values of Ca at three contrasting sites.





Appendix 2: Description of agricultural crop production model APSIM

The Agricultural Production Systems Simulator (APSIM) (Keating et al. 2003) has been comprehensively tested for its ability to simulate crop yield and soil water balance in experiments and commercial paddocks in Western Australia, covering a range of soil types, seasons and management regimes for wheat (Asseng et al. 1998; Oliver and Robertson 2009), canola (Farre et al. 2002), lupin (Farre et al. 2004) and in the South-East Australia for barley (Anwar et al. 2009) and for a range of crops and locations around Australia (Carberry et al. 2009). In order to simulate yields from the field, the APSIM wheat module was linked with the soil water module SOILWAT2 (Probert et al. 1998), the soil nitrogen module SOILN2 (Probert et al. 1998), and the surface residue module SURFACEOM (previously RESIDUE2, Probert et al. 1998). Simulations of annual pastures were carried out by linking SOILWAT2 and SOILN2 to the GRAZPLAN models of pasture and animal production pasture production (Moore et al. 1997; Freer et al. 1997), as described by Robertson et al. (2009).

The APSIM model has been used to predict yield and biomass differences as affected by climate change factors such as increased water stress, increased temperatures and increased CO2 (Asseng et al. 2004, Ludwig and Asseng 2006, Ludwig et al. 2009, Wang et al. 2009a,b). In APSIM air temperature affects several processes including leaf area growth, photosynthesis, senescence, root depth elongation and phenology (Keating et al. 2003). Increasing temperature can increase heat stress and accelerate the phenological development which results in a shorter growth period. Increased temperature also increases transpiration which increases water demand which can lead to water stress. However, the increased atmospheric CO2 concentration in future climates is likely to increase transpiration efficiency, radiation use efficiency and reduce the critical leaf nitrogen concentrations (Reyenga et al. 1999) which often counter-act the effect of the higher temperature. A similar set of effects of increasing temperature and atmospheric CO2 concentration is taken into account in the GRAZPLAN pasture growth model, as well as an accelerated decline in the digestibility of pastures with higher temperature.

Appendix 3: Default Sandalwood costs

Year of operation	Operation description	Details	Cost $ / ha	Notes and assumptions
0	Planning, marking out and pre-ripping	Preparation:		
		Labour $	35	Ripping 15 ha / day, one person @ $300/ day, Planning/ marking out 0.5 hours / ha one person
		Other $	92	tractor, $50/ hr, 1.5 ha / hr, ripper hire $150 / day, vehicle $10/hr
0	Machine planting host seedlings 1250/ha	Planting:		
		Labour $	120	2 people, 1 ha established every 2 hours, $30/hr / person
		Seedlings $	500	1250 seedlings / ha @ $0.40 / seedling delivered
		Other $	150	$30 for tree planter hire ($150 / day, 2 hours / ha), $100 for tractor (2 hours / ha @ $50/hr), vehicle $10/hr
0	Rabbit baiting	Weed/Pest Control		
		Labour $	15	estimate
		Fencing $		
		Other (oats) $	7	estimate





0	Pre-plant herbicide	Weed/Pest Control (year 0):		
		Labour $	22	used contract rate
		Fencing $		
		Other (chemical) $	34	knockdown $12/ha (2L ha Glyphosate @ $8/litre) + residual estimate $6/litre 3 l /ha
YEAR 0 TOTAL	975			
1	Overspray selective herbicide	Weed / Pest control (year 1)		
		Labour $	22	used contract rate
		Fencing $		
		Other (chemical) $	25	selective herbicide estimate
1	Rabbit baiting	Weed/Pest Control		
		Labour $	15	estimate
		Fencing $		
		Other (oats) $	7	estimate
1	Infill seedlings 10 % (hand plant)	Planting:		
		Labour $	30	1 person plants one hectare per hour
		Seedlings $	50	125 seedlings @ $0.40 delivered
		Other $	15	vehicle and hand planter hire
1	Hand planting nuts, 2 nuts every third host	Planting (nuts) year 1		
		Labour $	60	1 person plants 5 ha / day (2 hours per person per ha)

		Seed $	84	3kg of seed @ $28 / kg
		Other $	20	vehicle $10/ hr, hire planting equipment ($100/day) $10 per hour / ha
YEAR 1 TOTAL	328			
2	Infill nut planting 20% (hand planting)	Planting (nuts) infill		
		Labour $	45	1 person infills 1 ha / 1.5hour
		Seed $	17	0.6kg nuts per ha @ $28 / kg
		Other $	15	vehicle, planting equipment
3	Hand thinning small SW seedlings	Thinning/Infill:		
		Labour $	90	thin 150 sandalwoods per ha, 50 per hour per person
		Seedlings $		
		Other $	10	vehicle $10 / hr / ha
5	Light pruning of sandalwood	Pruning:		
		Labour $	180	prune 300 trees / ha, 50 trees per hour per person
		Other $	15	vehicle, tools
20+	Machine harvest and clean / grade wood	Harvest:		
		Labour $	14000	Approx. $930 / tonne, e.g. for 15 tonnes / ha.
Harvest / Debark / Grade 0.65 tonne/day 2 people				

		Other $	2500	loader @ $200/ day
pressure cleaners maintenance, $25/day				
20+	Transport clean logs to market	Transport Costs:		
		Timber $	TBA	$0.12 per tonne per km
TOTAL of all operations (excl. transport)	18175			

Other assumptions and notes

- Assuming site pre ripped, this could be excluded on certain soil types
- One pass machine planting of mixed seedlings (scalp, rip, plant), site could be established one pass without pre-ripping
- assumes no fencing
- assumes use of residual pre - plant herbicide (must be scalped away at seedling planting)
- Scale of operation greatly influence costs (larger scale achieves greater establishment cost efficiencies, small scale decreases cost efficiencies)
- Labour rates based at $30 / hour
- Rabbit control is an estimate, may need to verify what contract rates are
- Assumes no fertiliser

Appendix 4: Default Environmental Planting costs

Year of operation	Operation description	Details	Cost $ / ha	Notes and assumptions
0	Planning, marking out and pre-ripping	Preparation:		
		Labour $	35	Ripping 15 ha / day, one person @ $300/day, Planning/ marking out 0.5 hours / ha one person
		Other $	92	tractor, $50/hr, 1.5 ha / hr, ripper hire $150 / day, vehicle $10/hr
0	Machine planting seedlings 1500/ha	Planting:		
		Labour $	120	2 people, 1 ha established every 2 hours, $30/hr / person

		Seedlings $	600	1500 seedlings / ha @ $0.40 / seedling delivered
		Other $	150	$30 for tree planter hire ($150 / day, 2 hours / ha), $100 for tractor (2 hours / ha @ $50/hr), vehicle $10/hr
0	Rabbit baiting	Weed/Pest Control		
		Labour $	15	estimate
		Fencing $		
		Other (oats) $	7	estimate
0	Pre-plant herbicide	Weed/Pest Control (year 0):		
		Labour $	22	used contract rate
		Fencing $		
		Other (chemical) $	34	knockdown $12/ha (2L ha Glyphosate @ $8/litre) + residual estimate $6/litre 3 l /ha
YEAR 0 TOTAL		1075		
1	Overspray selective herbicide	Weed / Pest control (year 1)		
		Labour $	22	used contract rate
		Fencing $		
		Other (chemical) $	25	selective herbicide estimate
1	Rabbit baiting	Weed/Pest Control		
		Labour $	15	estimate
		Fencing $		
		Other (oats) $	7	estimate
1	Infill seedlings (hand plant)	Planting:		





		Labour $	30	1 person plants one hectare per hour
		Seedlings $	50	125 seedlings @ $0.40 delivered
		Other $	15	vehicle and hand planter hire
YEAR 1 TOTAL	164			
TOTAL of all operations	1239			

Other assumptions and notes

- Assuming site pre ripped, this could be excluded on certain soil types
- One pass machine planting of mixed seedlings (scalp, rip, plant), site could be established one pass without pre-ripping
- assumes no fencing
- assumes use of residual pre - plant herbicide (must be scalped away at seedling planting)
- Scale of operation greatly influence costs (larger scale achieves greater establishment cost efficiencies, small scale decreases cost efficiencies)
- Labour rates based at $30 / hour
- Rabbit control is an estimate, may need to verify what contract rates are
- Assumes no fertiliser

Appendix 5: Default Mallee Planting costs

Year of operation	Operation description	Details	Cost $ / ha	Notes and assumptions
0	Planning, marking out and pre-ripping	Preparation:		
		Labour $	35	Ripping 15 ha / day, one person @ $300/day, Planning/marking out 0.5 hours / ha one person
		Other $	92	tractor, $50/hr, 1.5 ha / hr, ripper hire $150 / day, vehicle $10/hr
0	Machine planting seedlings	Planting:		
		Labour $	120	2 people, 1 ha established every 2 hours, $30/hr / person

		Seedlings $	1000	2500 seedlings / ha @ $0.40 / seedling delivered
		Other $	150	$30 for tree planter hire ($150 / day, 2 hours / ha), $100 for tractor (2 hours / ha @ $50/hr), vehicle $10/hr
0	Rabbit baiting	Weed/Pest Control		
		Labour $	15	estimate
		Fencing $		
		Other (oats) $	7	estimate
0	Pre-plant herbicide	Weed/Pest Control		
		Labour $	22	used contract rate
		Fencing $		
		Other (chemical) $	34	knockdown $12/ ha (2L ha Glypho-sate @ $8/litre) + residual estimate $6/litre 3 l /ha
YEAR 0 TOTAL	1475			
1	Overspray selective herbicide	Weed / Pest control (year 1)		
		Labour $	22	used contract rate
		Fencing $		
		Other (chemical) $	25	selective herbicide estimate
1	Rabbit baiting	Weed/Pest Control		
		Labour $	15	estimate
		Fencing $		
		Other (oats) $	7	estimate
1	Infill seedlings (hand plant)	Planting:		
		Labour $	30	1 person plants one hectare per hour
		Seedlings $	50	125 seedlings @ $0.40 delivered
		Other $	15	vehicle and hand planter hire
YEAR 1 TOTAL	164			





5+	Machine harvest	Harvest:		
		Labour $	600	Approx. $20 tonne, e.g. for 30 tonnes / ha; FOR EACH HARVEST EVENT
		Other $		
5+	Transport to market	Transport costs:	TBA	$0.12 per tonne per km
TOTAL of all operations (exlc. Transport)	2239			

Other assumptions and notes

- Assuming site pre ripped, this could be excluded on certain soil types
- One pass machine planting of 2500 seedlings / ha (scalp, rip, plant), site could be established one pass without pre-ripping
- assumes no fencing
- assumes use of residual pre - plant herbicide
- Scale of operation greatly influence costs (larger scale achieves greater establishment cost efficiencies, small scale decreases cost efficiencies)
- Labour rates based at $30 / hour
- Rabbit control is an estimate, may need to verify what contract rates are
- Assumes no fertiliser

Appendix 6: Default Brushwood costs

Year of operation	Operation description	Details	Cost $ / ha	Notes and assumptions
0	Planning, marking out and pre-ripping	Preparation:		
		Labour $	35	Ripping 15 ha / day, one person @ $300/day, Planning/marking out 0.5 hours / ha one person
		Other $	92	tractor, $50/hr, 1.5 ha / hr, ripper hire $150 / day, vehicle $10/hr
0	Machine planting seedlings 3000/ha	Planting:		

		Labour $	198	2 people, 1 ha established every 3.3 hours, $30/hr / person
		Seedlings $	1200	3000 seedlings / ha @ $0.40 / seedling delivered
		Other $	250	$30 for tree planter hire ($150 / day, 3.3 hours / ha), $100 for tractor (3.3 hours / ha @ $50/hr), vehicle $10/hr, 3.3 hours / ha
0	Rabbit baiting	Weed/Pest Control		
		Labour $	15	estimate
		Fencing $		
		Other (oats) $	7	estimate
0	Pre-plant herbicide	Weed/Pest Control (year 0):		
		Labour $	22	used contract rate
		Fencing $		
		Other (chemical) $	34	knockdown $12/ ha (2L ha Glypho-sate @ $8/litre) + residual estimate $6/litre 3 l /ha
YEAR 0 TO-TAL	1853			
1	Overspray selective herbicide	Weed / Pest control (year 1)		
		Labour $	22	used contract rate
		Fencing $		
		Other (chemical) $	25	selective herbicide estimate
1	Rabbit baiting	Weed/Pest Control		
		Labour $	15	estimate
		Fencing $		
		Other (oats) $	7	estimate
1	Infill seedlings (hand plant)	Planting:		





		Labour $	30	1 person plants one hectare per hour
		Seedlings $	120	300 seedlings @ $0.40 delivered
		Other $	20	vehicle and hand planter hire
YEAR 1 TO-TAL	239			
7+	Machine harvest	Harvest:		
		Labour $	750	Approx. $25 tonne, e.g. for 30 tonnes / ha; FOR EACH HARVEST EVENT
		Other $		
7+	Transport to mar-ket	Transport Costs:	TBA	$0.12 per tonne per km
		Timber $		
TOTAL of all operations (excl. trans-port)	2842			

Other assumptions and notes

- Assuming site pre ripped, this could be excluded on certain soil types
- One pass machine planting of mixed seedlings (scalp, rip, plant), site could be established one pass without pre-ripping
- assumes no fencing
- assumes use of residual pre - plant herbicide
- Scale of operation greatly influence costs (larger scale achieves greater establishment cost efficiencies, small scale decreases cost efficiencies)
- Labour rates based at $30 / hour
- Rabbit control is an estimate, may need to verify what contract rates are
- Assumes no fertiliser

Appendix 7: Default Agricultural Crop costs and prices

		Wheat	Canola	Barley	Lupins	Oats	
Crop Price	$/tonne	260.60	505.40	223.35	210.60	168.10	Crop Prices are farm gate minus receival fees and freight
Planting Labour	$/ha	3.00	3.00	3.00	3.00	3.00	





Planting Other	$/ha	16.76	16.76	16.76	16.76	16.76	Includes fuel and repairs
Planting Seed	$/ha	13.03	5.00	11.17	16.85	16.81	
Weed Labour	$/ha	9.00	9.00	9.00	9.00	9.00	
Weed Other	$/ha	63.76	68.76	63.76	63.76	63.76	Includes fuel and repairs, herbicide/ pesticide
Fertiliser Material	$/ha	92.00	92.00	92.00	92.00	92.00	Includes transport and ferti-lizer costs
Harvest Labour	$/ha	3.00	3.00	3.00	3.00	3.00	
Harvest Other	$/ha	16.76	16.76	16.76	16.76	16.76	Includes fuel and repairs
Harvest Transport	$/ha	12.00	12.00	12.00	12.00	12.00	
Other Material	$/ha	10.47	10.51	10.43	10.19	10.00	Includes contract-ing costs and insur-ance (1% of grain value)

Notes:

Receival Fees $/tonne

Wheat 10.50
Barley 11.75
Lupins 10.50
Canola 16.70
Oats 12.00
Freight from Wickepin $/tonne 19.90
Planting seed costs calculated with following sowing rates (kg/ha)
Wheat 50
Canola 5
Barley 50
Lupins 80
Oats 100

Total fuel, labour and repairs are assumed to be $ / ha:

Fuel	36.96
Repairs	28.11
labour	15.00

These costs are split between operations, assuming 5 passes per paddock for:
1 pass seeding
3 passes spraying
1 pass harvest
Transport costs are split between harvest transport and fertilizer material.

Appendix 8: Default Pasture/Sheep costs and prices

PRICES AND COSTS	
Cast for Age Ewes ($/kg LW)	1.30
Sale Lambes ($/kg DW)	3.65
Dressing Percentage for lambs	47%
Sale fees, commissions, levies	5%
Wool Market Quote ($)	7.8
Wool Tax	2.0%
Selling Costs	4.5%
TOTAL COSTS / REVENUE ($)	
repairs, fuel, water	5000
INCOME	
Class	Freight $ / Head
CFA-Ewes	3.50
Ewe-Lambs	3.50
Wethers	3.50
Wth-Hogg	3.50
Wth-Lambs	3.50
VARIABLE COSTS	

Requisites	$ / Unit	Number
Wool Packs	11.50	23
Ear Tags	0.34	239
Rings	0.03	791
Shear/Crutch/Mark	$ / head	Number
Shearing	6.50	2141
Crutching	1.50	1350
Mulesing/Marking	1.50	791

Note: number will depend on flock number and structure predicted by model, and needs to be updated for each scenario

Animal Health	$ / head	Number	Repeats per year	
Drench Lambs	0	0	0	
Drench Adults	0.30	1350	2	
Drench Purchases	0.30	239	2	
Jetting	0.15	791	2	
Vaccine	0	0	0	
Liccide	0.55	1350	1	
Pasture Treatments				
	kg / ha	$ / t	Total Area	Frequency per year
Total Fertiliser	0	0	0	0
	mL / ha	$ / L	Total Area	Frequency per year
Total Spray	0	0	0	0
Feed supplement	$ / tonne			
	330			
Ram purchases	$ / head			
	600			
Interest				
Capital	8%			
Average interest period (months)	12			





Notes:





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