Forecaster v2.0

User Manual

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Introduction

Welcome to Forecaster v2.0

Forecaster is a system for predicting the growth of forest stands and their potential log yield.

Forest managers need to make projections of the timing, quality and quantity of log yields from a stand. These projections form the basis for operational scheduling, regime analysis (cost-benefit analyses of alternative stand management practices) and yield table generation. Projections need to be "best practice" and capable of standing up to rigorous internal and external audit (eg. for valuation and certification).

Forecaster can be used to schedule silvicultural operations, such as pruning and thinning, and is especially useful for scheduling intensively pruned regimes for radiata pine. The major function provided by Forecaster is stand growth and yield modeling - simulating the effects of genetics, site and management on the timing, volume and properties of log product yields from a stand. This function can be used to compare regimes and so determine the most appropriate regime in a specific situation.

How Forecaster Works

Forecaster uses a stem list as a model of a crop of trees growing on a site. Each stem in the list has the attributes necessary to support the detail required when predicting yield, such as DBHOB, height, pruned height, etc. Each stem also has a weighting which indicates the number of stems per hectare which the stem represents.

The stand (stem list on a site) is grown through the regime and any yields are estimated. Finally the resulting yield is available for reporting through standard reports and charts, and through exporting the information to XLS or CSV files.

Forecaster and Cruiser

Forecaster has been designed to integrate more closely with future versions of ATLAS Cruiser. For example the log product definitions will be able to be used in common between the two systems, thus improving the comparability of yield estimates from assessments and simulations.

However Cruiser will remain a specialized pre-harvest assessment system with many features only applicable to this type of forest inventory. These features include:

- The sampling framework. Cruiser supports several different sampling strategies (simple random, stratified, double) so that an assessment can be designed for maximum efficiency, to produce the most precise estimates at the lowest cost. Sample units can be either area-based (plots) or individual stems. This framework allows Cruiser to calculate yield estimates as well as their standard errors and degrees of freedom, which means error limits (confidence intervals / PLEs) can be reported.
- Derived assessments are re-groupings (or post-stratification) of sample units in order to represent a different population. Unlike Forecaster's stand-centric approach, Cruiser can cater for harvest units, which may comprise parts of several stands and so differ in age and species composition.

- A variety of in-field mensurational techniques including bounded, point and horizontal-line plots and sub-sampling for stem height and wood density are supported.
- Detailed stem quality description of measured stems in terms of their structure, branching, sweep, and taper. Cruiser also supports user-defined quality feature definitions, so that any stem section can independently be described and measured. User-defined variables can also be associated with whole stems, plots and strata, allowing very flexible assessment of potential yield.
- To support this flow of detailed measurement data from the field there are strong links with the data capture system, supporting the export of designed assessments and the import of completed, measured assessments.

As a simulation system, Forecaster has the ability to model more fully the progress of a stem through the silvicultural regime that is applied to it. This means that Forecaster can, for example, provide detail on internal structure such as defect core as a result of pruning.

In this section

This section contains the following topics:

Topics
Manual Organisation
Terminology
Navigation
Start-up Display
Working with Entities

Manual Organisation

This new version of the Forecaster documentation has been structured and formatted in order to deliver information in a manner that has been proven to facilitate adult learning:

- The Introduction section describes the fundamentals of Forecaster
- The Projects section describes Projects (the "work units" of Forecaster), how to analyse them access its results
- The next eight sections describe in more detail all of the entities that need to be set up and managed in order to analyse a Project
- The last sections describe specialised Forecaster tasks and features that are used less frequently

Manual Conventions

Conventions used by this manual when describing a procedure are as follows:

- *Italics* refers to a field name
- **Bold** refers to a button or key
- File | Exit refers to a menu option

Terminology

The following table describes the terminology used in this manual, and in Forecaster's forms:

Term	Description
BA	**B**asal **A**rea - the sum of sectional areas of all living stems at breast height, expressed in square metres *(1)*
Combination	A set of one of each of the Forecaster entities: Site, Crop, Function Set and Regime. This may define either just one scenario, or multiple scenarios if the Regime includes multiple Cutting Strategies and/or multiple clearfelling ages.
Commands	A combination of an event condition and an event, as specified in the Regime entity. A Regime command consists of: 1. an event condition that defines when the event will occur (e.g. MeanDOS>170mm), and 2. the event itself, which describes what will occur. (this may also include stem selection)
Condition	A logical expression (or group of expressions) which defines when an event or events within a regime command will occur (e.g. MeanDOS > 170mm)
Crop	The Forecaster entity that describes the characteristics of the crop to be simulated
Cutting Pattern	See Cutting Strategy
Cutting Strategy	The Forecaster entity that defines the cross-cutting (bucking) strategy used to predict log yields from simulated stems, by invoking either a priority-based or optimising bucker.
DBH	Tree **D**iameter at **B**reast **H**eight. In New Zealand, breast height is defined as 1.4 metres above ground on the uphill side of the tree. Elsewhere, including in Australia, 1.3 metres is used *(1)*
DOS	**D**iameter **O**ver **S**tubs - The horizontal measurement over pruned branch stubs on any pruning lift. Always measured on the largest whorl removed in that lift *(1)*
Entity	A Forecaster entity is one of the reusable "building blocks" used to define a Project. Entities are used to represent the site, crop, function set and regime. Other entities define reporting options, species sets, log product definitions and cutting patterns.
Event	An operation or directive contained within a command in a Regime entity.
Function Set	The Forecaster entity that defines the set of functions and models that will be used to simulate the growth of a crop
Log Product Definition	The Forecaster entity that defines the specifications for log products in terms of dimension, shape, branching and wood quality parameters.

Term	Description
MTH	**M**ean **T**op **H**eight. The implementation of MTH used in Forecaster is based on the standard definition used in New Zealand: The height predicted by the Petterson height/DBH curve for a DBH corresponding to the quadratic mean DBH of the 100 largest trees per hectare (based on DBH) in a stand *(2)*
Project	One or more entity combinations, which each define one or more scenarios. A combination of entities will give rise to multiple scenarios if there are multiple clearfell ages and/or cutting strategies within the regime.
Regime	The Forecaster entity that defines the operations to be simulated on the crop by defining commands containing event conditions and events (eg. pruning, thinning and clearfelling). Contains links to entities for stem selection strategies (used to select stems for pruning and thinning) and cutting patterns (used to predict log yields from production thinning and clearfelling).
Report Options	The Forecaster entity that defines the types of information that will be produced from one simulation, that is, when a Project is analysed. Only tables that are pre-defined in the Report Options will be available.
Report Manager	Tool used to manage the results from a simulation run (called 'Scenario Manager' in version 1.0).
Run	The analysis of a Project
Scenario	A sequence of events that could happen in practice, corresponding to one crop, site, function set, regime, clearfell age and cutting strategy. Scenarios are given a unique ID, and are the basis for comparisons of simulation results.
Simulation	The analysis of a Project
Site	The Forecaster entity that defines the characteristics of the land.
Species Set	The Forecaster entity containing a collection of one or more species that are used when constructing function sets and log product definitions.
Stem selection strategy	Criteria used within a regime to determine which stems in a stemlist are to be treated by a silvicultural event.

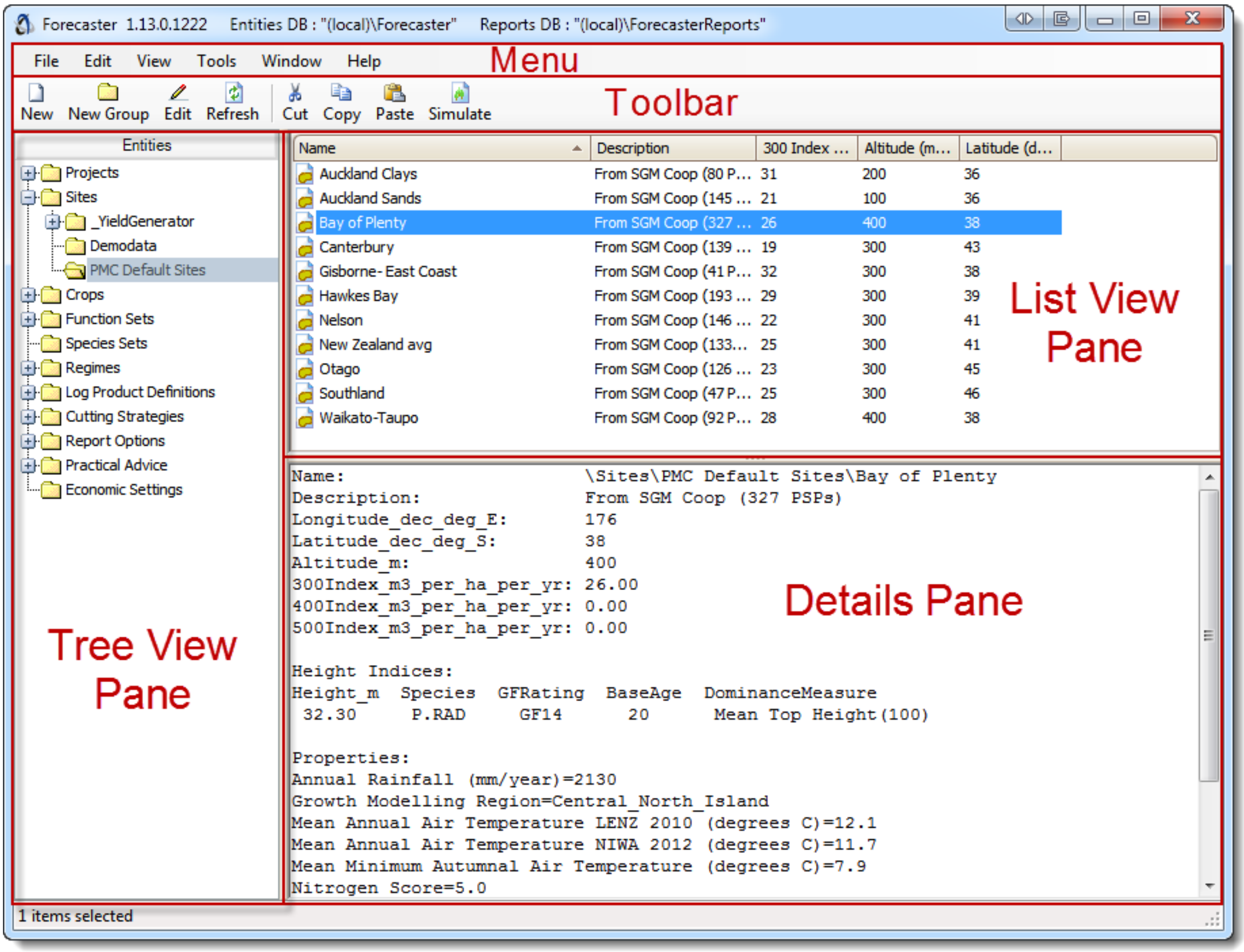
Main Interface

Getting Started

Forecaster can be started from the Start menu: **Start | All Programs | Scion | Forecaster**, or from the Forecaster shortcut, if the installation process has put one on the desktop.

Main User Interface

Forecaster's main user interface is similar in "look and feel" to Windows Explorer. The form's title bar displays the version of Forecaster being run, and the 2 databases to which it is connected:



The main sections of the interface are described below:

Section	Function
Menu Bar	Drop down menus containing more advanced options
Tool Bar	Buttons for performing common operations
Tree View Pane	Shows the hierarchical structure of folders for Projects and for each of the eight component entities in Forecaster's Entities database
List View Pane	Lists the contents of the group (folder) selected in the Tree View Pane. The list can be sorted on any column by clicking on that column's header.

Section	Function
Details Pane	Lists details of the entity selected in the List View Pane
Projects	A Project is a collection of component entities (crops, sites, etc) that are to be analysed. Note that a Project does not actually *contain* its component entities, but just *refers* to them, so that the entities can be re-used in any number of other projects.
Sites	A Site specifies the location of the crop with respect to altitude and map coordinates
Crops	A Crop defines the characteristics of the trees for which growth is to be simulated
Function Sets	A Function Set defines the models and functions that will be used to simulate the growth of the Crop on a Site
Species Sets	Species Sets are collections of one or more species, and are used when constructing Function Sets and Log Product Definitions
Regimes	Regimes are used to specify the timing and sequence of silvicultural events that are to be applied to a crop
Log Product Definitions	Log Product Definitions define the criteria and constraints to be used when bucking (cross-cutting) stems into logs
Cutting Strategies	A Cutting Strategy contains a set of log products (grades) that can be produced if that strategy is applied to the felled stand
Report Options	A set of Report Options defines the types of information that will be reported from a simulation
Simulate button	Pressing this button initiates the simulation (analysis) of the selected project

Navigation

Forecaster behaves very much like Windows Explorer in the manner in which the user navigates around, and manages its database contents.

Working with Folders

The following table shows the actions that can be performed with folders:

Action	Key Points
Create a new folder	Select a master folder and either: • Select File | New Group, or • Select the **New Group** ToolBar button, or • Right-click and select **New Group** Using the same procedure, any number of sub-folders may be created in a group. This allows entities to be stored and managed under a meaningful hierarchy e.g. Region X, Forest Y, Compartment Z.
Rename a folder	• Select the folder in the List View Pane • Right-click and select **Rename** • Type in new name
Delete a folder	• Select the folder in the List View Pane

Action	Key Points
	• Press the **Delete** key or • Right-click and select **Delete**
Expand/Collapse a folder	Left-click on a folder's expansion button (+) in the Tree View Pane to display its subfolders. Click on its collapse button (-) to hide all of its subfolders.
View a folder	Left-click on the folder in the Tree View Pane to display its contents in the List View Pane.
Show folder options	Right-click on the folder. Relevant options and commands associated with that folder are displayed.

Menus

The following are descriptions of the menu commands, and associated Toolbar buttons:

Menu	Drop Down Options	Description
File	Open New New Group Exit	Opens a selected item Creates a new item in the selected group (folder) Creates a new sub-group in the selected group Exits the program
View	Refresh	Refreshes groups (folders) and entity names from the database. Use this to synchronize your view with other users accessing the same database.
Edit	Edit Cut Copy Paste Delete	Opens a selected item for editing Copies selected item to clipboard and deletes original. Item can then be pasted in a new location. Copies an item for pasting to another location with Paste Moves or copies an item marked with Cut or Copy Deletes an entity (after confirmation)
	Note: The Edit Menu offers standard Windows editing features that can be used to manage folders and entities. These are also available using the mouse right-click. Note that entities that are referred to by others (for example, a log product definition that is listed in a cutting strategy) cannot be deleted until the reference is removed or referring entity is deleted.	
Tools	Simulate Species List Options	Starts a simulation on a selected project Opens a form for editing the list of species Opens the tabbed form for editing the system and

Menu	Drop Down Options	Description
		user options
Window	Close All Windows <Window Name>	Closes all windows. If changes have been made in a form then the user is prompted to save first. Switches focus to the selected window
Help	Help About Licence Details	Displays on-line help documentation Displays current version numbers for Forecaster and its components. Shows the licensed options contained within your system.

Working with Entities

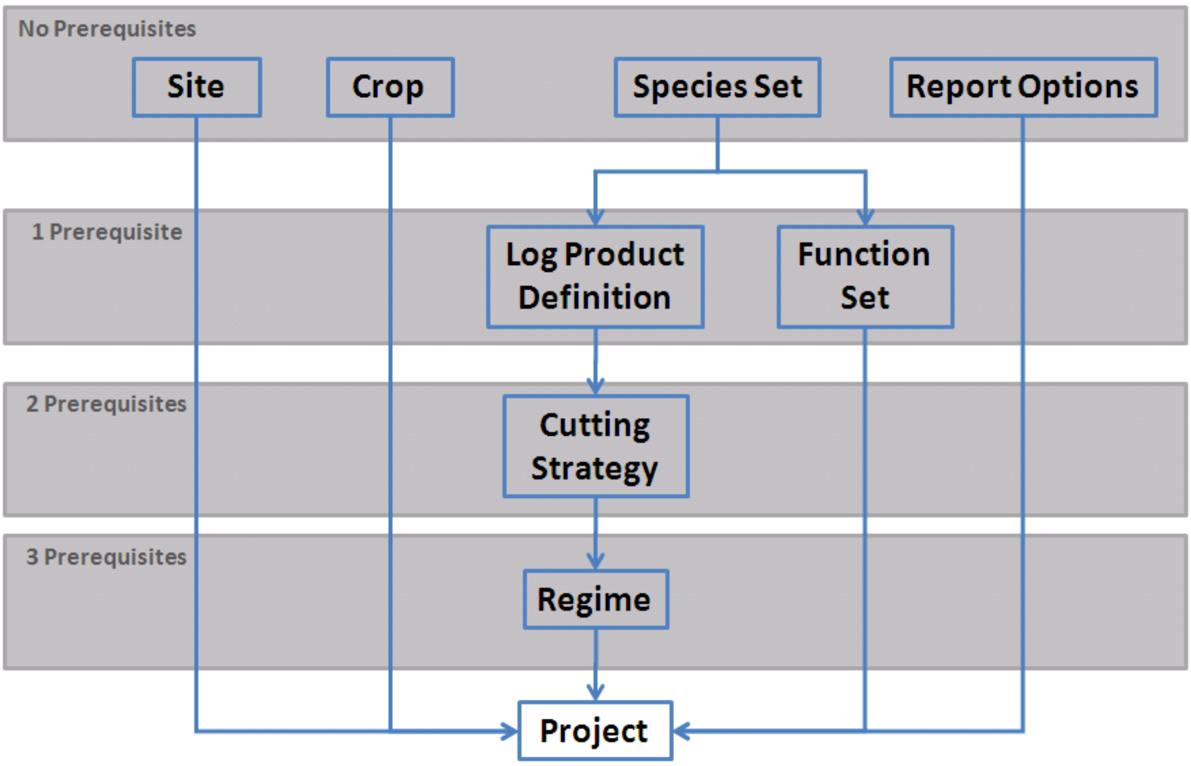
For each entity type there is a tree structure containing both folders (Groups) and entities of that type. A new entity can be created by selecting the required folder in the Tree View Pane, then either right-clicking in the List View Pane, or clicking on the **New** button on the toolbar.

Other operations can be performed on an entity by right-clicking it, and selected from the context menu:

- Cut
- Copy
- Paste
- Delete
- Rename
- Import (from CSV file)
- Export (to CSV file)

There are eight Forecaster entities that provide the information required for a simulation. Five of these have no pre-requisites (that is, they don't contain any other entities), so they can be created in any order. However, both a Function Set and a Log Product Definition require a pre-defined Species Set. Similarly, a Cutting Strategy requires pre-defined Log Product Definitions, and a Regime will require a Cutting Strategy with associated Log Product Definitions (unless the Regime has no production thinning or clearfell events).

A Project is defined as a combination of Site, Crop, Function Set, Regime and Report Option entities.



Projects

Projects are simply ways of bringing together the component entities (crops, sites, etc.) and running the simulation to produce information about the state of the crop and its yield. A project does not contain its component entities, but just refers to them, so that the entities can be re-used in any number of projects. In this way a function set, for example, could be applied to a large number of crops with the simulations all described in different projects. Any changes made to the function set will affect all projects that refer to it.

Projects can be constructed as a combination of sites, crops, function sets and regimes. The full list of combinations can be refined to include only those that are relevant. When the simulation engine processes a project it iterates through the list of combinations. The full set of results from the whole list is called a simulation.

A Project can also, optionally refer to an Economic Settings entity, which will enable the results from a simulation to include an economic analysis.

Scenarios

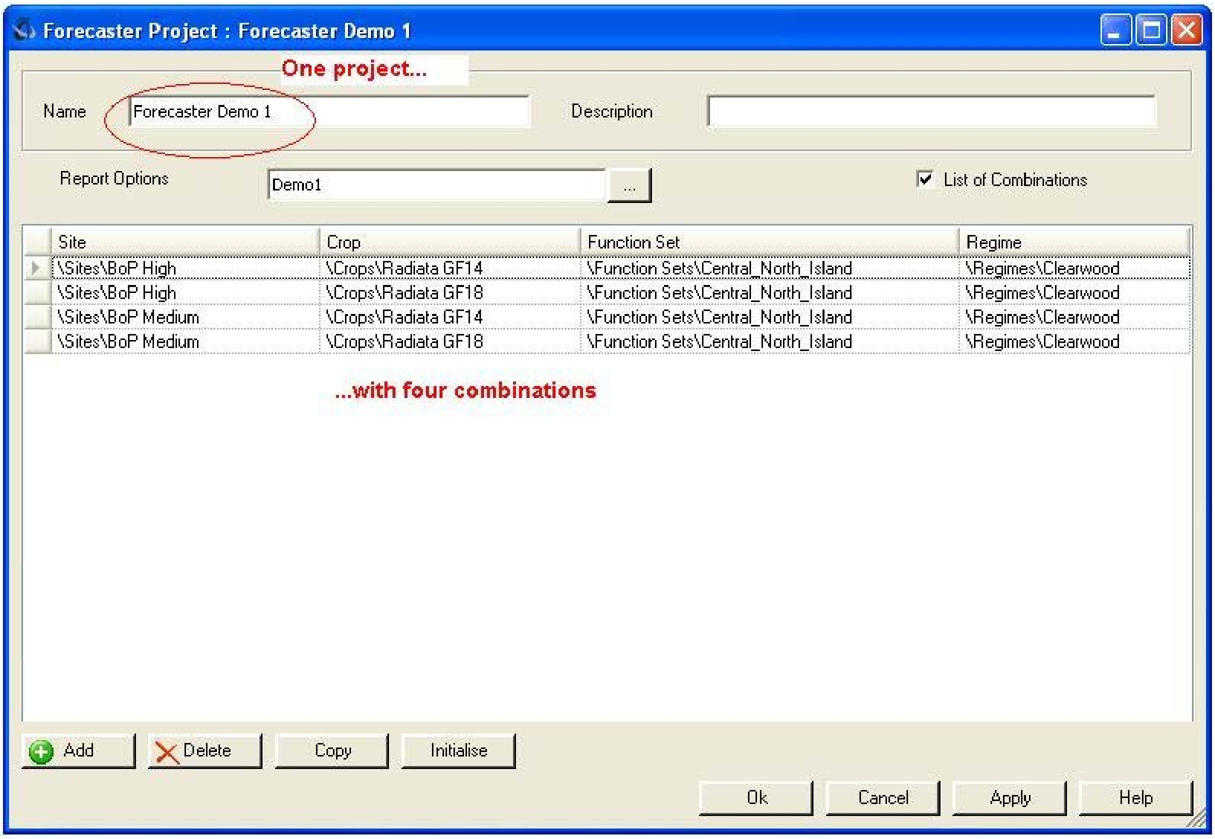
Within a simulation, each possible outcome is called a scenario. A scenario is a sequence of events that could happen in practice, and so corresponds to the combination of one of each of the following:

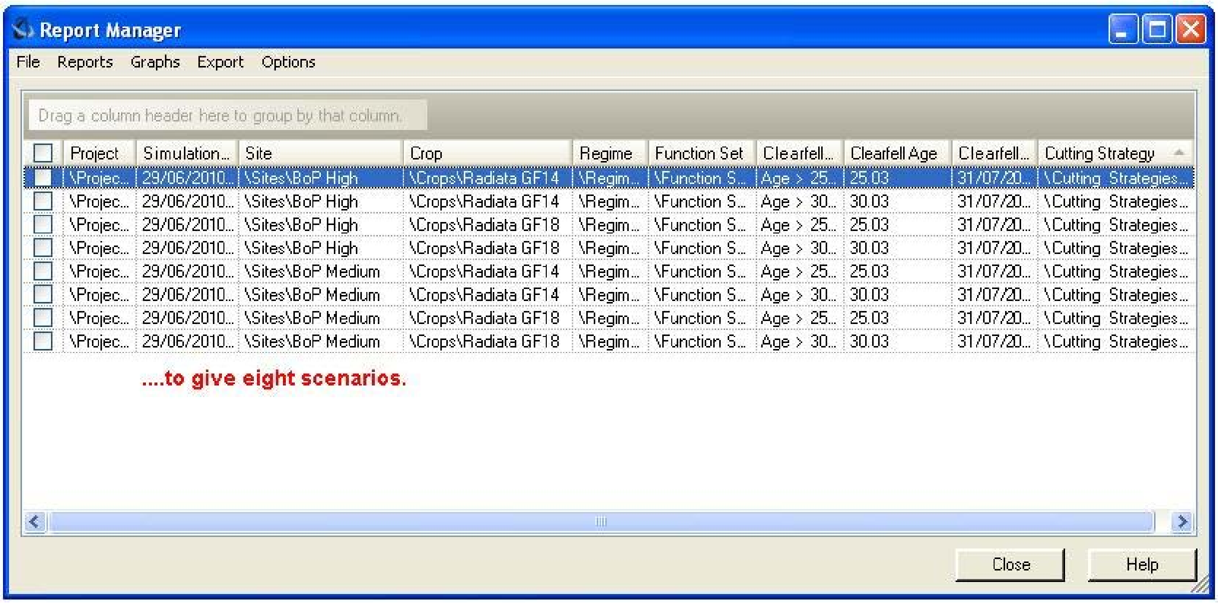
- Crop
- Site
- Function Set
- Regime
- clearfell age
- Cutting Strategy

A combination of Site, Crop, Function Set and Regime can generate multiple scenarios. This is because a Regime may include more than one clearfell age, each with more than one Cutting Strategy. In reality, a stand can only be felled at one age, and stems can only be bucked once, so each of these options becomes a unique scenario.

The scenario is the basis for comparing the results arising from differences in the component entities or in harvest details (clearfell date and Cutting Strategy). Each scenario has a unique identity, not only within simulations but also across simulations (and across installations of the system).

The relationship between Projects, Entity Combinations and Scenarios is shown below:





In this section

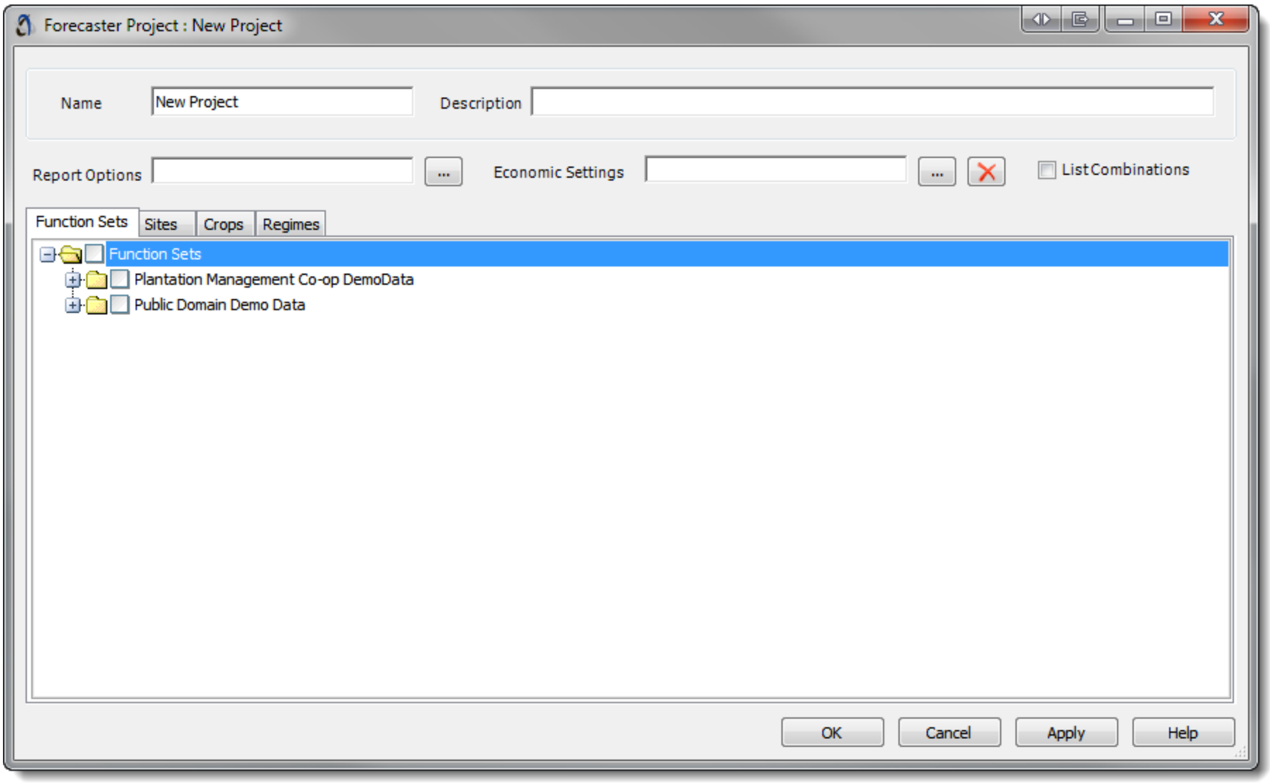
This section contains the following topics:

Topics
Setting Up a Project
Run Simulations
Message Viewer

Report Manager

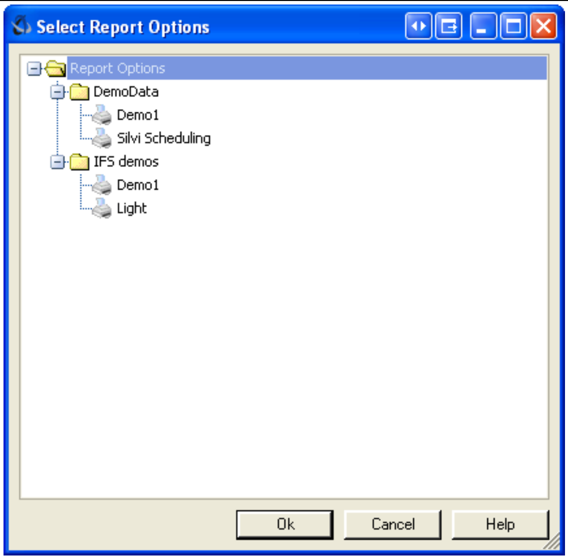
Setting Up a Project

A new Project is created by selecting the folder in which the Project is to be created, then either right-clicking in the List View Pane, or clicking on the **New** button on the toolbar. The New Project form will be displayed:



The following table describes the fields and buttons in the New Project form:

Field/Button	Function
Name/Description	Fields for displaying and editing the unique name for the project, and a description that helps to identify it.
Report Options	Displays the currently-set Report Options. If blank, this needs to be set by clicking the [...] button which opens the Select Report Options form:

Field/Button	Function
	 Select the relevant Report Options, and click **Ok**.
Economic Settings	Displays the optional Economic Settings entity associated with the Project. Clicking the [...] button allows the tree of existing Economic Settings entities to be browsed in order to select one of them. Clicking the [X] button removes the current Economic Settings entity from the Project.
List of Combinations	If this checkbox is ticked, a new form is displayed showing all possible combinations. If the checkbox is cleared, the entities view is restored. See below for more information on the List of Combinations display.
Entities tabs	Tabs are present for all 4 of the major entity types. To select for for instance the relevant crops, click on the Crops tab and click in the tick-box next to the relevant crop. The entity tabs are: • Function Sets - A function set defines the models and functions that will be used to simulate the growth of a crop on a site. • Sites - Sites are used to define the physical characteristics of the piece of land and its potential for tree growth. A "stand" in the usual sense is a combination of a particular crop growing on a particular site. The separation of site and crop allows multiple alternative crops to be simulated on a given site. • Crops - A crop is used to define the characteristics of the trees for which growth is to be simulated. • Regimes - Regimes are used to specify the sequence and timing of silvicultural events that are applied to a crop. Regimes comprise a series of commands, and each command has two parts: one or more conditions, and one or more events. The condition(s) defines when to carry out an event, and the event defines the operation to be undertaken and which stems it will apply to. **Note:** If a plant and measurement event is included in a regime then crop selection is not required for a combination.

Entities and Combinations Explanation

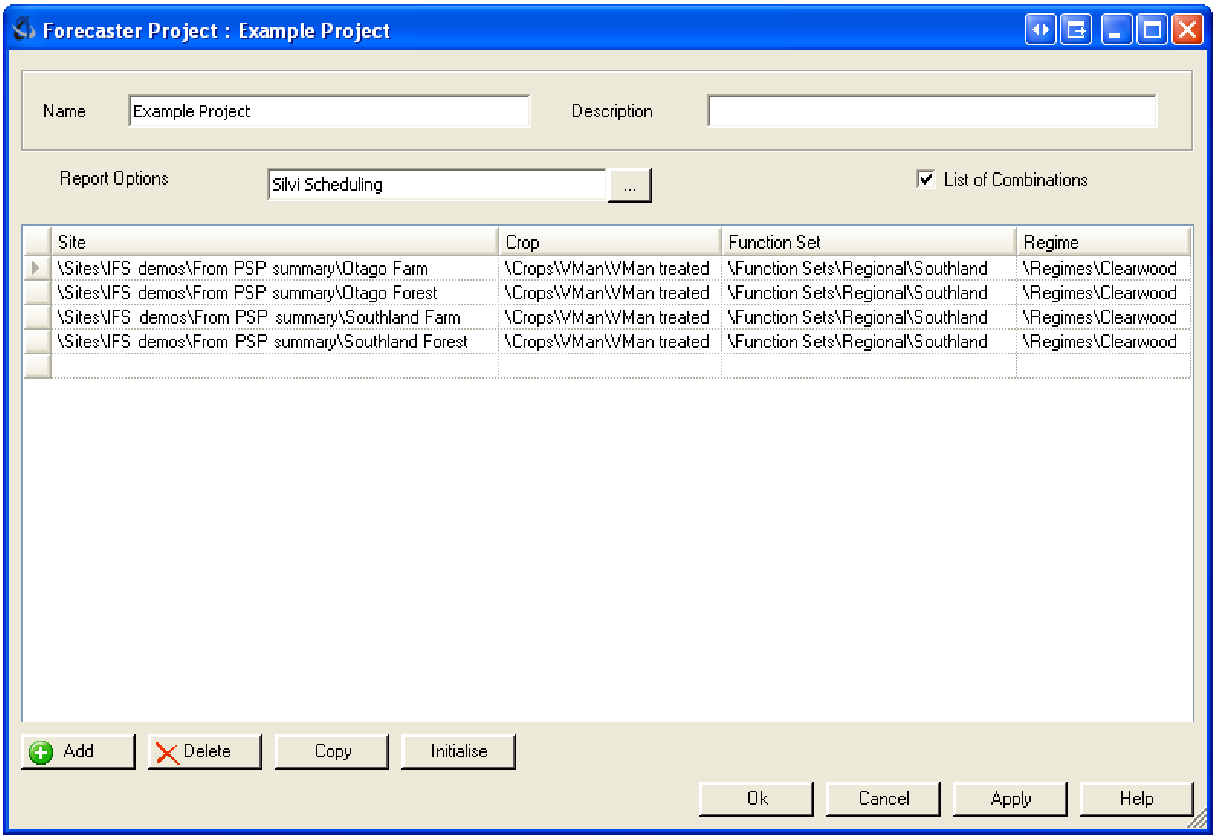
The entities to be used in the project are selected by clicking on the box next to the required model. This is done for each of the tabs:

- Function Set
- Sites
- Crops
- Regimes

The selection process generates a number of combinations, for example if 1 Function Set, 2 Sites, 4 Crops, and 2 Regimes are selected (ticked) then 16 combinations will be generated (1 x 2 x 4 x 2 = 16).

Combinations View

This is the combinations view that is generated after the **Initialise** button is selected:

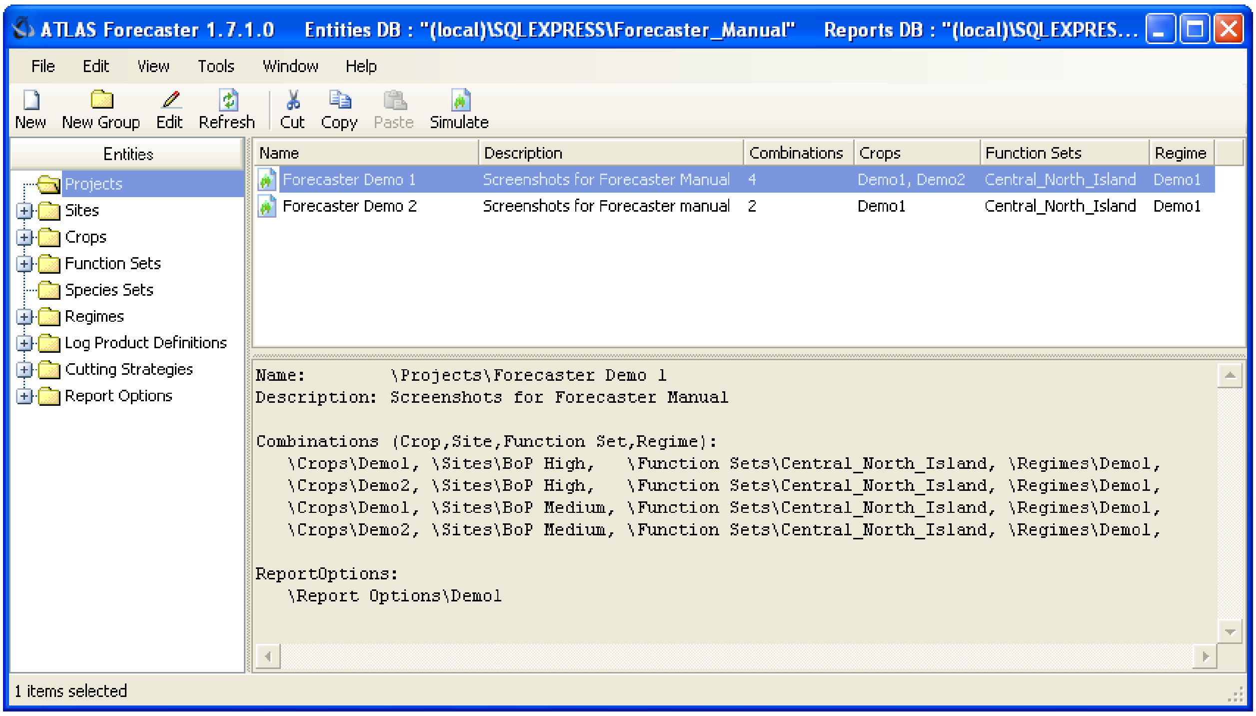


The following table describes the fields and buttons in the Combinations form:

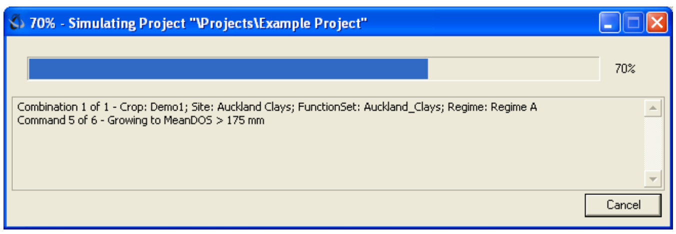
Field/Button	Function
Initialise button	Click the **Initialise** button to generate or update the list of combinations that is based on the entities ticked in the entity selection view.
Line item	Each line is equal to one combination of Site, Crop, Function Set and Regime. **Editing a combination** Double-clicking on an entity in a combination displays a list from which a new model or parameter may be selected.
Add button	Clicking this button adds a new combination which can be edited as described above.
Delete button	Select a combination and click **Delete** to remove the combination from the project. This can be useful in a large simulation where some combinations do not make sense.
Copy button	Select a combination and click **Copy** to add an identical combination to the list. This is a quick way to create a new combination with most of the same entities as an existing combination. For example: If the Crop, Function Set and Site are the same, but they need to be combined with different Regimes, then create the first Regime combination. It is then quicker to copy the first Regime combination as many times as required and make the Regime changes to each combination.

Running Simulations

A Simulation is run by selecting a Project, and clicking on the **Simulate** button on the toolbar.



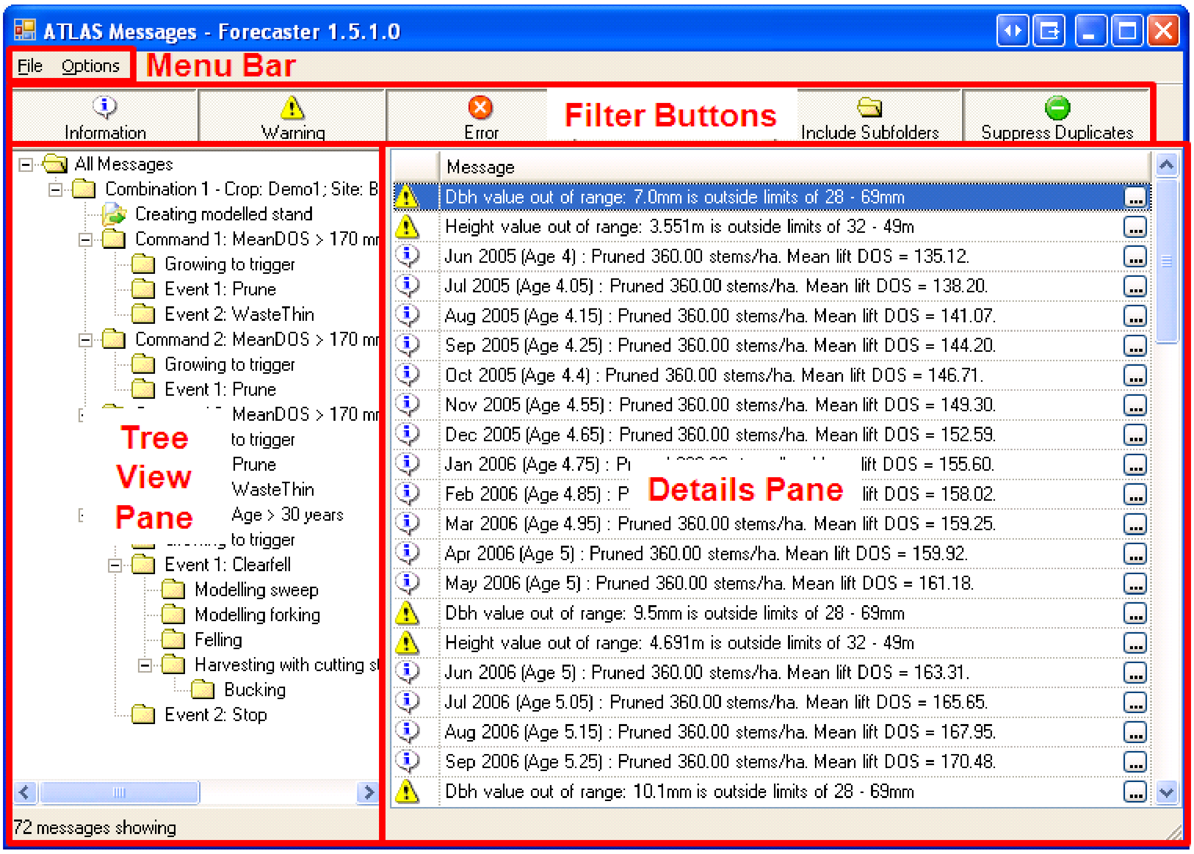
Example Procedure to Simulate a Project

Step	Action	Key Point
1	Open the Projects folder	In the Tree View Pane, click on the expand button (+) next to the Projects Master Folder.
2	View the Demo folder	In the Tree View Pane, click on the Demo folder
3	Select a Project	In the List View Pane, click on the Project "Forecaster Demo 1" to select it.
4	Run the simulation	Click on the **Simulate** button. The selected Project will then be analysed, displaying a progress bar to indicate its progress:  If the simulation is successful, the Report Manager is displayed, allowing the results of the simulation to be examined. If either the simulation has failed, or the "Show Messages" option is enabled (ticked) in the Tools menu, the Message Viewer is displayed.

Message Viewer

The Message Viewer is a reporting tool which displays error and information messages generated during a simulation. As there are often many steps to a simulation, and many messages may be generated for each step, a filtering mechanism is provided to displayed only those messages that are of interest.

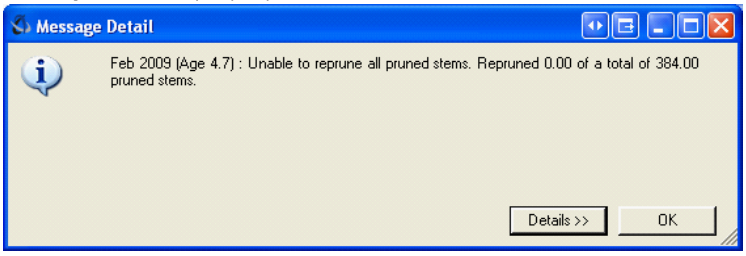
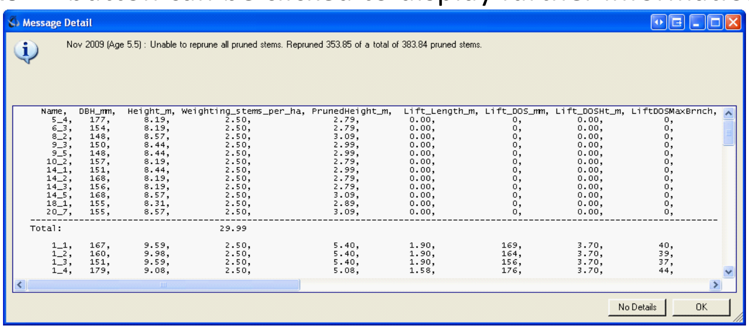
The Message Viewer initially displays messages for the entire simulation. However, by clicking on a folder for a particular stage of the simulation, only messages for that stage are displayed.



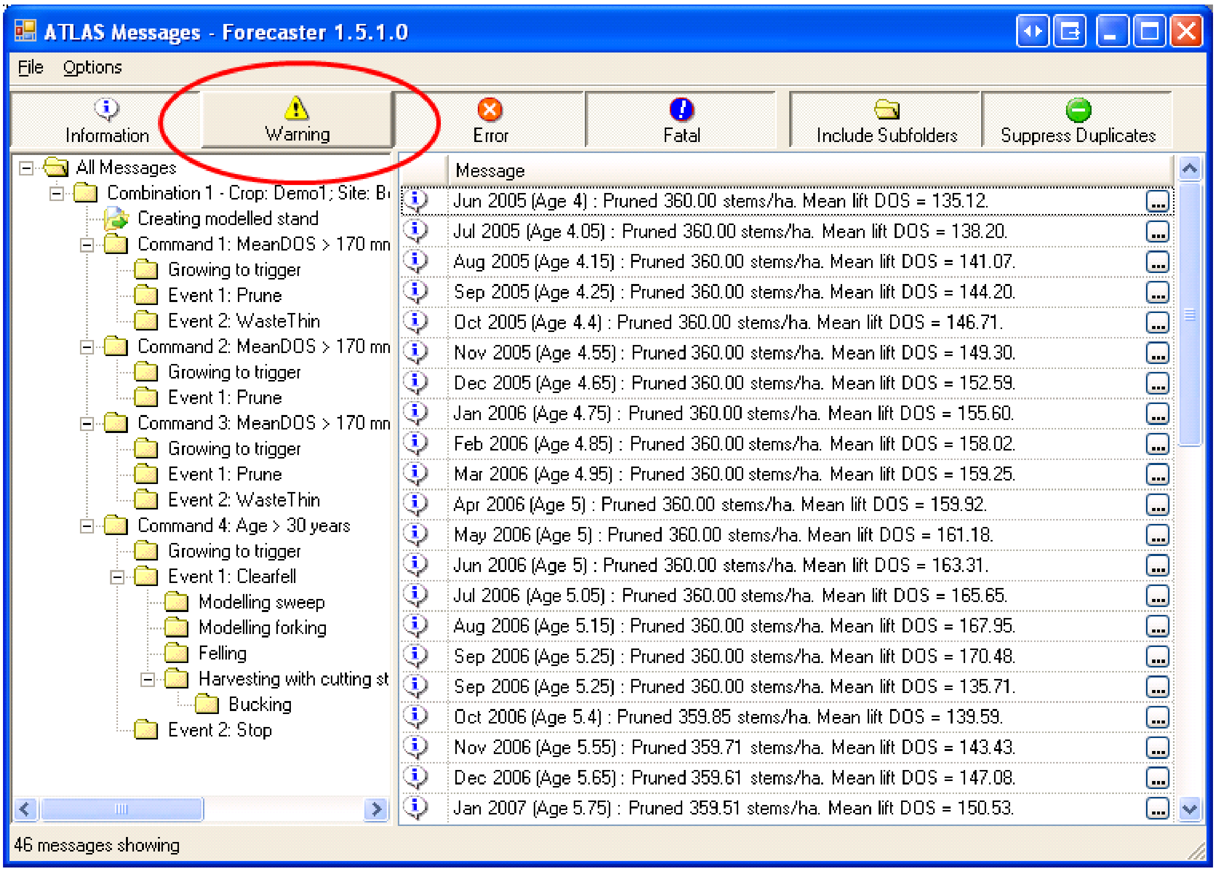
The following table describes the fields and buttons in the Message Viewer form:

Field/Button	Function

Menu Bar	• File:
	  • Open - allows a previously-saved message list to be opened and viewed
	  • Save as - saves the current list as an XML file (this can sometimes be required by the support staff at Scion to help in troubleshooting a problem)
	  • Print to PDF - saves current messages as a PDF file.
	• Options - the Print display may be changed to landscape.

Filter Buttons	These are a series of buttons that toggle the specified type of message between being displayed, and not being displayed. See the screenshot at the end of this topic for an example: • Information - toggles all information messages. • Warning - toggles all warning messages. • Error - toggles all error messages. • Fatal - toggles all fatal messages. • Include Subfolders - Toggles messages from all sub-folders. • By default, when a folder is selected to display messages relating to that stage of the simulation, all messages within sub-folders are also displayed. By clicking the **Include Subfolders** button, the sub-folder messages are not displayed. • Suppress Duplicates - hides all duplicated messages, showing just the first instance.
	Displays Message Detail popup.  The **Details >>** button can be clicked to display further information: 

Message viewer with warnings hidden



Report Manager

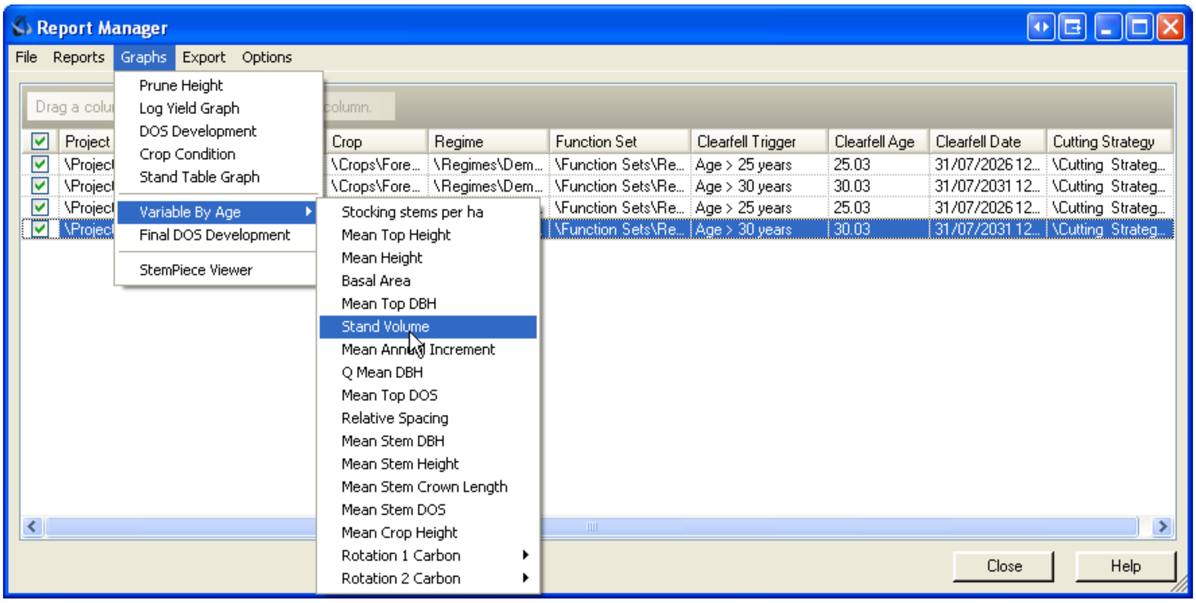
The Report Manager allows reports and charts to be generated for one or more scenarios produced for each so that the selected scenarios can be directly compared (i.e. the x and y scales are the same across all charts). Current standard reports only contain a single scenario.

The Report Manager can be run in either of two ways:

- Following successful simulation of a project, the Report Manager will open displaying all scenarios from that project.
- By clicking on the menu **Tools | Report Manager** Report Manager will open displaying all scenarios which have been saved to the reports database. The more scenarios saved to the reports database, the longer it will take for the Report Manager to open. When run in this mode, the Report Manager will allow selected scenarios to be deleted.

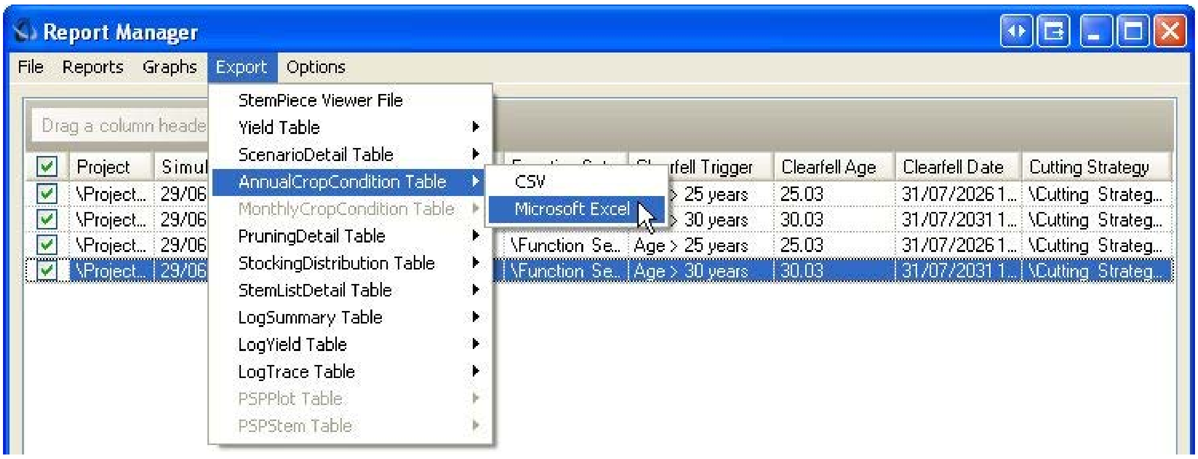
Report Manager Example

In this example a Project has been run, giving four scenarios. All four scenarios have been selected using the check boxes on the left.
A number of standard graphs and reports are available from the Graphs menu (or by right click on a selected scenario). In this example, the user has selected a chart showing Stand Volume by age for the four scenarios:



Standard reports are created as PDF files. It is also possible to export report tables as either CSV files or Excel files via the Export menu.

Note: The only tables available (those not greyed out) will be those that were either ticked in the Reports Options, or were required by Forecaster to generate requested standard graphs or reports.



The tables available for export are described in Available Report Tables.

Species Sets

Species Sets are collections of one or more species, and they are used when constructing Function Sets and Log Product Definitions. A Species Set is constructed as a sub-set of the Master Species List, which is maintained in the configuration settings.

A Species Set may contain just one species, or it may contain multiple species. A Species Set with multiple species can be useful when:

- crops being simulated contain stems of more than one species (relevant only for crops defined at the stem list information level), *and*
- all of those species may be modelled using the same basic functions (including the selected Growth Model)

In this way, Species Sets can be used to cluster together species which have similar mensurational characteristics, for example stringy bark eucalypts.

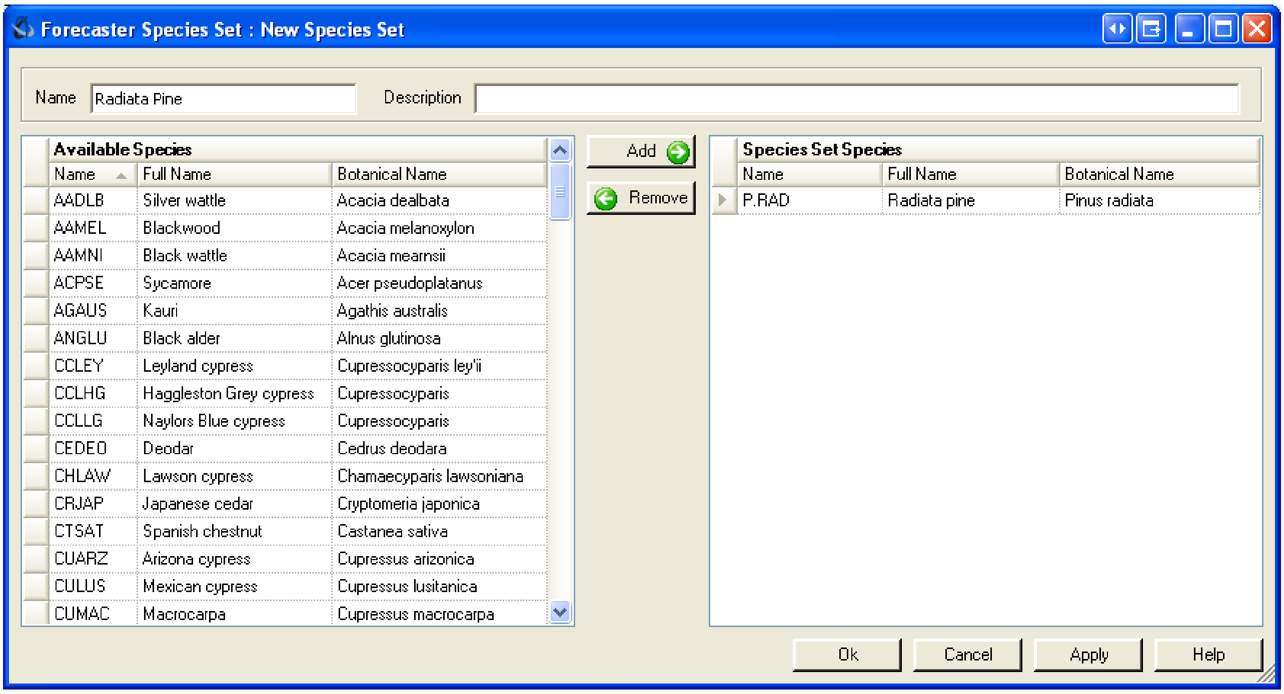
In this section

This section contains the following topics:

Topics
Creating a Species Set
The Master Species List

Creating a Species Set

The Species Set form



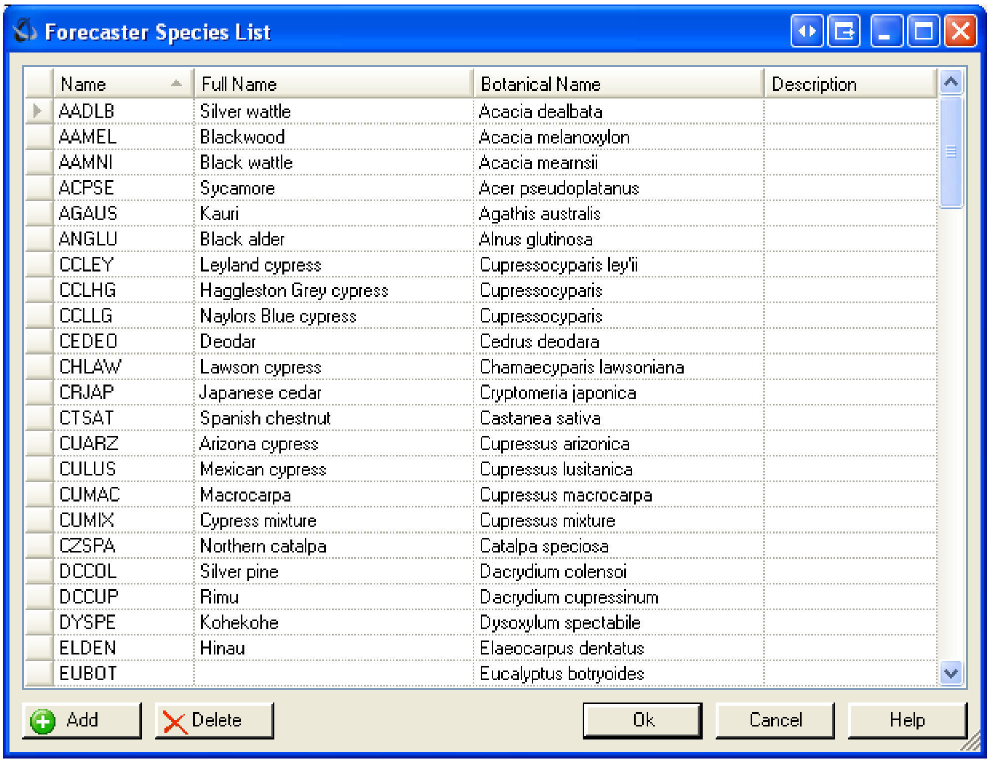
Creating a new Species Set

Step	Action	Key Point
1	Display the New Species Set form	• Right-click on the Species Set master folder (Note that for Species Sets, no subfolders can be created under the master folder) • Choose **New**
2	Enter a *name* and *description* as required.	
3	Create a list of species	• Highlight the species you wish to include, and click **Add** • Once your list is complete, click **Ok** or **Apply**

The Master Species List

The Master Species List

The Master Species List is the list of all species available for use in Forecaster. It is accessed via the **Tools | Species List** menu item:



Note that the list can be sorted on any column by clicking on that column's header.

Adding a Species to the Master Species List

Follow these steps to add a species to the Master Species List:

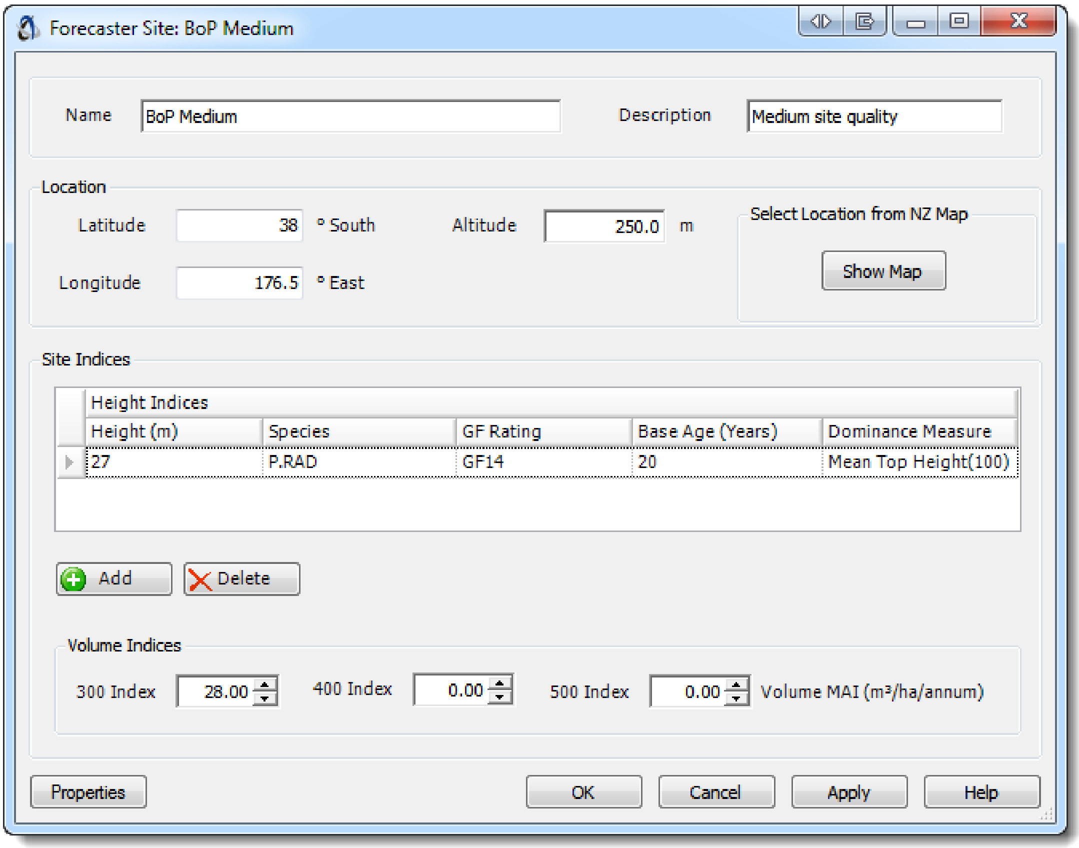
Step	Action	Key Point
1	Open the Master Species List	Select the **Species List** option on the **Tools** menu
2	Add new species, as required	Click **Add,** and complete all fields. **Note:** Once added, a species entry can be edited, but not deleted. For this reason, it is important to double-check that the species is not already in the list.
3	Update the list	Click **Ok**

Sites

This section describes the setting up of sites for a project. There are two methods that can be used to specify site locations:

- Direct entry of site data
- Selection of the site from a map (See Spatial site selection)

This is an example of a completed site:



A set of standard sites will be available, providing regional estimates of Site Index and 300Index based on New Zealand PSP data.

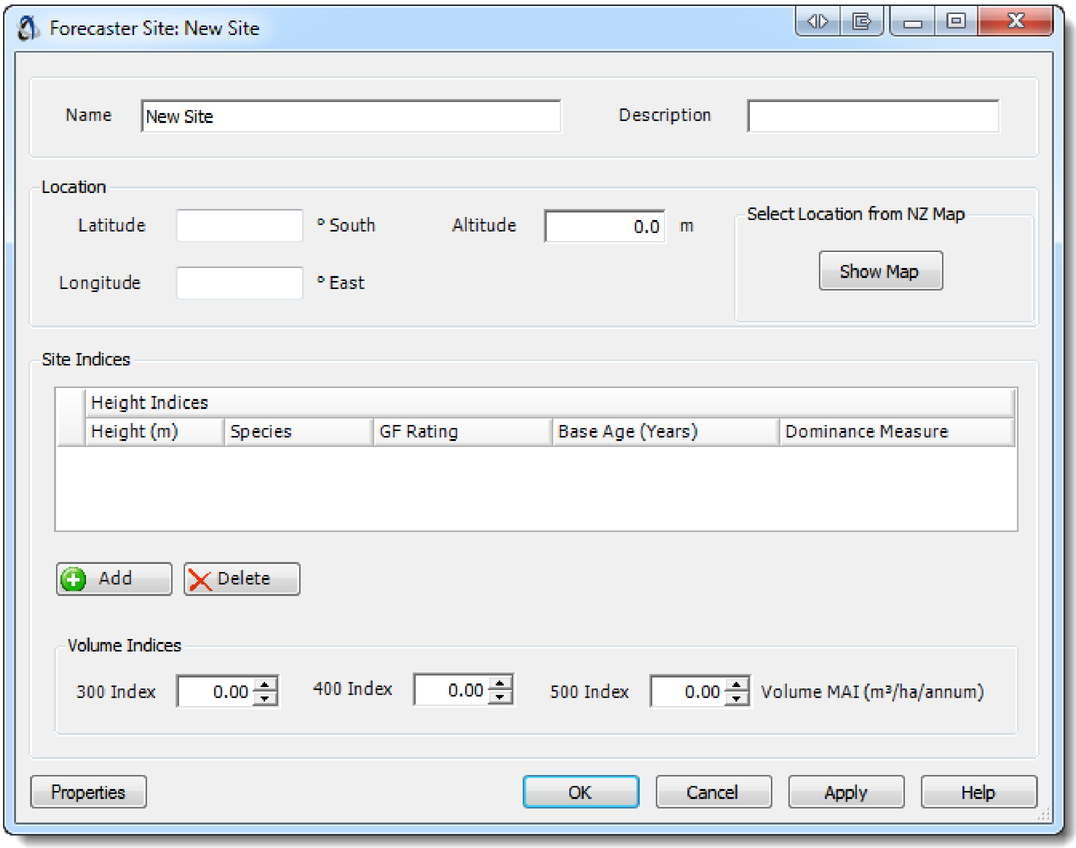
In this section

This section contains the following topics:

Topics
Setting Up Sites
Spatial Site Selection

Setting Up Sites

Sites are used to define the physical characteristics of the piece of land and its potential for tree growth. A "Stand" in the usual sense is a combination of a particular Crop growing on a particular Site. The separation of Site and Crop allows multiple alternative Crops to be simulated on a given Site. When a new Site is created, an empty Site form is displayed:



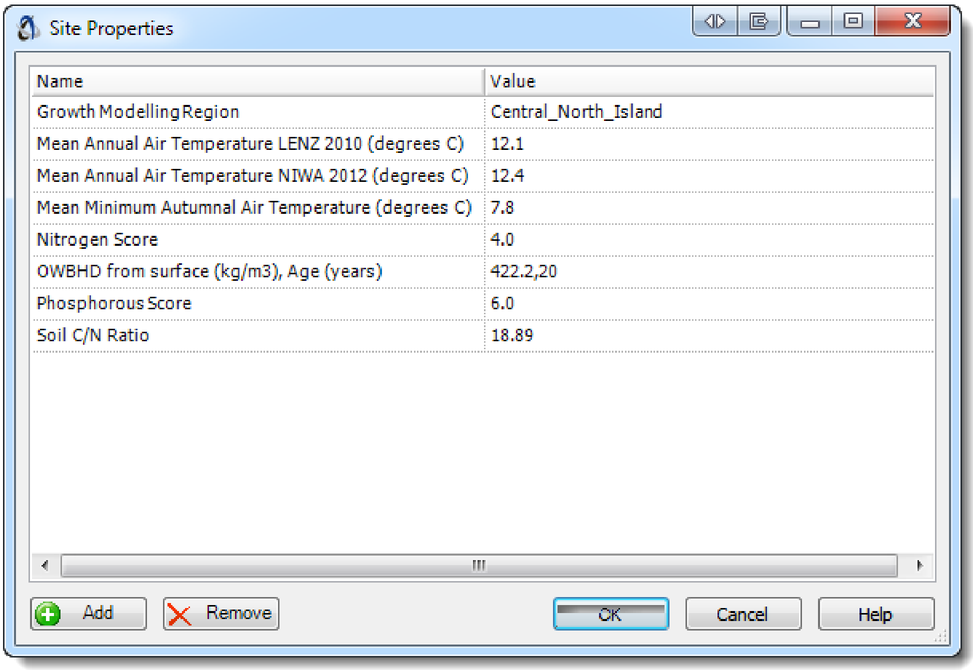
Site Form Details

The following table describes the fields and buttons in the Site form, and their usage:

Field/Button	Function
Name/Description	A Site must have a name, but the other attributes may be optional, depending on the choice of FunctionSet. A description should be entered to help users decide whether a pre-defined Site is appropriate for a particular simulation.
Location and Altitude	Latitude and altitude are required by the 300 Index growth model and some wood property models. All values can be either entered directly into the form or populated using the Spatial Site Selector. The units are: • X Location - degrees East • Y Location - degrees South • Altitude - metres above sea level
Show Map button	Opens the spatial site selection interface. Using this, a New Zealand Site can be selected from a map, and its attributes and properties populated from geo-spatial surfaces (see Spatial site Selection).
Site Indices	Site Indices are of two types: 1. A height index provides an indication of potential height growth. Site Index as used in STANDPAK is an example of a height index. Height indices should be defined clearly - for example, the traditional

<table>
<tr><th>Field/Button</th><th>Function</th></tr>
<tr><td></td><td>STANDPAK height index is based on Mean Top Height at age 20 of radiata pine of GF 7.
2. Volume index - A index of volume growth, such as the the 300Index, provides an indication of potential volume growth of the site.

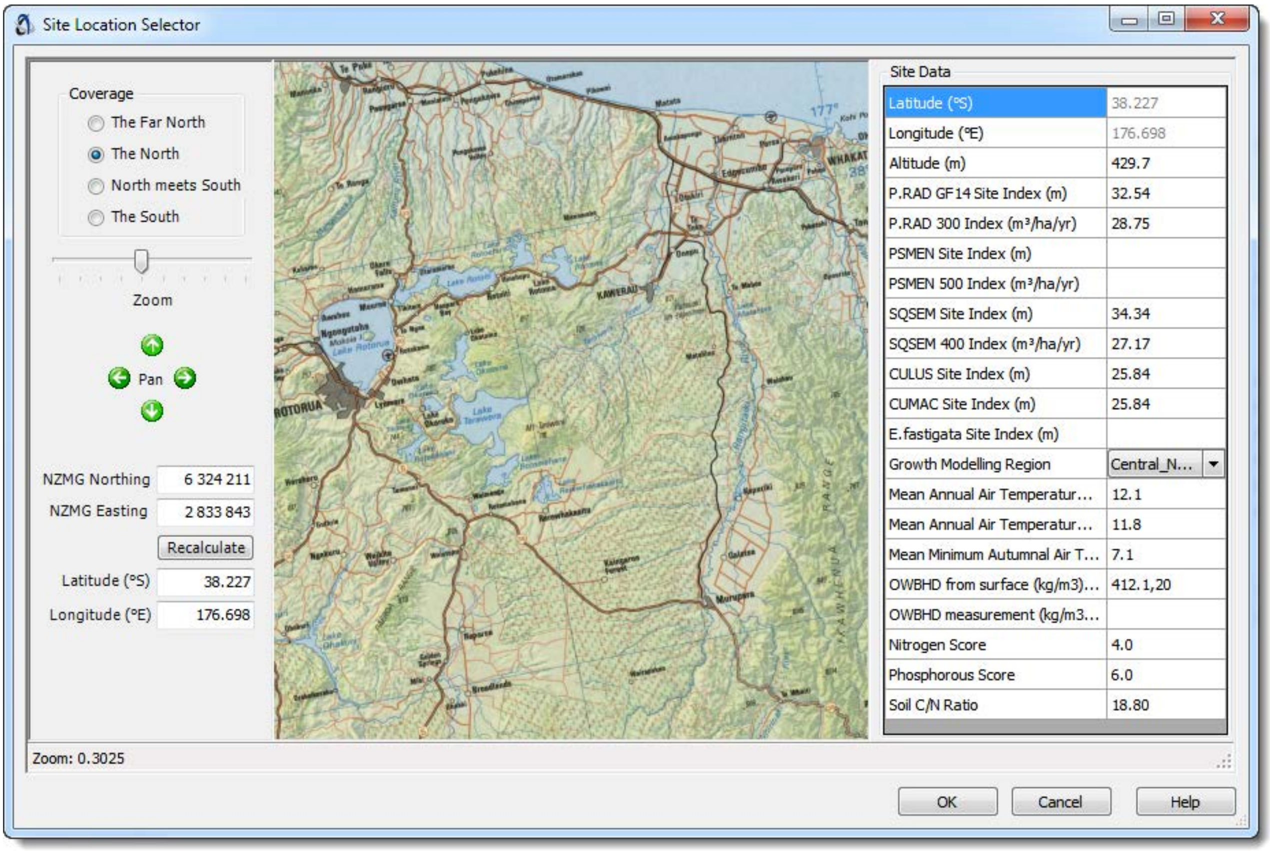
Note: the GF rating on the Site needs to match that on the Crop to allow the indices to be used in the simulation. If they don't match, or if the Site index fields (either height or volume) are left blank, appropriate values will be calculated, based on the measured crop parameters entered.</td></tr>
<tr><td>Add/Delete buttons</td><td>The Add button inserts a blank line at the bottom of the Height Indices list. Enter a height and base age, and for each of the other fields, select from the picklists.
The Delete button removes the selected height index line.</td></tr>
<tr><td>Properties button</td><td>Opens the Properties form, allowing the site's properties to be added, reviewed or modified:



Note: the properties' names and values must be consistent with those expected by the models and functions that use them. A site's properties are used by some growth models and wood properties models (see Density Models and Stiffness Models), and they can be used to override any corresponding properties specified on the FunctionSet (see Properties).</td></tr>
</table>

Spatial Site Selection

The Site Selector form allows the location of a site within New Zealand to be selected directly from a map:



When a location is selected, various parameters and properties for the site are automatically determined from underlying geo-spatial surfaces, and then presented in the data grid on the right-hand side of the selector form.

Selecting a Location Using the Spatial Interface

Follow these steps to select a location using the spatial interface:

Step	Action	Key Point
1	Select the appropriate coverage	There are four coverages based on the LINZ New Zealand Small Scale Topographic Maps 1:500,000 series. Choose the coverage appropriate for the Site's location.
2	Navigate to the required location	The following functions allow you to move to the required location on the map: • Zoom In/Out - use the **Zoom** slider or the mouse wheel • Move - use the **Pan** buttons, or left-click and drag to pan the view over the map • Select a location - left-click the mouse Note that the location's accuracy is unlikely to be better than ±200m.

Step	Action	Key Point
3	Select the Site	Left-click the mouse to select the current location for the Site. This will look up values on each of the spatial surfaces for that location (or an area surrounding it, see Sampling Area), and then display them in the data grid. Note that the surfaces may have "gaps" in them - for example urban areas, water bodies and mountains may not return values, but they should return values for any potentially productive sites. Also, some site properties do not yet have surfaces available for them (PSMEN site and 500 index, and EUFAS site index) and so their cells will be left empty.
4	Make any modifications needed	If necessary, manually change (or enter, for empty cells) values in the data grid.
5	Complete the selection	Press the **OK** button to confirm the selection of the new location. This will return you to the site's maintenance form.

Selecting a Location Using Co-ordinates

Follow these steps to select a location using the direct co-ordinates:

Step	Action	Key Point
1	Enter coordinates for the location	Enter the coordinates for the site's location in the appropriate fields as either: • NZMG Northing and Easting, or • NZGD49 Latitude and Longitude Coordinates can be obtained from a GIS or mapping tool, or a hard copy map, and then entered into these fields.
2	Use those coordinates	Click **Recalculate**. This will update the other pair of coordinates, and then interrogate the spatial surfaces for the newly-specified location. The resulting values are displayed in the data grid on the right-hand side of the form.
3	Make any modifications needed	If necessary, manually change (or enter, for empty cells) values in the data grid.
4	Complete the selection	Press **OK** to close this form and populate the site parameters to the site form.

Geo-spatial Surfaces

Overview

Data that can be represented by a single-value function of location is made available by a set of geo-spatial surfaces. Each surface contains the data for a single type of measurement (altitude, temperature etc.) for the whole of New Zealand as a grid of values, each of which represents that measurement for any point within the geographic bounds of its grid cell.

The set of spatial data for any site is established by accessing the appropriate surfaces, using the location's coordinates (see Spatial Site Selection), and stored on the site as either attributes or properties (see the following table).

Surfaces Available

Surface	*Property Name*	*Grid Cell Size*
Altitude	n/a	100m
Radiata Site Index	n/a	1km
Radiata 300 Index	n/a	1km
Radiata Density Index	OWBHD from surface (kg/m3), Age (years)	500m
Redwood Site Index	n/a	100m
Redwood 400 Index	n/a	100m
Cypress Site Index	n/a	100m
Soil Nutrition - Nitrogen	Nitrogen Score	100m
Soil Nutrition - Phosphorous	Phosphorous Score	100m
Soil - Carbon/Nitrogen Ratio	Soil C/N Ratio	100m
Mean Annual Temperature (NIWA)	Mean Annual Air Temperature NIWA 2012 (degrees C)	500m
Mean Annual Temperature (LENZ)	Mean Annual Air Temperature LENZ 2010 (degrees C)	100m
Mean Minimum Autumnal Temperature	Mean Minimum Autumnal Air Temperature (degrees C)	100m
Growth-Modelling Region	Growth Modelling Region	100m

Sampling Area

When reading from a surface, the value returned is that attributed to the cell within which the specified location falls. However, a representative value for a larger area (such as a stand), is typically of more interest. To enable this, a sample area is defined, centred on the location of interest, and the returned value is based on the values of the cells that fall within that area (as a weighted mean). The area (in hectares) to be used for sampling is specified in **Tools | Options | General** as **SpatialSurfaceSampleArea** (see System Settings). A larger area will return more generalized and stable values, whereas a smaller area will return values that are more accurate, but more variable. An area of zero hectares will result in a single point sample.

Crops

A Crop is used to define the characteristics of the trees for which growth is to be simulated. A "stand" in the usual sense is a combination of a particular Crop growing on a particular Site. The separation of Site and Crop allows the growth of a given Crop to be simulated on multiple Sites.

Standard Crops

Example Crops are available for use in tutorial exercises.

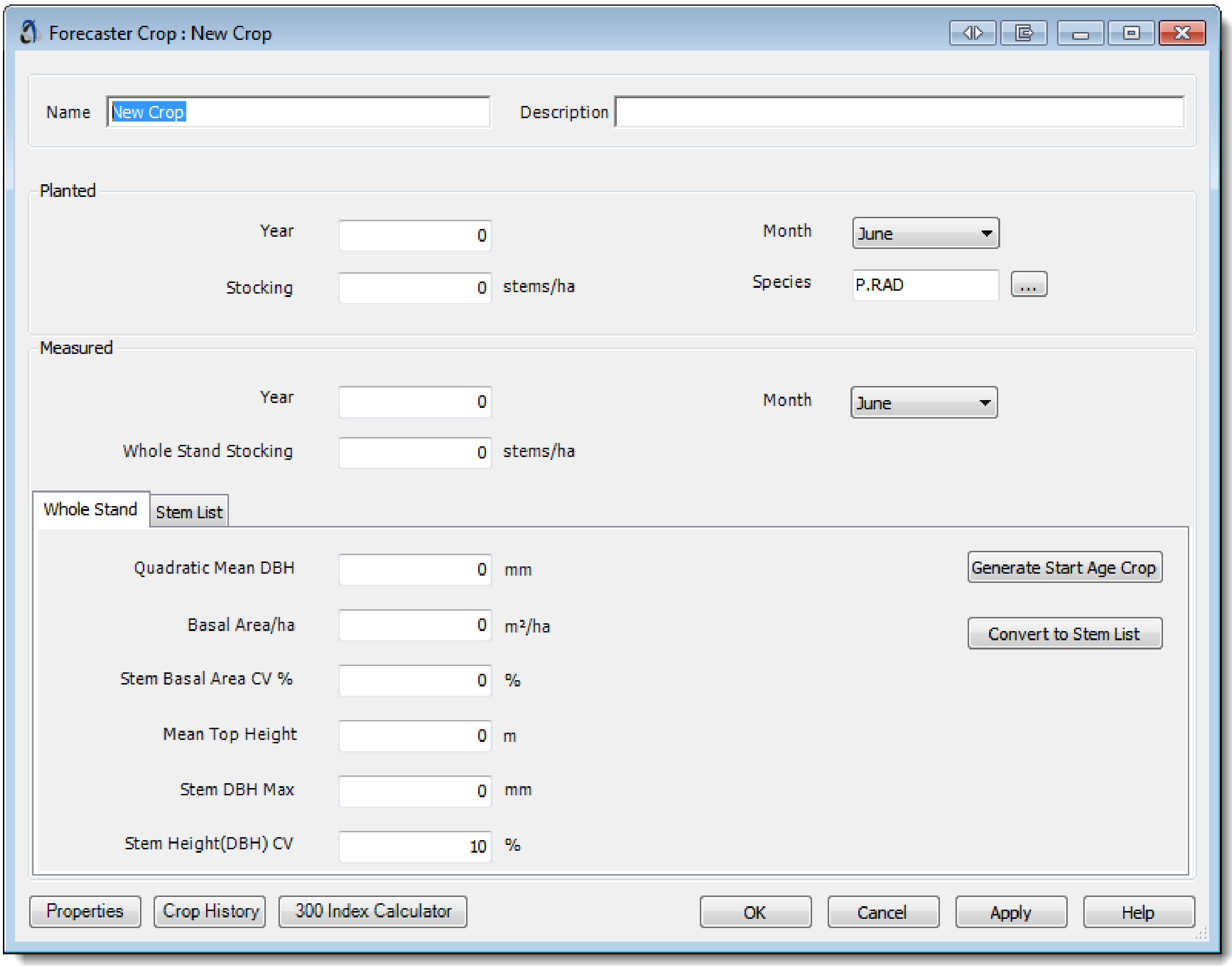
In this section

This section contains the following topics:

Topics
Setting Up Crops
Crop Measurements
Stem Basal Area Coefficient of Variation Calculation
Initial Crop Examples

Setting Up Crops

When a new Crop is created, the New Crop form is displayed:

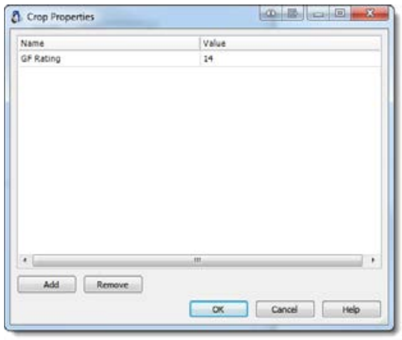


The following table describes the fields and buttons in the Crop form, and their usage:

Field/Button	Function
Name/Description	A crop must have a name. A description is useful so that users can quickly decide whether a pre-defined crop is appropriate for a particular simulation.
Planted	Information at planting is required, including: • year, • month, • planted stocking and • species (selected from the species list)
Measured	Information at the start date for the simulation is then entered, including: • year and month of the measurement, and • whole-stand stocking at the time of the measurement
Whole Stand tab	This allows mean stand parameters to be entered (as in STANDPAK). Estimates of variance for both BA and height are also required.

Field/Button	Function
	See Crop Measurements for more detail on parameter definitions and their calculation.
Stem List tab	This allows actual stem-level measurement data to be entered. For example, if you measure 50 stems and the estimated stocking is 500 stems/ha, then each stem measured will have a weighting of ten. Stem lists must be imported into Forecaster from a CSV file (from Excel, for example) or from SilviQC. To open a stem list in Forecaster a crop file must be imported. This crop file contains a link to the file that holds the stem list data. More than one stem list can be referenced in a crop file for bulk loading of stem lists into Forecaster. ATLAS SilviQC produces a crop and a stem list in CSV format which can be imported straight into Forecaster. See Crop Measurements for more detail on parameter definitions and their calculation.

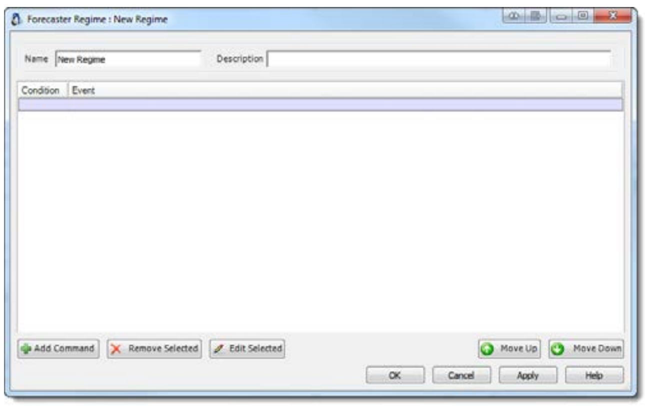
<table>
<tr><th>Field/Button</th><th>Function</th></tr>
<tr><td>Properties button</td><td>Clicking the Properties button brings up the Crop Properties form, allowing additional user-defined crop properties to be entered:



The names and values must be consistent with those expected by the various models and functions. Some currently implemented growth models require properties to be set, including:

<table>
<tr><th>Model</th><th>Property Name</th><th>Values</th></tr>
<tr><td>PPM88 Growth Model</td><td>GF Rating</td><td>whole number from 2 to 22</td></tr>
<tr><td>PPM88 Growth Model</td><td>Relative Closure</td><td><leave blank></td></tr>
</table>

Crop properties can over-ride those specified on the site or function set (see Using Properties).</td></tr>
<tr><td>Crop History button</td><td>Clicking the Crop History button opens the Crop History form. This is used to record historical events applied to a crop - i.e. silviculture which is known to have occurred between time of planting and time of the crop's measurement. If specified, crop history is merged with the regime during simulation. Use this form to specify the operations that have been performed on the stand at known dates.


</td></tr>
<tr><td>300 Index Calculator button</td><td>Allows various calculations to be performed using the 300 Index calculator.</td></tr>
</table>

Using Crop data

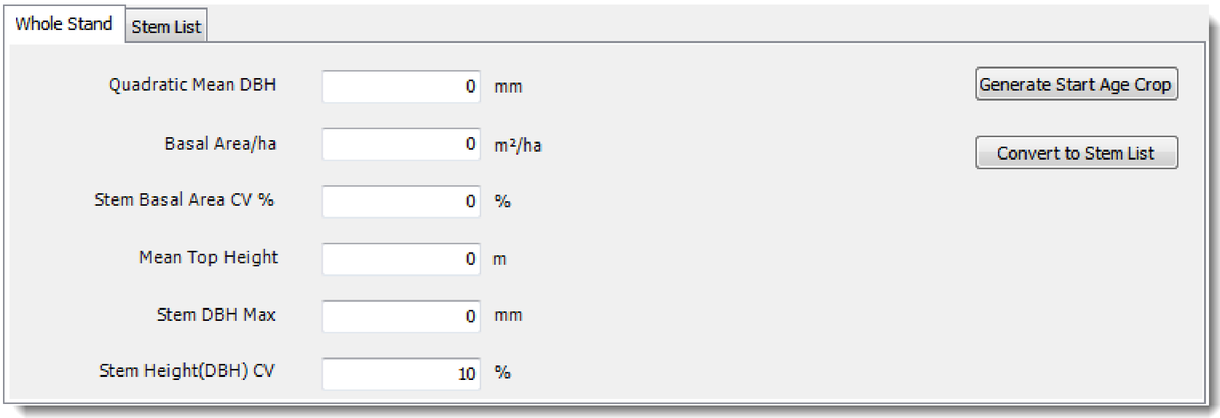
It is important to note that Forecaster always works with a stem list. If stem list data is not provided by the user, then at the time of simulation, Forecaster generates an initial stem list for the simulation from information entered in the Whole Stand tab.

Crop Measurements

This topic describes detail on parameter definitions and their calculation as required for setting up crops.

Whole Stand

This option allows a crop to be defined by a stand-level summary consisting of average values and measures of spread. Entering a crop at whole stand level still requires significant assumptions in order for Forecaster to derive a starting stem list:

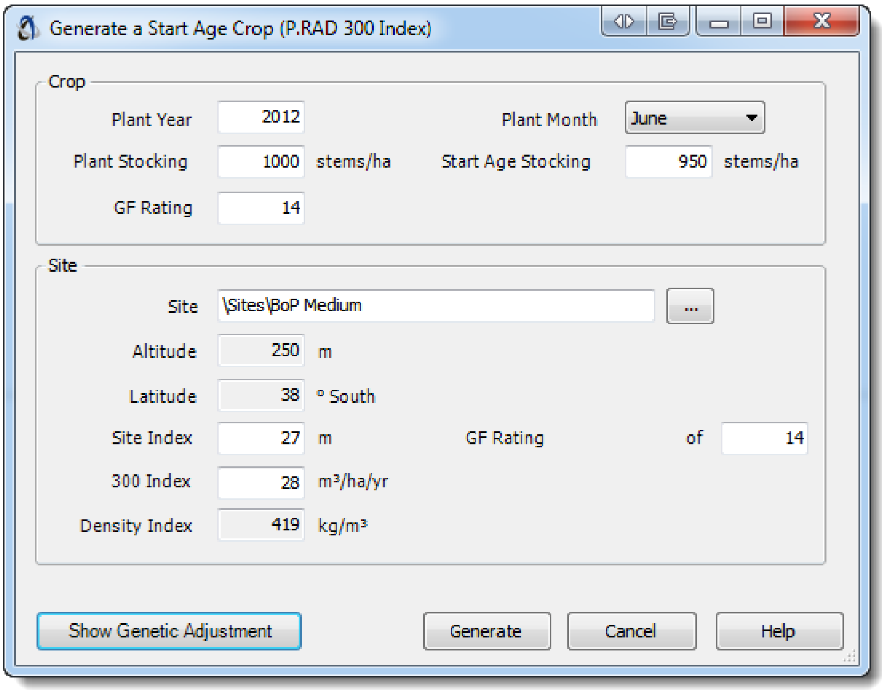


The following table describes the fields and buttons in the Whole Stand tab:

Field/Button	Function
Basal Area/ha (m^2/ha)	Over-bark area of stump per hectare if each tree was felled at breast height above ground
Stem Basal Area CV%	Coefficient of variation is the measure of dispersion of the distribution of stem basal area (CV = Standard deviation/ mean)
Mean Top Height (m)	The average height in meters of the stem of quadratic mean DBH of the largest diameter (DBH) 100 stems per hectare
Stem DBH Max (mm)	The DBH of the largest stem within the stand
Stem Height (DBH) CV%	The coefficient of variation is a measure of dispersion of the distribution of stem height (CV = Standard deviation/mean)
Generate Start Age Crop	Allows a starting crop to be generated (see below)
Convert to Stem List	Produces a matching stem list (see below)

Generating a Starting Point Crop

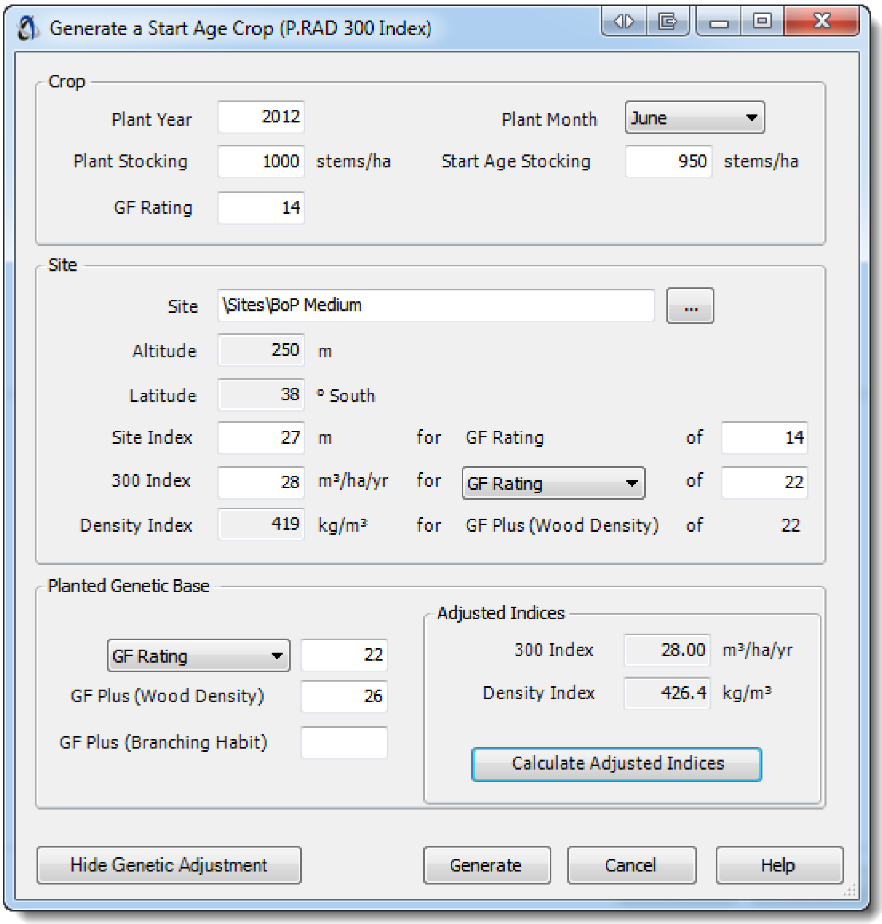
A radiata pine crop can be generated as a starting point for a simulation by clicking the **Generate Start Age Crop** button. This uses site productivity, the 300 Index growth model, and planted stocking to derive a crop at a young age (the actual age will differ depending on the productivity of the site, as a height-age model (#189) is used to determine when 5m MTH is reached). The algorithms behind this were developed from historical PSP measurements and young age silvicultural quality control measurements[4]. This feature is available only to members of the FFR Radiata Theme.



Enter the date of planting and the planted stocking (the *GF Rating* of the tree-stock planted will be set to a default initial value of 14). The stocking at age 3 will be initialized with 95% of the planted stocking on first entry into this field - this can be over-written if desired. Initial values for the productivity of the planted site are obtained by browsing and selecting a Forecaster site. The altitude and latitude fields, as well as the site index and 300 index, are populated from the selected site. If there are several height indices in the site's list, the one closest to the planted stock's genetic quality is used. If the genetic quality measure is different, then the highest value for radiata pine will be returned.

Genetic Improvement of Starting Point Crop

An adjustment for genetically-improved stock can be made clicking the **Show Genetic Adjustment** button (clicking that button again hides the detail):



The genetic base of the site's 300 Index must be specified by selecting a quality measurement type and value. Note that the same genetic measurement type must used for the planted stock and the site's 300 index (i.e. both must be either *GF Rating* or *GF Plus (Growth)*). Once this is entered, the improved 300 index for the site is generated by pressing the **Calculate Adjusted Indices** button. The resulting value reflects the likely productivity of the planted stock on this site(33). Currently there is no support for improving the site index for tree-stock of higher genetic quality, however, the site index value can be altered directly. An adjusted density index will also be calculated if a value has been entered for the *GF Plus (Wood Density)* trait of the planted stock(34,38).

On clicking **Generate**, the 300 Index growth model is used to estimate the basal area and mean top height at age three. From these values the Whole Stand tab of the crop form is filled out using starting point equations that predict the maximum DBH and the variation about the mean DBH and conditional mean height. If a value has been entered for *GF Plus (Wood Density)*, it is attached to the crop as a property,

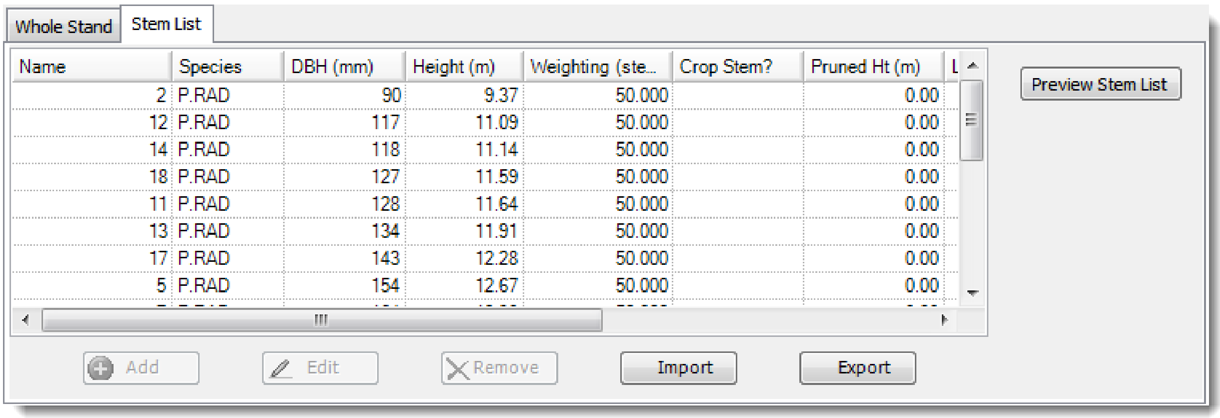
Convert to Stem List

Clicking the **Convert to Stem List** button will generate a corresponding stem list, and populate the Stem List tab. The stem list is generated so that the stand stocking, basal area and mean top height are conserved, and the variation in DBH and height are approximated. DBHs are generated around the quadratic mean DBH using the specified coefficient of variation and the maximum DBH. Stem heights are generated around the height/DBH curve (passing through mean top DBH / mean top height) using the conditional mean height from the curve and the coefficient of variation around this mean.

Stem List

Provided data is available, measured crops should be entered as stem lists wherever possible. This ensures that simulation is based on real known data rather than being inferred from basic stand summary statistics. Note that the stem list should be representative of the entire population you wish to model.

If silviculture QC data is normally only collected for the crop element of a stand, and the data is to be used to initialise a Forecaster simulation, then it is worth considering measurement of a small number of followers so that a meaningful stem list can be formed. For instance, if 6 pruned stems are normally measured per pruning QC plot, then 1 follower could also be measured. Stem weightings need to reflect the relative stockings of both the crop and follower elements.



Note: Each stem *must* have a name (typically a number), species, DBH, and weighting (the number of stems/ha which this stem represents). In addition, some stems must also have heights recorded.

The following table describes the fields and buttons in the Stem List tab:

Field/Button	Function
Name	Stem number or ID
Species	Species name (e.g. P.RAD)
DBH_mm	Over bark diameter at breast height in mm.
Height_m	Measured height of the stem in m. Not that this value can be missing
Weighting_stems_per_ha	The number of stems per hectare that the measured stem represents. The sum of all stems' weightings equals the stocking.
Import	Imports a stem list from a CSV file (see Importing Entities from CSV Files).
Export	Exports the crop's stem list to a CSV file.
Preview Stem List	Produces a Stem List Chart (see below)

Optional Fields

The following optional fields can also be used:

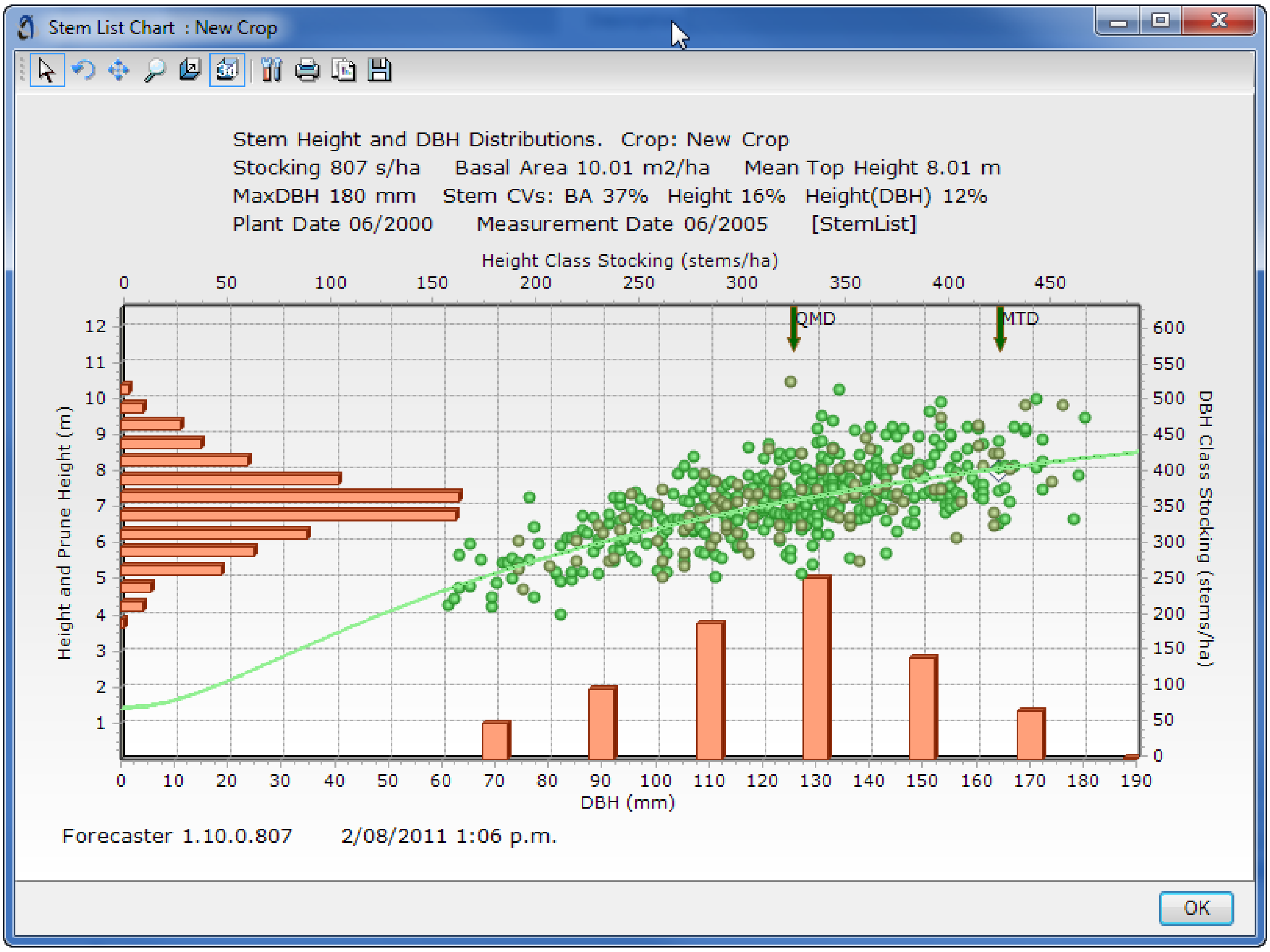
- Is_Crop_Stem - set to either TRUE or FALSE. If TRUE, this stem will be pruned in the next simulated pruning event. This field is used to force Forecaster to prune stems which have already been identified as crop stems.
- PruneHeight_m - the vertical distance up the stem from ground level to the first dead or live branches not removed by pruning. If this value is missing, the stem is assumed to be unpruned.
- Lift_DOS_mm
- Lift_DOS_Height_m
- Lift_DOS_Max_Branch_mm
- Properties (unused currently)

Missing Stem Heights

If any stem heights are missing in the stem list, Forecaster will attempt to fill-in values by fitting a height/DBH relationship to those stems that have both DBH and Height measured. This relationship is then used to estimate the missing heights as a function of DBH.

Stem List Preview

A Stem list, whether generated by Forecaster (from Stand Subset, Whole Stand) or taken from actual plot measurements (Stem List), can be previewed via the Stem List Chart. This is a summary report showing the distributions of height and DBH, their range and the relationship between them:



It may include pruned heights:

All stems in the stem list are plotted according to their DBH and Height values, against the bottom, horizontal axis and left, vertical axis. Actual values are indicated by the olive circles, and predicted values by green circles. The mean top diameter, mean top height point is drawn as a diamond shape. Arrows from the top axis show the position of the mean top diameter (MTD) and quadratic mean diameter (QMD). The height/DBH curve is drawn through the stem points showing the average height as a function of DBH.

The distribution of stocking (stems per hectare), as recorded in the weighting associated with each stem, is shown by DBH along the bottom, horizontal axis. The right, vertical axis measures the stocking by DBH class. The distributions of stocking by stem height (and prune height if measured) are shown along the left, vertical axis. The top, horizontal axis measures the stocking by height class.
Basic stand parameters of stocking, basal area and mean top height are included in the report heading together with the maximum DBH and the percentage coefficients of variation of stem basal area, height and height about the height/DBH curve average.
Holding the mouse over points or bars on the report will pop-up the X,Y values of the item. Clicking and dragging from top, left to bottom, right will zoom to the selected rectangle. The reverse gesture will un-zoom.

The tool-bar at the top of the form can be used to change the style of the report and print, copy and save.

How to calculate stem weighting

For bounded plots, the weighting of a stem is equal to the number of stems in that plot which are represented by that stem, scaled to the hectare level. It can be calculated by the formula:

$$W = \frac{1}{\text{Plot area x No. plots}}$$

For example, if we have the following DBHs (mm):

Plot 1 area = 0.02 ha - 127, 149, 132, 137, 119, 124

Plot 2 area = 0.01 ha - 141, 98, 135, 144

To calculate the stem weighting for the plots information above:

$$\text{Plot 1 weighting} = \frac{1}{0.02 \times 2} = 25$$

$$\text{Plot 2 weighting} = \frac{1}{0.01 \times 2} = 50$$

Name	Species	DBH_ mm	Height_ m	Weighting_ stems_per_ha	PrunedHeight_ m
1_1	P.RAD	127	7.5	25	3.4
1_2	P.RAD	149		25	4.2
1_3	P.RAD	132	7.8	25	3.5
1_4	P.RAD	137	8.0	25	3.6
1_5	P.RAD	119	7.5	25	3.8
1_6	P.RAD	124		25	3.2
2_1	P.RAD	141	8.2	50	4.4
2_2	P.RAD	98		50	
2_3	P.RAD	135	7.8	50	3.4
2_4	P.RAD	144	8.2	50	4.8

300 Index Calculator

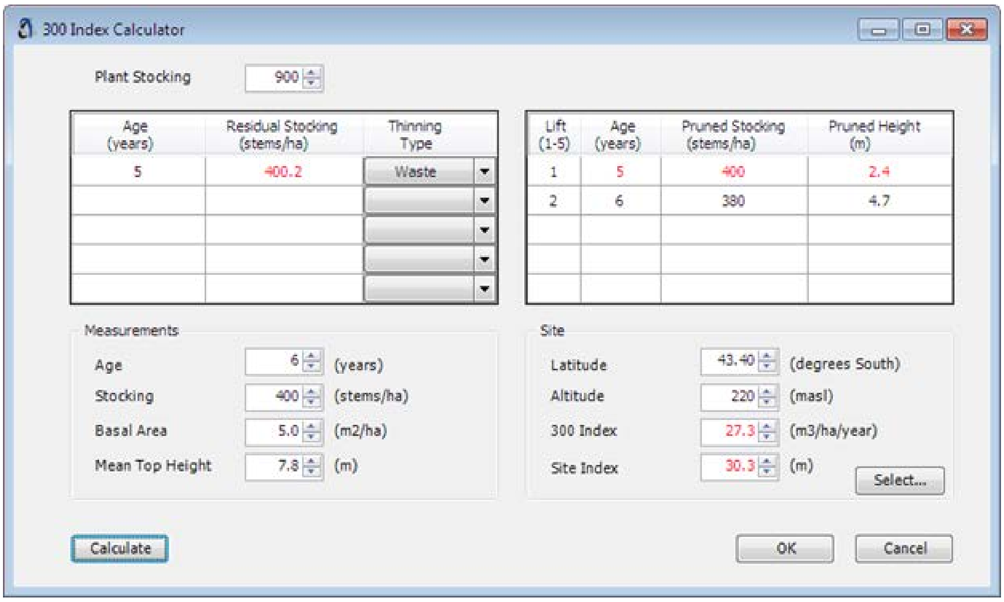
This form implements the algorithms documented in the Future Forests Report No. FFR-R035 (5), and implemented in the Forest Carbon Predictor 3 beta (April 2011), but note that the calculator currently only works for integral ages. This function is only available to members of the FFR Radiata Theme.

The calculator can be used to predict the following:

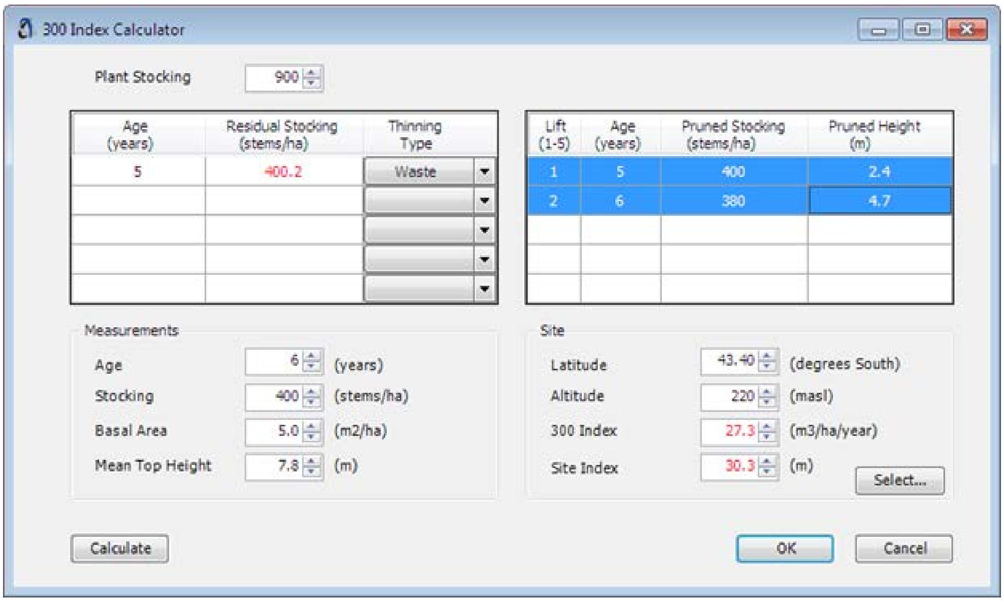
- The residual stocking of a thinning
- Pruning age, pruned stocking and pruned height
- Stocking, basal area and mean top height at a given age
- Plant Stocking
- 300 Index and site index

General Operation

Various fields will be initialised using values entered in the "Whole Stand" tab of the Crop form. Values which have been calculated will be shown in red. The screen shot below shows the result of entering certain values (shown in black), and then clicking the **Calculate** button. If **Calculate** is clicked again, then any calculated values (i.e. those shown in red) will be recalculated.



The Latitude, Altitude, 300 Index and Site Index may be initialised with values from an existing Site by clicking the **Select...** button. Note that the values of Latitude and Altitude will be remembered from the previous calculation. Multiple cells can be selected in either of the pruning or thinning grids using the mouse or arrow keys. For example, hitting the **Delete** key with the pruning fields selected (shown below) will delete all pruning values:

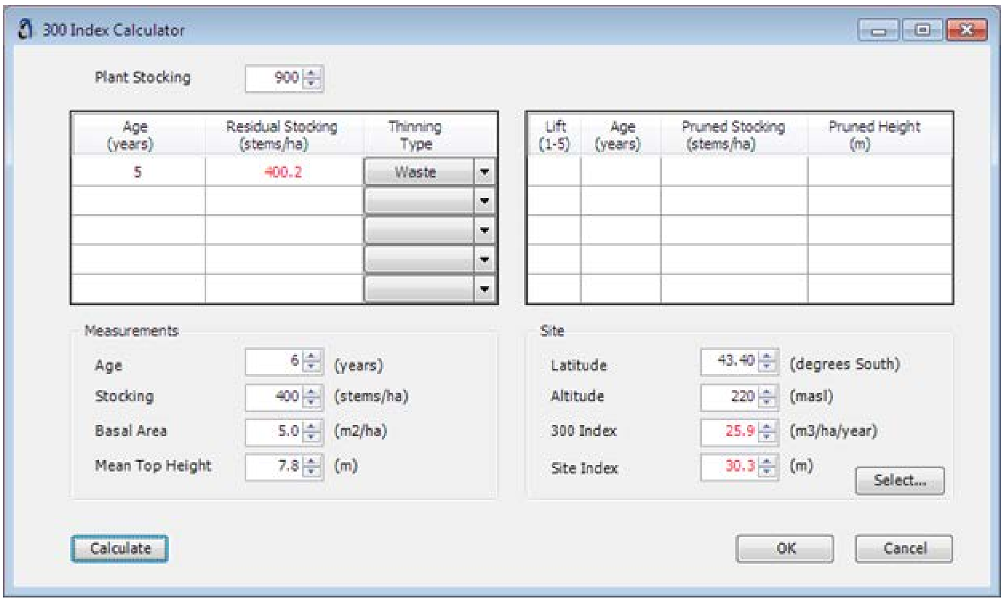


Clicking the **OK** (or **Enter**) will copy the values (both entered and calculated) back into the Crop form. If there are any prunings or thinnings specified then these will be added to the crop history, overwriting any existing historical events present. These events will also need to be entered for any Regime used with this Crop.

Clicking the **Cancel** (or **Esc**) will discard any changes made in this form, and return to the Crop form.

Calculating the Residual Stocking of a Thinning

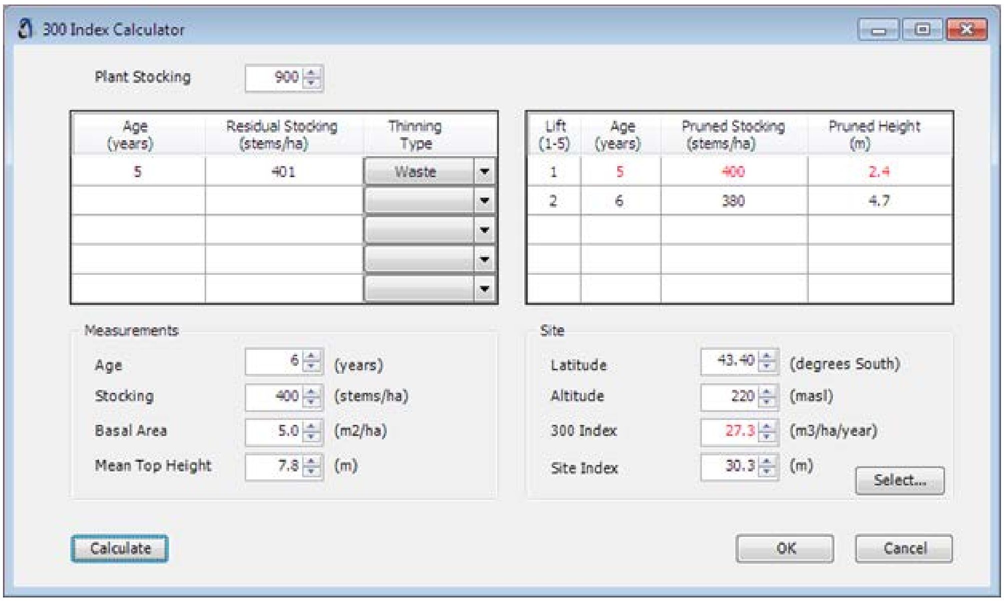
This can be used to calculate the residual stocking of a thinning, given the thinning age, plant stocking, measurement and site information. For example, in the following form the **Calculate** button has been clicked after entering the required information:



This prediction can only be made with one thinning or the final thinning in a series.

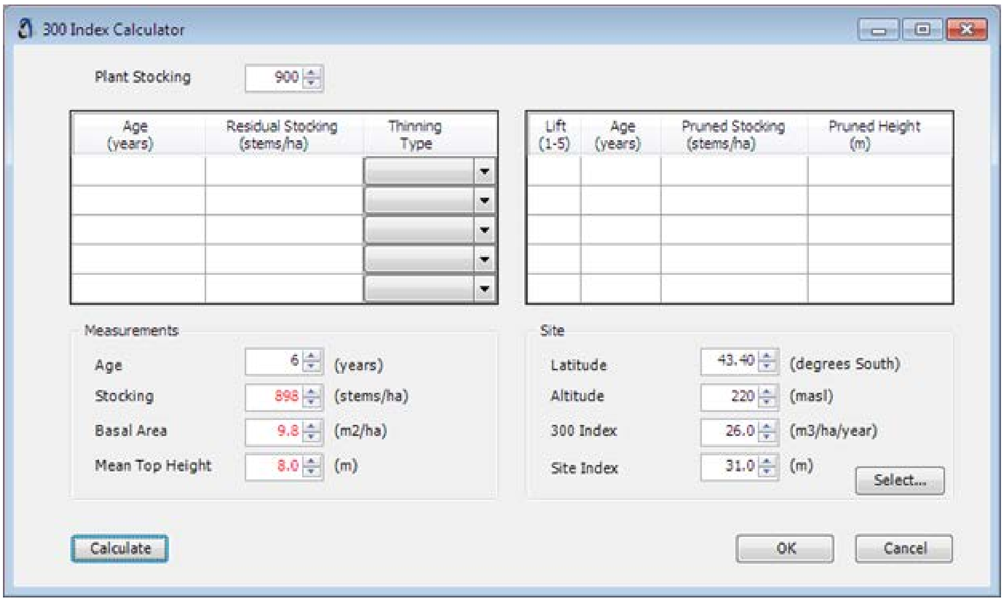
Calculating Pruning age, Pruned Stocking and Pruned Height

The last thin prior to (or at) the measurement age must be specified in order to calculate age stocking and pruned height of prior lifts. Also, measurement and site information must be entered. For example, in the following form the **Calculate** button has been clicked after entering the required information:



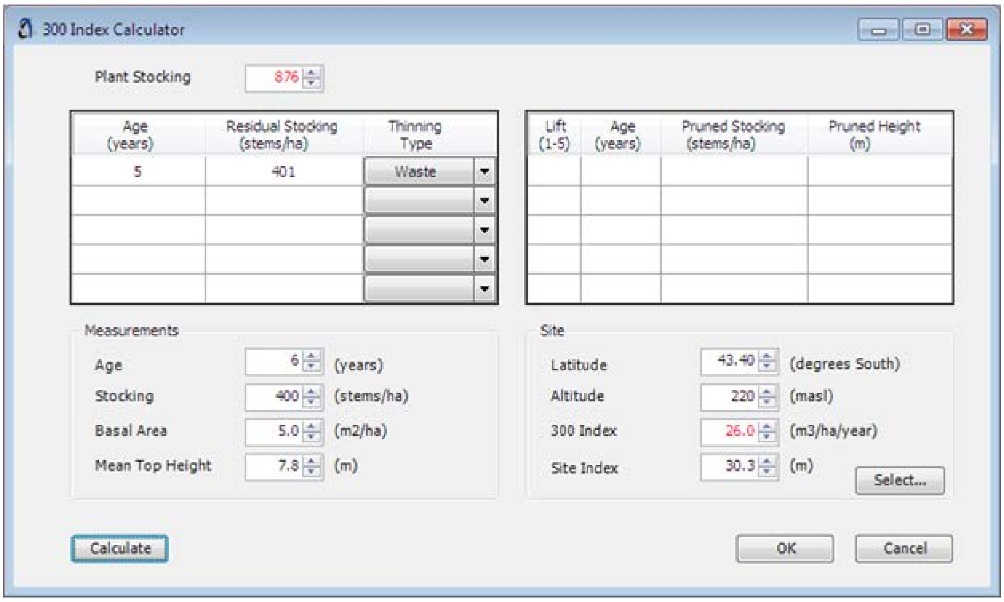
Calculating Stocking, Basal area and Mean Top Height

In order to calculate the stocking and/or basal area and/or mean top height, the plant stocking, measurement age, altitude, latitude and 300 Index and/or Site Index must be entered. 300 Index is required if basal area is to be calculated, while Site Index is required if mean top height is to be calculated. For example, in the following form the **Calculate** button has been clicked after entering the required information:



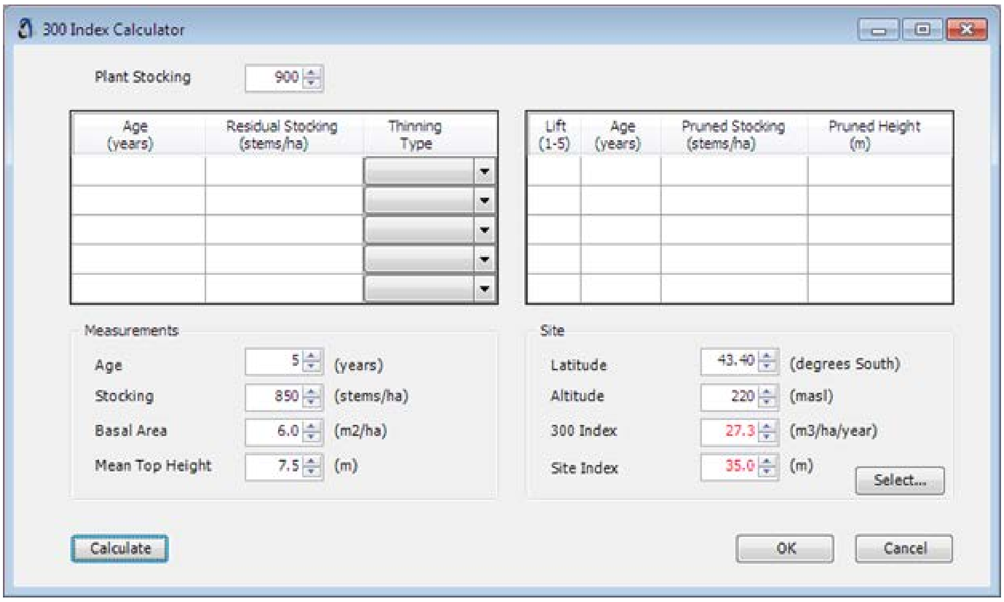
Calculating Plant Stocking

This requires the measurement age and stocking to be specified. For example, in the following form the **Calculate** button has been clicked after entering the required information:



Calculating 300 Index and Site Index

To calculate 300 Index, measurement data (i.e. age, stocking and basal area) must be entered. Similarly, to calculate Site Index, age, stocking and mean top height must be entered. For example, in the following form the Calculate button has been clicked after entering the required information:



Stem Basal Area Coefficient of Variation Calculation

An example of how to calculate the Stem Basal Area Coefficient of Variation (CV) % is shown below:

Stem	Plot Area	Weighting	DBH	DBH²	Stem Basal Area (g)
1_1	0.02	25	127	16,129	0.012668
1_2	0.02	25	149	22,201	0.017437
1_3	0.02	25	132	17,424	0.013685
1_4	0.02	25	137	18,769	0.014741
1_5	0.02	25	119	14,161	0.011122
1_6	0.02	25	124	15,376	0.012076
2_1	0.01	50	141	19,881	0.015615
2_2	0.01	50	98	9,604	0.007543
2_3	0.01	50	135	18,225	0.014314
2_4	0.01	50	144	20,736	0.016286

$$\text{Mean Stem Basal Area (sq.m)} = \Sigma \frac{0.012668 + 0.017437 + 0.013685 + \ldots}{10}$$

$$= 0.013549$$

$$\text{Variance} = \frac{(0.012668^2)^2 + (0.017437^2)^2 + (0.013685^2)^2 + \ldots - \frac{(0.012668^2 + 0.017437^2 + 0.013685^2 + \ldots)^2}{10}}{9}$$

Standard Deviation = 0.002864

$$\text{Stem Basal Area CV\%} = \frac{100 * 0.002864}{0.013549}$$

$$= 21.13611$$

To calculate Quadratic Mean DBH:

$$\text{Quadratic Mean DBH (mm)} = \sqrt{\frac{127^2 + 149^2 + 132^2 + 137^2 + 119^2 + 124^2 + 141^2 + 98^2 + 135^2 + 144^2}{10}}$$

$$= 131.3$$

An alternative calculation of Stem Basal Area CV% is:

$$\text{Variance of DBH}^2 = \frac{(127^2)^2 + (149^2)^2 + (132^2)^2 + \ldots - \frac{(127^2 + 149^2 + 132^2 \ldots)^2}{10}}{9}$$

Standard Deviation of DBH^2 = 3646.106

$$\text{Stem Basal Area CV\%} = \frac{3646.106 * 100}{17250.6}$$

$$= 21.13611$$

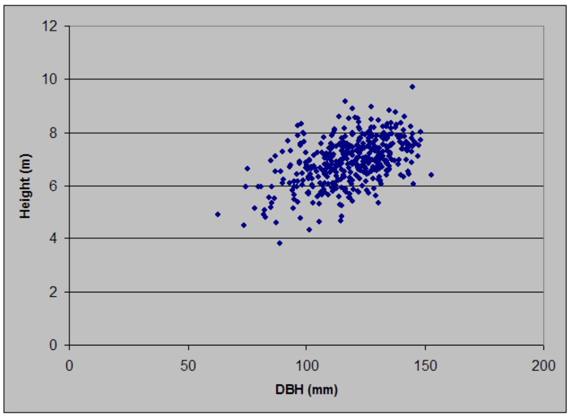
Initial Crop Examples

The subset information required to construct a crop includes the subset stocking, subset mean height and subset mean DBH. In addition, the maximum DBH of the whole stand and the height coefficient of variation of the whole stand must be entered.

The following charts show examples of the distribution of height and DBH of an initial crop derived from subset measurements. 360 stems/ha were selected from 850 stems/ha. This subset had a mean height of 7m, mean DBH of 127mm. The height CV was 10%. The differences in the maximum DBH result in differences in the spread of DBH. All these stands have the same basal area and mean top height.

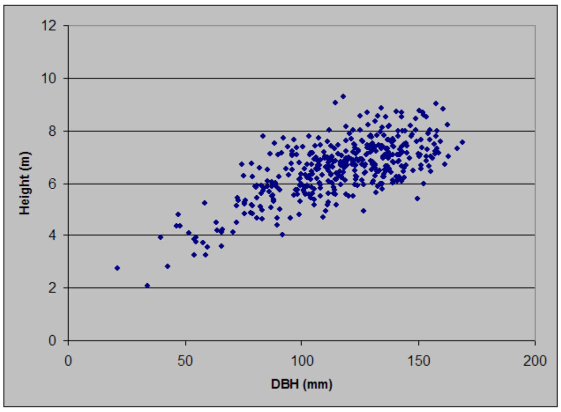
Crop Name	Description
Example 160	Maximum DBH 160mm
Example 180	Maximum DBH 180mm
Example 220	Maximum DBH 220mm

The distribution of stem height (m) and DBH (mm) for an initial crop with a maximum DBH of 160mm:



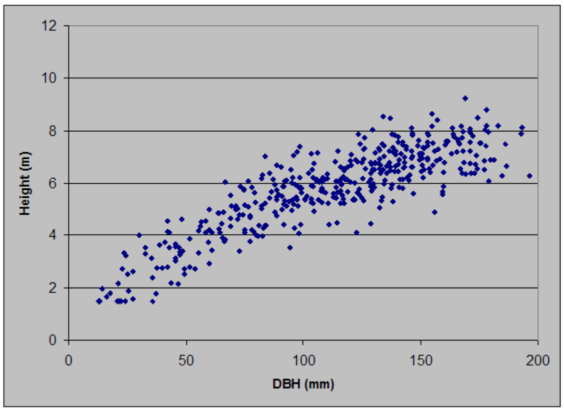
Example DBH 160mm max

The distribution of stem height (m) and DBH (mm) for an initial crop with a maximum DBH of 180mm:



Example DBH 180mm max

The distribution of stem height (m) and DBH (mm) for an initial crop with a maximum DBH of 220mm:

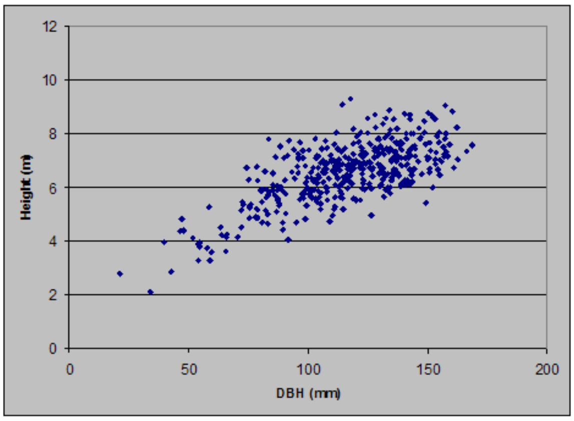


Example DBH 220mm max

For finer control over the variation in DBH the subset information can be converted to whole stand and then the stem basal area CV altered:

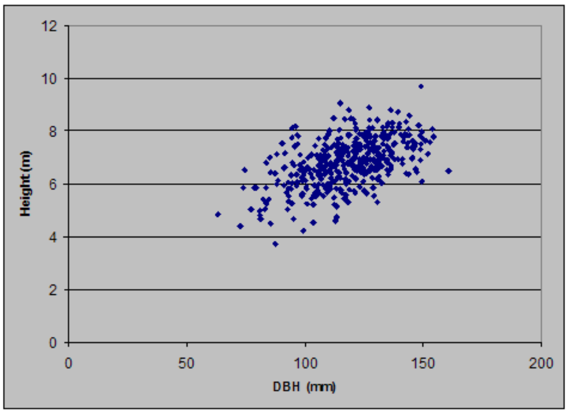
Crop Name	Description
Example BA CV43	Stem basal area CV 43%
Example BA CV30	Stem basal area CV 30%

The distribution of stem height (m) and DBH (mm) for an initial crop with a maximum DBH of 180mm and a stem basal area CV of 43%:



Example BA CV 43%

The distribution of stem height (m) and DBH (mm) for an initial crop with a maximum DBH of 180mm and a stem basal area CV of 30%:

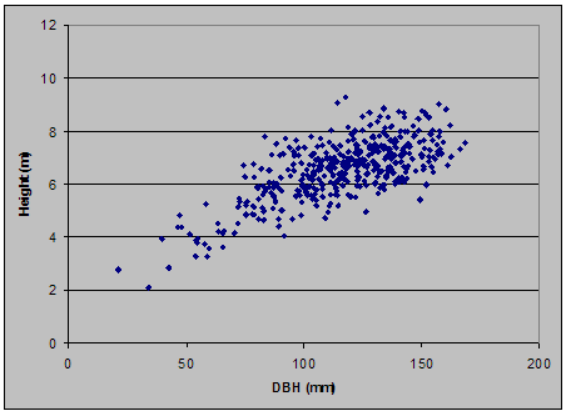


Example BA CV 30%

To control the variation in stem height, alter the stem height CV:

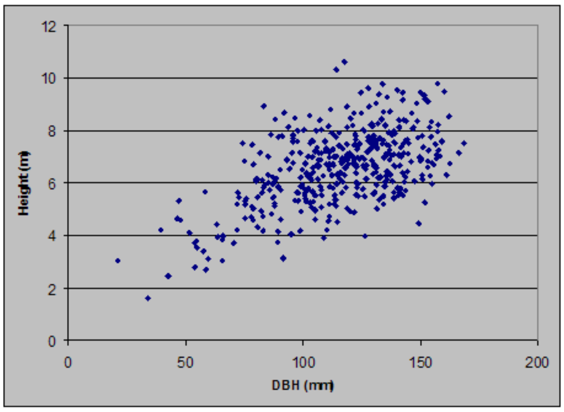
Crop Name	Description
Example Height CV 10	Stem height CV 10%
Example Height CV 15	Stem height CV 15%

The distribution of stem height (m) and DBH (mm) for an initial crop with a maximum DBH of 180mm and a stem height CV of 10%:



Example Height CV 10%

The distribution of stem height (m) and DBH (mm) for an initial crop with a maximum DBH of 180mm and a stem height CV of 15%:



Example Height CV 15%

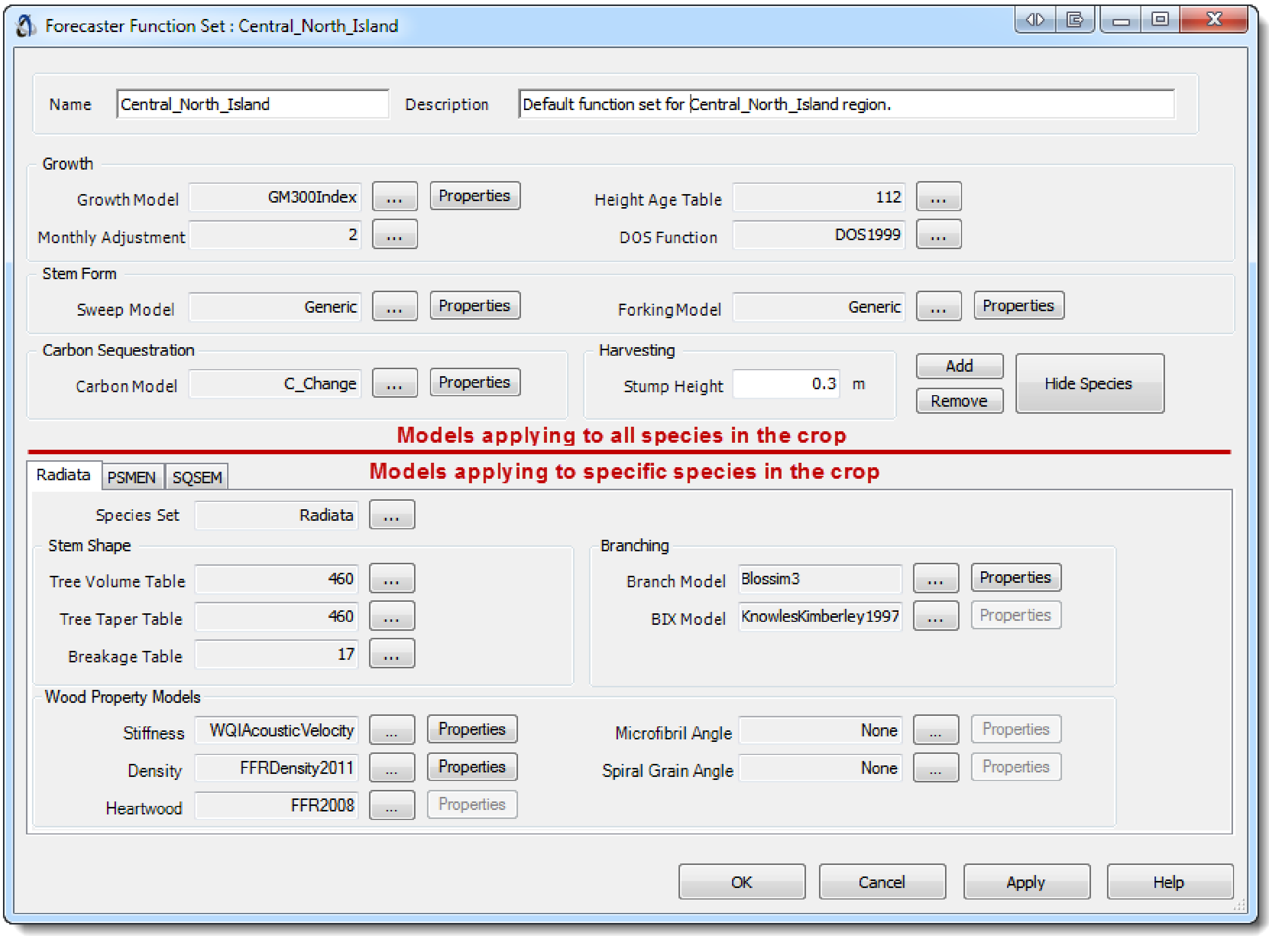
Function Sets

Function Sets

A Function Set defines the models and functions that will be used to simulate the growth of a Crop on a Site. The first set of models (those above the red line in the form below) is specified once within a Function Set, and will apply to *all* species. These models include:

- Growth model
- Monthly Adjustment table
- Height-Age table
- DOS function - three functions are available: the **Standard** function is in the Public Domain, while the **Interim 1994** and **DOS 1999** functions are available only to members of the Radiata Management Theme of Future Forests Research Limited (FFR)
- Sweep model
- Forking model

In addition, a standard stump height must be provided for use in felling simulation. All other models (those below the red line in the form below) are specified separately for each Species Set:

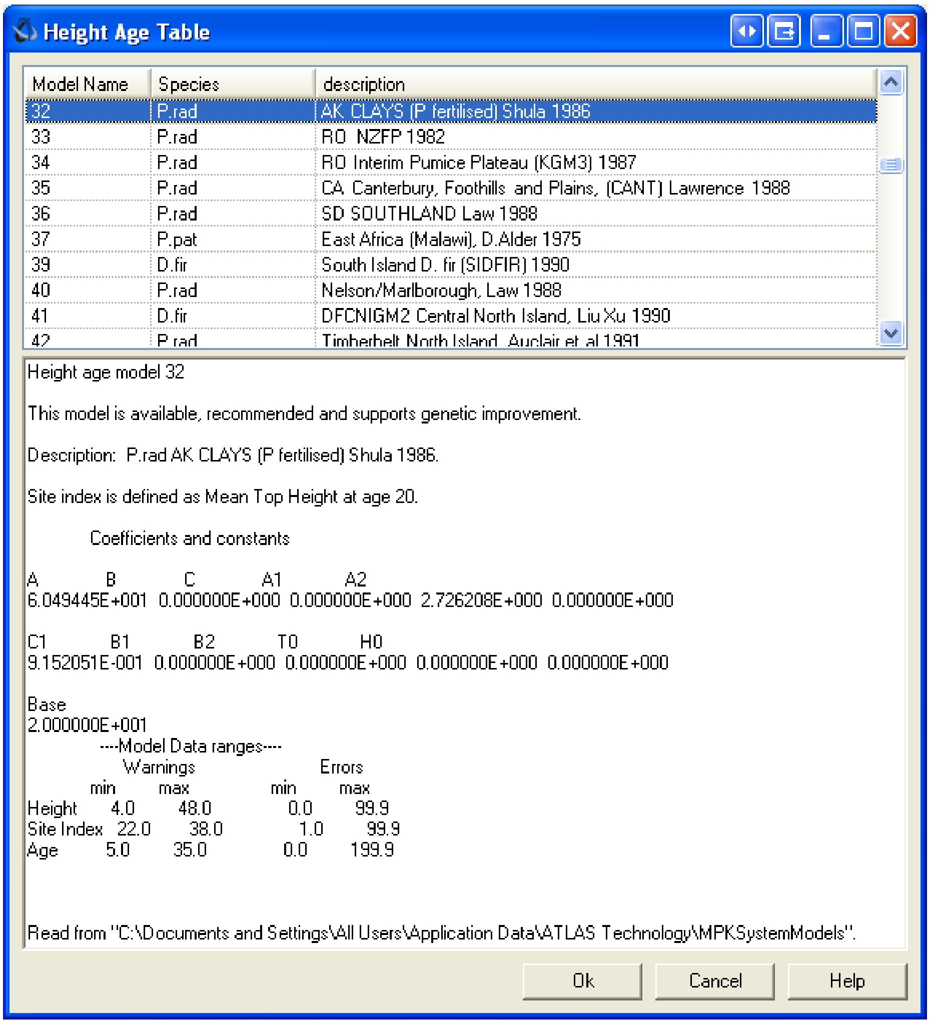


Note: For most projects there is a 1:1 relationship between the crop-based models and the species-based model.

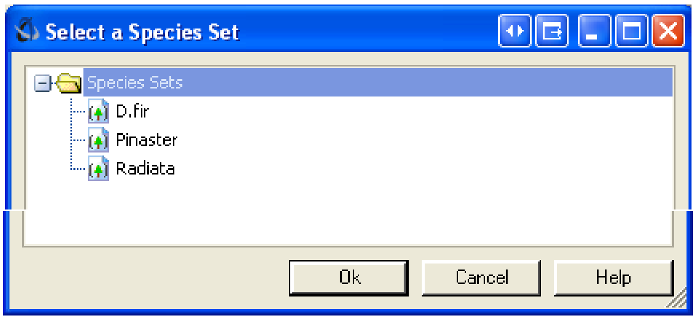
Field/function

The following table describes the fields and buttons in the Function Set form:

Field/Button	Function
Name	A name for the Function Set (the name must be unique within the containing folder).
Description	A description that helps identify the Function Set.
Stump Height	The height above ground level at which the trees will be cut during the felling phase of a simulation.
Properties buttons	Where available, this button brings up a form that allows relevant properties for the associated model to be added, edited or removed. See Using Properties for further information on Properties, and Model Availability for information on the models currently available, and the properties that each requires.
... button	Displays a form for selecting a model or table from a list of all those available for that model/table type. Clicking on a column header allows the items to be sorted on that column. In the form's lower pane, details of the selected model or table are displayed. For example, for the Height Age Table:



Field/Button	Function
Show/Hide Species button	This button toggles between showing and hiding the Function Set elements that correspond to the Species Sets defined for the Function

Field/Button	Function
	Set. Each element is displayed in a separate tab.
Add/Remove buttons	When showing the species-specific elements, these buttons allow the addition and removal of elements for the Function Set.
Species Set	Used to specify the Species Set to be associated with a new Function Set element. Pressing the [...] button displays the Species Set Selection form:  Select the required Species Set, and click Ok

Adding models and functions

In Forecaster, as in STANDPAK and ATLAS Cruiser, many functions can be added directly by users, and will then be available via the Function Set entity.

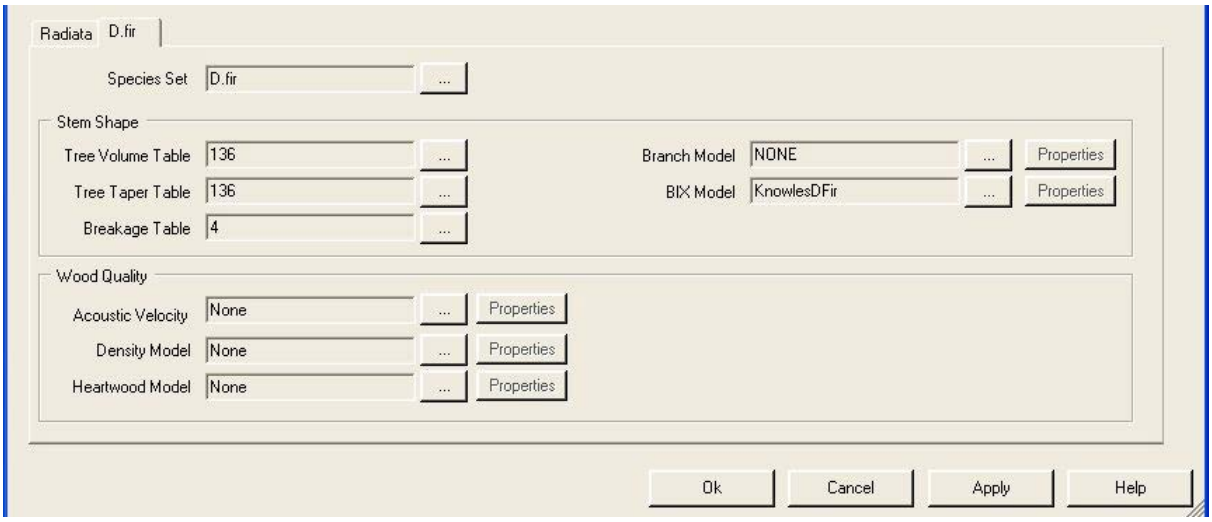
In this section

This section contains the following topics:

Setting Up New Function Sets

Species Sets

The **Add** button allows other models and functions to be specified separately for each Species Set (Species Sets must first be defined by grouping one or more species from the Species List). This allows a Function Set to be defined for a range of species groupings which have some unique models but share a common growth model.



Note: Any Properties required by models will be listed (see Site Properties and Crop Properties), and those set via the Function Set can often be over-ridden by those on the Crop or Site (see Using Properties).

Properties

A Property is an associated name and value, that is used to provide specific, relevant information to the system during a simulation by being attached to one of the entities involved. A property's value can be alphabetic, numeric, or a set of comma-separated numeric values. For example, a Crop may have a property named "GF Rating" with a value of 18. This is represented as: `GF Rating=18`.

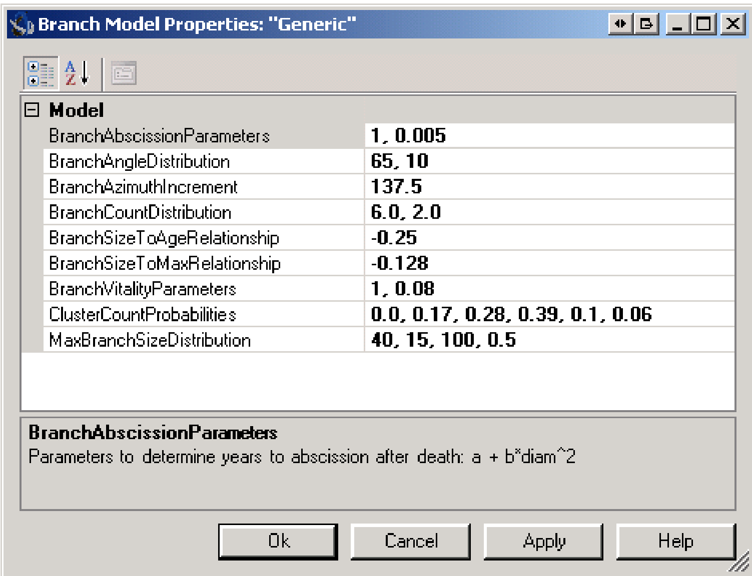
Many models and functions need configurable parameters or values for independent variables that are specific to their particular purposes. Properties are used to provide those values.

During a simulation, the value used for a particular property within a scenario can be sourced from the crop, the site or the function set. When Forecaster constructs a stand (a crop on a site) it looks, in order, first to the crop, and then to the site and finally to the function set in order to find values for the properties required by the specified models. This precedence allows for specific values on the crop to over-ride more generic values on the site, which in turn can over-ride any default values on the function set.

For example, density models often require a value for stand-average breast-height outer-wood density. If this is measured on a crop then that value can be specified via a property on the crop. If the crop hasn't been measured for density but an average for the site (e.g. that forest) is known, then that value can be specified via a property on the site. Failing either of these, the function set can provide a default value.

Model Properties Example

In this example, properties for the Generic Branch Model are being displayed:



Models Available

Forecaster provides a framework within which various models and functions have been implemented. Some of these models are public domain and are therefore available to all Forecaster users, while others are proprietary and available only to individual companies or members of specific research collaboratives. Some of these proprietary models can be made more widely available subject to the payment of a royalty to the model owners.

When you first enter your license details into Forecaster, the models and functions for which you have access rights is determined.

It is also possible for users to add their own models to the system, for more details contact the Help Desk.

This topic contains the following sub-topics.

Sub-topic
Growth Models
Height/Age (Site Index) Models
Monthly Adjustment Tables
Volume and Taper Equations
Breakage Equations
Branch Models
Branch Index (BIX) Models
Sweep Models
Forking Model
Stiffness Models
Density Models
Heartwood Model
Carbon Model
Microfibril Angle Model
Spiral Grain Angle Model
Contacts for Models

Growth Models

Several growth models have been implemented in Forecaster, including:

Model	Description
GM300Index	The 300Index Growth Model(11,46) for radiata pine was initially developed by the New Zealand Farm Forestry Association, with subsequent improvements by the Plantation Management Cooperative and Future Forests Research. It is now available only to members of the Radiata Management Theme of Future Forests Research Limited (FFR). The 300Index is a volume productivity index, and is defined as the mean annual volume increment, in m^3/ha/yr, at an age of 30 years, assuming a final stocking of 300 stems/ha, timely pruning to 6m, and thinning to final crop at completion of pruning. Thinning and pruning effects are modelled using a time-shift approach. The model has been validated and improved a number of times, and found to be unbiased(40,41,44,45).
GM400Index	The 400Index Growth Model(49) for coast redwood was jointly developed by the New Zealand Redwood Company Ltd. and NZ Forestry Ltd. It is now available only to companies who are members of *both* the Radiata Management and the Diversified Species Themes of Future Forests Research Limited (FFR). The 400Index is a volume productivity index, and is defined as the mean annual volume increment, in m^3/ha/yr, at an age of 40 years, thinning to 400 stems/ha at 15 m MTH. Neither thinning nor pruning effects are currently included in the model. The model was developed as an "interim" model (largely based upon the limited dataset from which it was developed), however a validation study concluded that the model's performance was generally reasonable(50).
GM500Index	The 500Index Growth Model(42) for Douglas-fir was initially developed by the New Zealand Farm Forestry Association, with subsequent improvements by the Douglas-fir Research Cooperative. It is now available only to members of the Diversified Species Theme of Future Forests Research Limited (FFR). The 500Index is a volume productivity index, and is defined as the mean annual volume increment, in m^3/ha/yr, at an age of 40 years, thinning to 500 stems/ha at 15 m MTH. Thinning effects are modelled using a time-shift approach. Pruning effects are not included in the model. The model has been validated (and improved) a number of times, and found to be generally unbiased(43).
GM1000Index	The 1000Index Growth Model(47) for Eucalyptus fastigata was developed by the Eucalypt Cooperative. To achieve consistency with other recent models, the growth model was modified by

Model	Description
	Mark Kimberley in 2013 to use (and output) a volume MAI-based productivity index. It is now available only to companies who are members of BOTH the Radiata Management and Diversified Species Themes of Future Forests Research Limited (FFR). The 1000Index is a volume productivity index, and is defined as the mean annual volume increment, in m^3/ha/yr, at an age of 15 years, for an index regime planted at 1250 stems/ha, with no pruning or thinning. Neither thinning nor pruning effects are currently included in the model. The model has not been validated against independent data.
ITGM	The Individual Tree Growth Model developed by the Stand Growth Modelling Cooperative. It is now available only to members of the Radiata Management Theme of FFR.
NZ Regional State-Space Models	Eight models are available, covering most of New Zealand. These models were developed by the Stand Growth Modelling Cooperative. It is now available only to members of the Radiata Management Theme of FFR.
Lusitanica and Macrocarpa	The two growth models[(48)] Lusitanica and Macrocarpa were developed for NZ-grown cypress species by Scion. They are now available only to companies who are members of *both* the Radiata Management and Diversified Species Themes of Future Forests Research Limited (FFR). The models run using a Site (height) Index (there is no volume-based productivity index). Thinning effects are modelled using a time-shift approach. Pruning effects are not included in the model. There are no known validation studies.
NZ1	This is a public domain model for radiata pine growing on low to medium basal area fertility sites.
Proprietary Models	A number of models have been implemented for the use of individual organisations.

Height / Age (Site Index) Models

Height/age models usually use a sigmoid curve for predicting stand height (mean top height or dominant height) as a function of age. These models are often considered as fixed components of growth models but may be specified independently in some cases. If a growth model does require a mandatory height/age model, then specifying a different height/age model can break key assumptions of the growth model and potentially invalidate the growth results.

The curve is usually indexed at a “base” age which in NZ is conventionally set at 20 years for radiata pine and 40 years for Douglas fir. This allows measures of site index to be used to characterise the stand height growth on specific sites.

Site index can be predicted from environmental variables[(13)].

Monthly Adjustment Tables

These tables list the proportion of annual growth that has occurred by the end of each month. Three measures of growth are included:

- mean top height
- basal area
- stem diameter

Scheduling is often based around height growth so this value is used for most applications. The tables are derived from experimental data, and so do not allow for year-to-year variation in growing conditions, or long-term changes in climate.

As an example, the following is the monthly growth adjustment table (Table 2, public domain):

Month	**Height**	**Basal Area**
Jan	0.120	0.109
Feb	0.085	0.096
Mar	0.055	0.065
Apr	0.025	0.034
May	0.015	0.035
Jun	0.030	0.060
Jul	0.030	0.077
Aug	0.050	0.093
Sep	0.100	0.101
Oct	0.150	0.107
Nov	0.180	0.110
Dec	0.160	0.113

Volume and Taper Equations

Volume equations are used to predict the total inside-bark volume of the stem from measures of breast-height over-bark diameter and stem height. Taper equations predict volumes of stem sections and inside-bark diameter at any level from ground-level to the stem height. "Compatible" equations are constructed so that the sum of the volume of any complete sequence of stem sections is equal to the volume predicted by the volume equation.

A library of these equations (models) are available for selecting from when constructing a function set. Equations are usually specific to a single species or species group, and are often applicable to one region or locality over a particular range of stem size and age. Other factors that influence stem shape include silviculture, genetics and environmental effects such as exposure.

A number of equations are available for radiata pine. Equation 237 has been commonly used to represent stems of average form within New Zealand(35). Equation 460 uses additional stand information and prune height to predict the shape of each stem, which makes it appropriate for comparing silvicultural regimes where the final crop stocking differs(36).

Safe Calculation of Stem volume

Every tree volume and taper equation used within the Forecaster system contains information about the data from which it was derived. This can be viewed by looking at the details of the equation in the equation selector from the function set form. For example, the volume equation 237 reports the following:

Range of data:

min DBH	max DBH	min Height	max Height	mean Volume
28.0	69.0	32.0	49.0	2.5

where DBHs are in centimetres, heights are in metres, and the volume is in cubic metres.

If the volume is calculated for any stem outside the data range, a warning message is produced but the calculation proceeds. As a typical regime may run from an early age, and the stem list will represent all stems from suppressed to dominant, volume equations will routinely be applied to small stems outside their data range. Some types of equations may fail to calculate volumes for small stems and simply return zero.

To make the system more robust, the volume calculations now support a "safe" mode. In this mode, all calculations on small stems are performed on a stem within the range of the equations data (minimum stem), and the results are scaled down to apply to the target stem. This mode is used by default. The scale factor is the ratio of the DBH2Height of the target stem to the minimum stem.

To illustrate the differences, two sets of regimes were run. The first set used volume and taper equation 237.

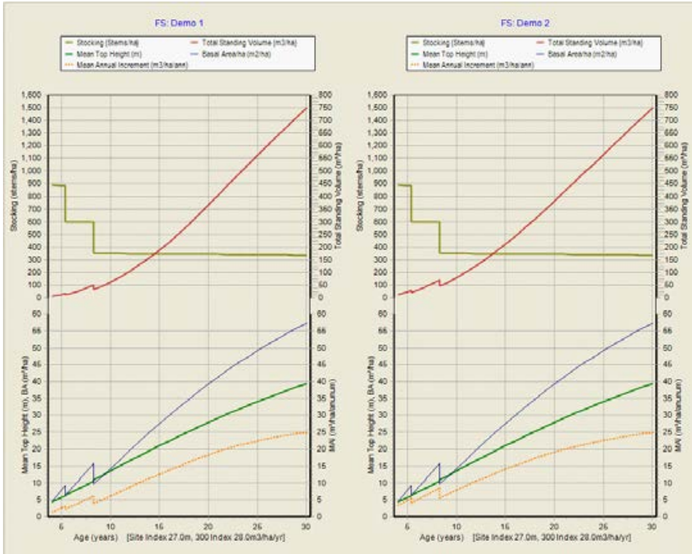


Figure 1 Crop Development. Demo 1 = "safe"; Demo 2 = extrapolated

The crop development is shown in Figure 1. No change is seen in mortality or the development of basal area or mean top height. However the total standing volume starts more slowly when the stem volumes are calculated safely (FS: Demo 1). This is visible in both the volume and MAI curves before age 15. When the two volume curves are overlaid (Figure 2) it is clear how they converge at around age 25, at which age all stems in the stem list are larger than the volume equation’s minimum values.

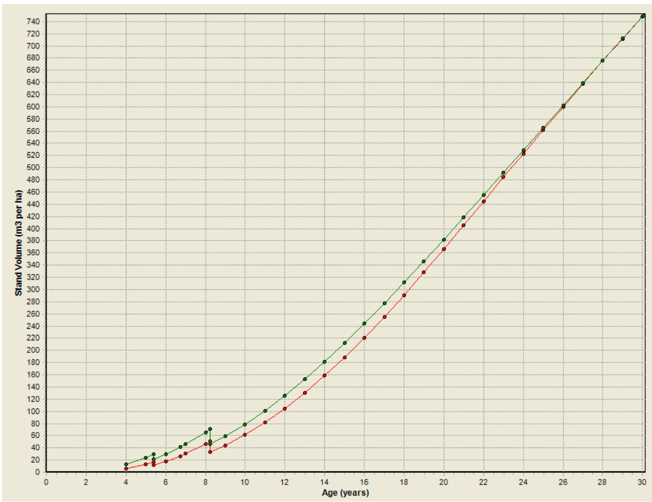


Figure 2 Total Standing Volume - T237. Red=Safe; Green=Extrapolated

Although T237 is often used as a volume equation for radiata of average form[35], it is characterised by a narrow range of base data. When a volume equation with a broader basis is used, the differences between the “safe” mode and extrapolations are much smaller.

Equation 460 has the following range:
Range of data:

min DBH	max DBH	min Height	max Height	mean Volume
16.0	77.0	12.0	50.0	2.3

This equation produces the following total standing volume curves (Figure 3) when used in the same regime in both “safe” and extrapolated mode. No differences are visible after age 9.

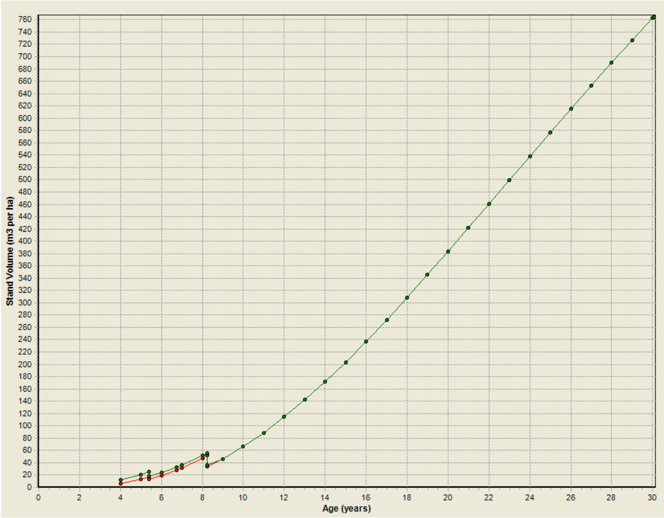


Figure 3 Total Standing volume - T460. Red=Safe; Green=Extrapolated

Breakage Equations

Breakage equations are used to predict:

- the probability that a stem will break when felled
- the average height at which a stem will break, and
- the distribution of break heights about the average

These equations are used as part of the simulation of harvesting within Forecaster. Because breakage can vary significantly from stem to stem, stochastic estimates are produced to simulate this variation. This allows Forecaster to give a more realistic estimate of the effect of breakage on the amount of volume recovered and the log mix.

Most breakage equations only predict the first break point, while some predict multiple break points and sections of shatter on the felled stem.

Branch Models

Two branch models are available:

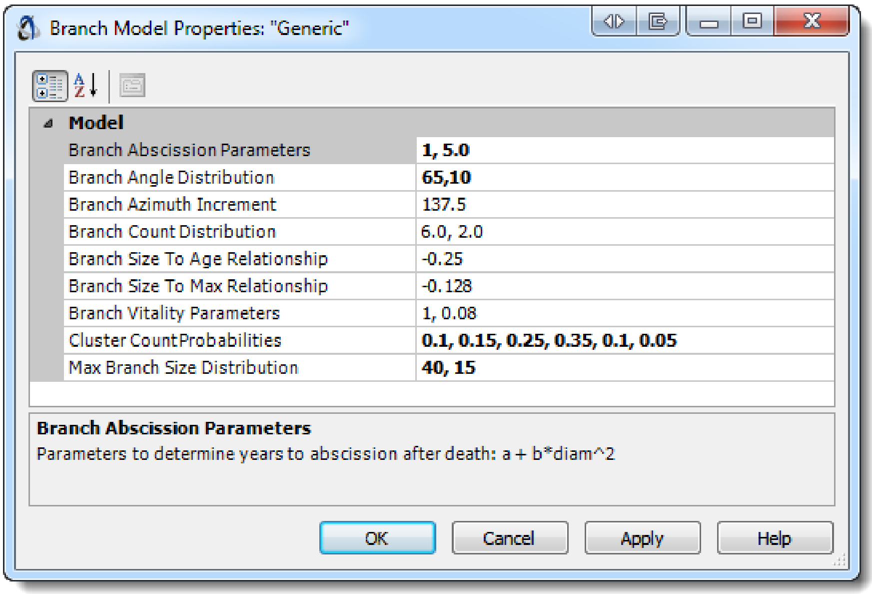
1. the public domain Generic Branch Model, and
2. BLOSSIM, which is available only to members of the Radiata Management Theme of [Future Forests Research Limited (FFR)].

Generic Branch Model

The generic model is available to all users. It is a species-independent model, i.e. although it is based on the branching habit of radiata, it can be parameterised to represent other species. Unlike for BLOSSIM, modelled branches do not respond to the stand's region, therefore users need to set parameters that are appropriate for the situation being simulated.

Generic Branch Model Properties

The generic functions and default parameters are based on results published by Madgwick 1994 [(18)], Grace et al 1999 [(16)], and other published work on Pinus radiata. The lengths of annual shoots are determined using a height/age model.



The following table describes the functions of the fields in the Branch Model Properties form:

Field	Description
Branch Abscisson Parameters	Branch Abscisson The number of years between the time of death and the time when the branch is shed is related to the branch diameter (D in mm) at time of death. Predicted from: $y = a + bD^2$ where y is the number of years from death to abscission. Defaults are a=1 and b=0.005.
Branch Angle Distribution	Branch Angle This is the angle between the stem and the upper side of the branch and is predicted stochastically from a normal distribution bounded at 1 and 179. By default the mean angle is N(65degrees, 10degrees) from Madgwick 1994 (18). This assumes that branch angle is constant over time, whereas some published results suggest the angle may increase with age.
Branch Azimuth Increment	Branch azimuth Increment An azimuth is randomly assigned to the largest branch in a cluster from U(0,<360). Smaller branches are directed at a fixed increment in order from the azimuth of the largest branch. Default increment is 137.5 degrees, from Grace et al 1999 (16).
Branch Count Distribution	Number of Branches Distribution This value is used to determine the number of branches modeled in each cluster. Default values from Madgwick 1994 (18): • Average Number of Branches per Cluster : 6.0 • Standard Deviation: 2.0 The distribution is predicted stochastically from a normal distribution bounded at 1.
Branchsize To Age Relationship	Branch Diameter Growth to the Maximum Predicted from $D = D_{max} (1 - e^{kage})$ Branch sizes are mm and age is years. Default is k = -0.25 after Madgwick 1994 (18).
Branchsize To Max Relationship	Size of Smaller Branches in a Cluster Predicted from $D_n = D_{largest} e^{a(n-1)}$ where n is branch rank such that D1 is the size of the largest branch in mm. Default is a = -0.128 from Madgwick 1994 (18).
Branch Vitality Parameters	Branch Vitality The number of years a branch lives is related to its maximum size (mm). Predicted from: $\text{Years Live} = a + bD_{max}$

<table>
<tr><th>Field</th><th>Description</th></tr>
<tr><td></td><td>Defaults are a=1 and b=0.08 from Madgwick 1994 [18].</td></tr>
<tr><td>Cluster Count Probabilities</td><td><u>Probabilities of Number of Clusters</u>
This parameter determines the probability of the number of branch clusters modeled per shoot. This is derived stochastically from a look-up table of probabilities. The default values set for the Generic models follow those defined by Grace et al 1999 [16] but exclude single-cluster shoots:
<table>
<tr><th>P(1 cluster)</th><th>P(2 cluster)</th><th>P(3 cluster)</th><th>P(4 cluster)</th><th>P(5 cluster)</th><th>P(6 cluster)</th></tr>
<tr><td>0.0</td><td>0.17</td><td>0.28</td><td>0.39</td><td>0.1</td><td>0.06</td></tr>
</table>
The table shows that there is a 0.1 or 10% chance that a given shoot will only have one cluster, a 0.15 or 15% chance it will have 2 clusters, a 0.25 or 25% chance it will have three and so on. There are only six probabilities displayed but more can be created for the probability of seven, eight……X clusters, as long as all the probabilities add to one. The Clusters are equi-spaced within the annual shoot with the last cluster at the top of the shoot.</td></tr>
<tr><td>Max Branch Size Distribution</td><td><u>Maximum Size of Largest Branch in a Cluster</u>
Predicted stochastically from a normal distribution bounded at 0 with a scale factor for dominance and spacing (as shown by Grace et al 1999 [16]). Default is N(40mm, 15mm) xF from Madgwick 1994 [18]. F is:

$$F = \frac{a}{\sqrt{N\bar{h}_{100}}}\left(\frac{dbh}{dbh}\right)^{b}$$

Where N is stems per hectare

h_{100} is mean top height (m)
dbh (numerator) is breast-height diameter over-bark in mm
dbh (denominator) is stand mean breast-height diameter over-bark in mm
a is 100, b is 0.5
</td></tr>
</table>

BLOSSIM - Branch Location, Orientation and Size SIMulator

The BLOSSIM branch model for radiata pine predicts the location and vitality of every branch whorl, and the size and angle of every branch in each whorl [16]. It can also grow the branches forward through time.

BLOSSIM versions

With Forecaster v1.10, an updated BLOSSIM model (version 4) was included. BLOSSIM v4 allows users to input the GFPlus branch habit score or branch breeding value. These are measures of branch cluster frequency, and enable the model to vary the number of branch clusters on the stem (for example, is the seedlot “long-internode” or “multinodal”?). Changes in branch cluster frequency may indirectly affect other branching characteristics. For example, it is generally perceived that long-internode seedlots have larger and steeper branches, and lose their tops more easily than a more multinodal seedlot. Because branch cluster frequency (along with branch diameter and branch angle) influences internode length, the current changes to BLOSSIM will allow the user to better examine the trade-offs between growth and clear-cutting potential.

With Forecaster v1.13, BLOSSIM was updated to v4.1, which introduces two new model properties in order to more realistically model the presence of large branches. They are:

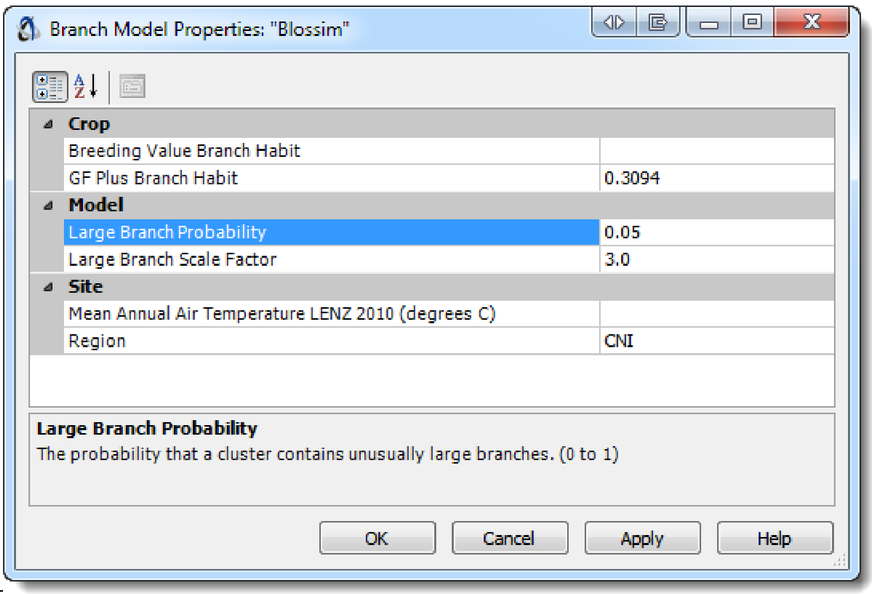
1. Large Branch Probability. A value between zero and one that indicates the likelihood that a cluster will include large branches, and
2. Large Branch Scale Factor. A value greater than or equal to one – this is a multiplier used to scale-up the size of the branches on a cluster which has been selected to contain large branches.

Default values for these properties are 0.05 and 3.0 respectively, these values should result in most stems containing several large-branched clusters. Use the values 0.0 and 1.0 to revert to the behaviour of v4.0.

Note: BLOSSIM v4 model outputs should be treated as “preliminary”, as further amendments to BLOSSIM are required to capture other changes in branch development that occur with changes in branch cluster frequency. For this reason, BLOSSIM v4 has been made available alongside the previous version (v3.2), i.e. *both* appear in the FunctionSet form's list of available branch models (where suitably licensed). The latest version is the model named "**Blossim**", and the previous version is the model named "**Blossim3**". Thus, existing FunctionSets will use the new model.

BLOSSIM Model Properties

Whereas BLOSSIM v3 had only one property (the branch modelling region), BLOSSIM v4.1 requires values to be set for several new properties. These can be set via the Properties form for BLOSSIM in the FunctionSet maintenance form (as shown below), though some may be more appropriately set on either a Crop or a Site (see under Properties).



Note that it is not necessary to set a value for *both* of the Branching Habit properties – if there is a value set for the **Breeding Value Branch Habit** (at any level, i.e. on the Crop, Site or FunctionSet) it will be used in preference by BLOSSIM, but failing that, a value is expected for **GF Plus Branch Habit** (again, at any level), and from it a value for **Breeding Value Branch Habit** will be derived. The **GF Plus Branch Habit** has a default value of 0.3094.

Branch Index (BIX) Models

Branch Index Definition

The diameter of the largest branch in each quadrant of a log is measured. The average diameter of these four branches is the Branch Index (source: Maclaren, J.P. Radiata Pine Grower's Manual (FRI Bulletin no. 184). New Zealand Forest Research Institute 1993). Branch Index is commonly abbreviated to BIX.

Summary of BIX Models

The popup accessed from the function set display lists the following four options which include three BIX models derived from STANDPAK implementations:

- None
- Inglis/Cleland 1981 - applicable to Radiata pine, and available to all users;
- Knowles/Kimberley 1997 - applicable to Radiata pine, and available only to members of the Radiata Management Theme of Future Forests Research Limited (FFR);
- Knowles Douglas fir - applicable to Douglas fir, and available only to members of the Diversified Species Theme of FFR.

All three models use the same kind of mechanism to predict BIX at the log level but with slightly different function forms and coefficients. The BIX models work with 5.5 metre height classes. First, an average BIX value for each height class is created for the entire crop. At the time of felling, each individual stem piece is then calibrated by the average crop BIX values (for each height class). When the stem piece is being assessed by the bucker, the average BIX for a candidate log is calculated from the height class BIX values.
Note: The BIX is modelled only at time of clearfell, it is not modelled through the crop's lifetime.

How BIX is Predicted at the Crop Level

For each 5.5 metre height class, the crop's average BIX is calculated from:

- Crop stocking
- Thinning ages
- Mean Top Height at each thinning
- Residual stocking at each thinning
- Mean DBH at age 20
- Mean SED by 5.5 metre height class

How BIX is Related from Crop Level to Stem Level

When a stem is felled and made into a stem piece, branch indices are calculated at the mid-point of each 5.5 metre height class along the stem piece. To do this, an SED adjustment factor is applied to the crop BIX previously calculated using the SED of the stem's height class. The function used for this adjustment has the form:

BIXi = (c0 + c1(SEDi/CSEDi)) CBIXi where:

BIXi	Branch index (BIX) for this stem piece at height class i
SEDi	Small end diameter (SED) of the stem piece for height class i
CSEDi	mean SED of the crop for height class i
CBIXi	BIX for log height class i for this crop
c0,c1	Coefficients which differ between the three models

Where the end of the height class extends beyond the top of the stem piece, the SED ratio term is dropped since leaving this in tends to over-predict BIX. The BIX calculated here is at the stem piece level.
When a log is cut from this stem piece, a volume-weighted average BIX value is calculated for the log based on the BIX values of the height classes it spans (and the proportion of its volume made up by each of those height classes).

Constraining Log Product Definitions on BIX Model Output

Where a log product definition is constrained using maximum branch size as calculated by a BIX model, then the BIX of a candidate log is converted to maximum branch size by using a function of the form:

MAXBR = (BIX + d0)/d1

When bucking a stem piece into a log and the log specification indicates that it is using BIX branch modelling and has a maximum branch size constraint set, the maximum branch derived from the BIX for the candidate log and checked against this constraint. The maximum branch function above is used when the specification is checked.

BIX Models

1. Inglis/Cleland (1981)

The Inglis Cleland model is available to all users.

BIX is calculated for the standard log height classes in each diameter class as follows :

BIXi = b1 + b2/IS + b3D + b4/H + b5/SI + b6D/SI + b7A/FS where:

BIXi	BIX for standard log height class
IS	Initial stocking (sph)
D	DBH at age 20 (cm)
H	Predominant mean height (PMH) at last thinning (m)
SI	Site index (m)
A	Age of removal (years)
FS	Final stocking (sph)

The coefficients are :

Coefficient	Log height class		
	1	2	3+
b1	-0.3006	-3.8658	-4.6623
b2	2265.3	0.0	0.0
b3	0.0423	0.0	0.0
b4	14.24	25.94	16.77
b5	0.0	0.0582	0.09
b6	0.0	3.5253	3.5369
b7	0.0	0.0	13.31

The following restrictions are placed on the equation:

- For the first log: IS >= 600 sph
- For the third log and above, if FS > 200 sph : A <= 30 years
- For the third log and above, if FS <= 200 sph : A <= 35 years
- If no thinnings: H = 20.0m
- 9.0m < H < 28.0m
- Minimum BIX >= 2.5 cm

SED adjustment uses the following coefficients:

c0 0.3915
c1 0.6085

The Maximum branch size function uses the following coefficients:

d0 1.036
d1 0.6085

2. Knowles/Kimberley (1997)

The Knowles Kimberley model is available to only members of the Radiata Management Theme of FFR.

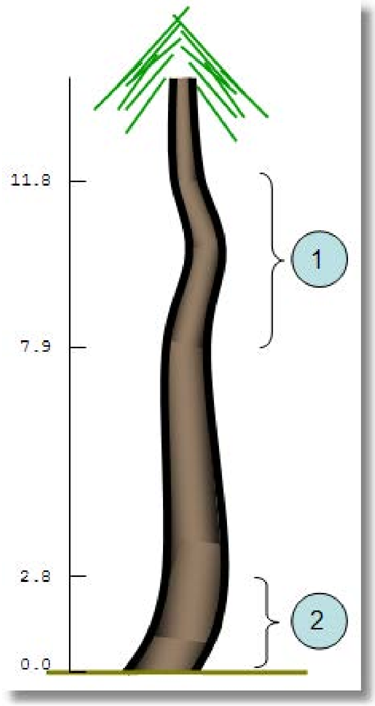
3. Knowles Douglas Fir

The Knowles Douglas Fir model is available only to members of the Diversified Species Theme of FFR.

Sweep Models

A generic sweep model has been implemented and is available to all Forecaster users. Sweep is defined as a lack of straightness for all or part of a tree. It is an important characteristic as many log grades are restricted by the amount of deflection or sweep they are allowed. The term deflection means the amount a tree or log deviates away from a straight axis.

The sweep model works by generating sweep regions (sections of the stem that are not straight) and determining their position, length, shape and severity. For example, the diagram below show two generated regions of sweep. Region 1 is "Normal" sweep, from 7.9 to 11.8m with severity about 0.5 (50%) of end DOB. Region 2 is a Hockey Stick from the ground to 2.8m with severity about 0.6 of end DOB.



Pre-harvest assessment data can be used to estimate the frequencies of the number of swept regions (Region Count Probabilities), the distribution (mean and standard deviation) of the sweep severity as a proportion of end DOB (Region Deviation Distribution), the distribution of region lengths (Region Length Distribution) and the frequency of the different types of sweep shape (Region Type Probabilities).

An impression of the results of a given set of parameters (in a specific function set) can be obtained by using the stem piece viewer on the results of a simulation. The viewer produces a diagram of each stem piece (butt or leader) showing the shape, size, branches and logs. See Stem Piece Details Chart for further information on Stem Piece Viewer.

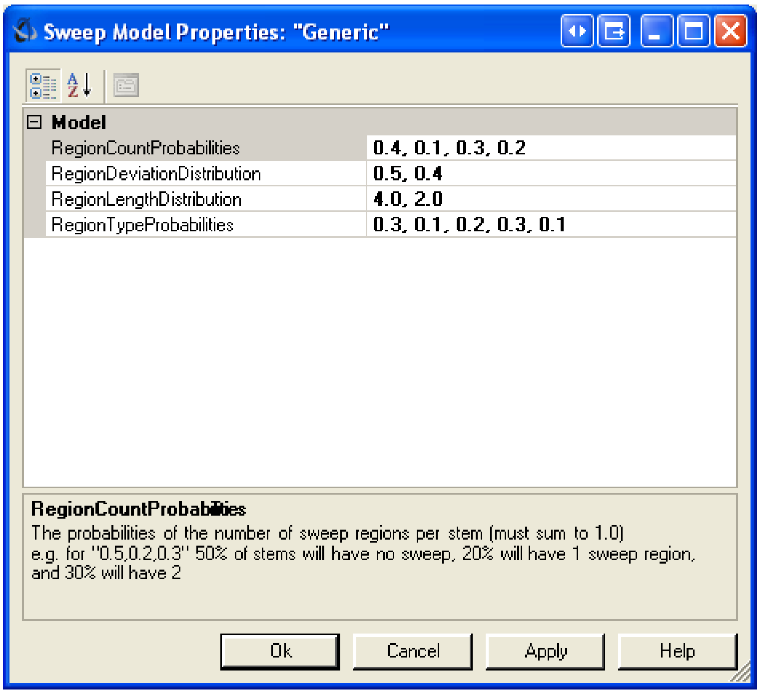
The same five default shape types assessed in an ATLAS Cruiser pre-harvest assessment are modelled in Forecaster:

- Normal Sweep
- Bend
- Hockey Stick
- Leader Replacement
- Wobble

Modelling unswept stands

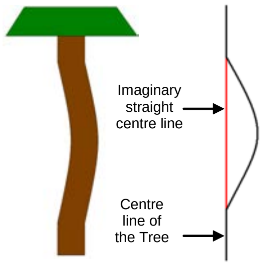
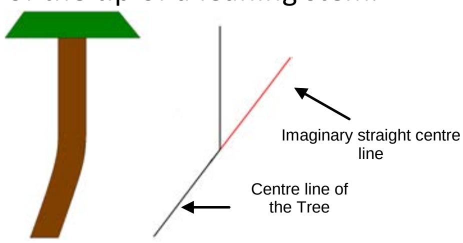
To model all stems without sweep, click on sweep model Properties in the function set, and set the RegionCountProbabilities to 1 so that all stems will have no sweep regions.

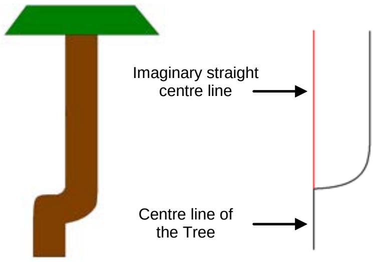
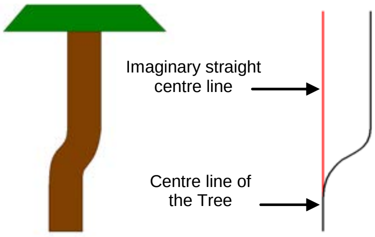
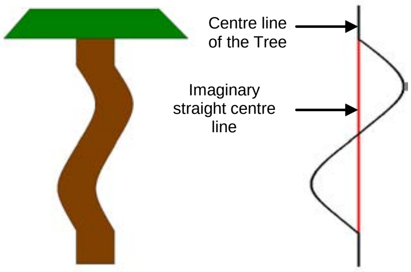
Sweep Model Properties form



Field/Description

The following table describes the functions of the fields and buttons in the Sweep Model Properties form:

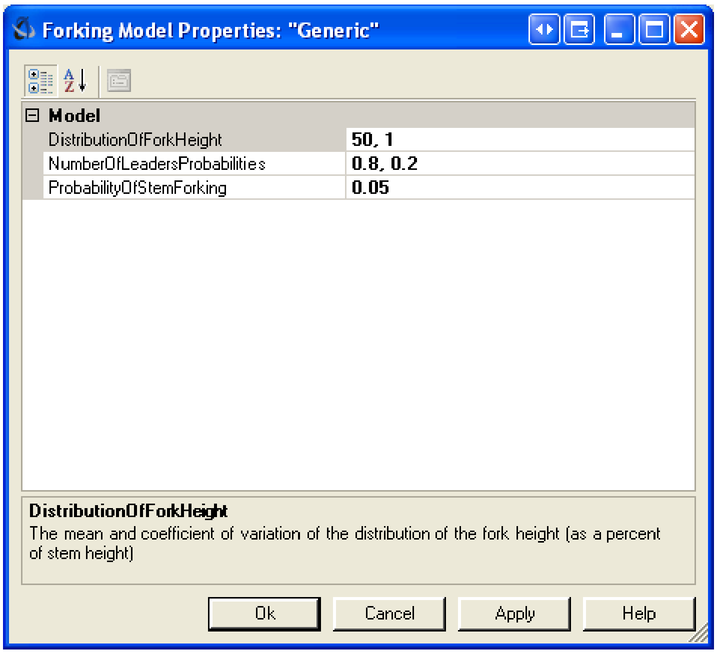
Field	Description
Region Count Probabilities	This is a list of the probabilities of finding zero, one, two, ... swept regions on the stem. The example above indicates 40% of stems will have zero swept regions, ie straight stems, 10% will have 1, 30% will have 2 and 20% will have 3.
Region Deviation Distribution	The mean and standard deviation of the distribution of proportional deviation. The example above shows a mean deviation of 0.5 of the DOB at the end of the swept region. The distribution of these proportional deviations is considered approximately normal.
Region Length Distribution	The mean and standard deviation of the distribution of the length (m) of swept regions. In the example above the standard deviation is 2 metres and mean 4 metres. The distribution of these lengths is considered approximately normal.
Region Type Probabilities	These are the probabilities of the different types of sweep in the following order:
	Normal Sweep - normal sweep deflects away from a straight axis then rejoins the original line of the stem axis. 
	Bend - The bend results in a change in direction of the stem's centre line. A bend often results from the phototropic straightening of the tip of a leaning stem. 

Field	Description
	Hockey Stick - a swept region of this shape can start at ground level or above a straight section. The centre line finishes in parallel to the original stem axis. 
	Leader Replacement - similar to a hockey stick, except it has two curves in its shape rather than one. Typically results from a branch replacing the original leader. 
	Wobble - wobble sweep type starts and finishes on the same axis but deviates in two different directions. 

Forking Models

Forking (multiple leaders) is a stem malformation that occurs quite commonly and can affect stem value. A generic forking model has been implemented in Forecaster that allows a proportion of stems to have 2 or more leaders. It does not permit more than one level of forking, but the point of forking can be anywhere between prune height (or breast height on an unpruned stem) and twice breast height below the stem height.

Forking Model Properties form



Field/Description

The following table describes the functions of the fields in the Forking Model Properties form:

Field	Description
Distribution Of Fork Height	The mean and coefficient of variation (std deviation/mean) of the percentage fork height. This is a percentage of the interval between prune height (or breast height on an unpruned stem) and twice breast height below the stem height. The default parameters (50,1) gives a broad distribution of prune height centred at about half height.
Number Of Leaders Probabilities	The probabilities of 2, 3, 4, ... leaders. By default, 80% of stems that fork have 2 leaders and 20% have 3. There is no limitation to the number of leaders that can occur provided the probabilities sum to 1.
Probability Of Stem Forking	The probability of a stem forking. This is 5% in the default parameters. <u>Modelling unforked stands</u> To model all stems without forking, click on forking model Properties in the function set, and set the probability of stem forking to zero.

Diameter of Leaders (For information only)

The diameters of the leaders are determined by assuming that the diameters of branches in a cluster are related by

$D_n = D_{largest}e^{a(n-1)}$

where n is branch rank such that D1 is the size of the largest branch in mm. The value of a used is -0.128. Given this assumption and the number of leaders, the diameter of the largest can be calculated by requiring the sum of the squared leader diameters to equal the stem diameter at the point of forking. This requirement "conserves" sectional area and is consistent with the pipe model of stem diameter development.

Stiffness Models

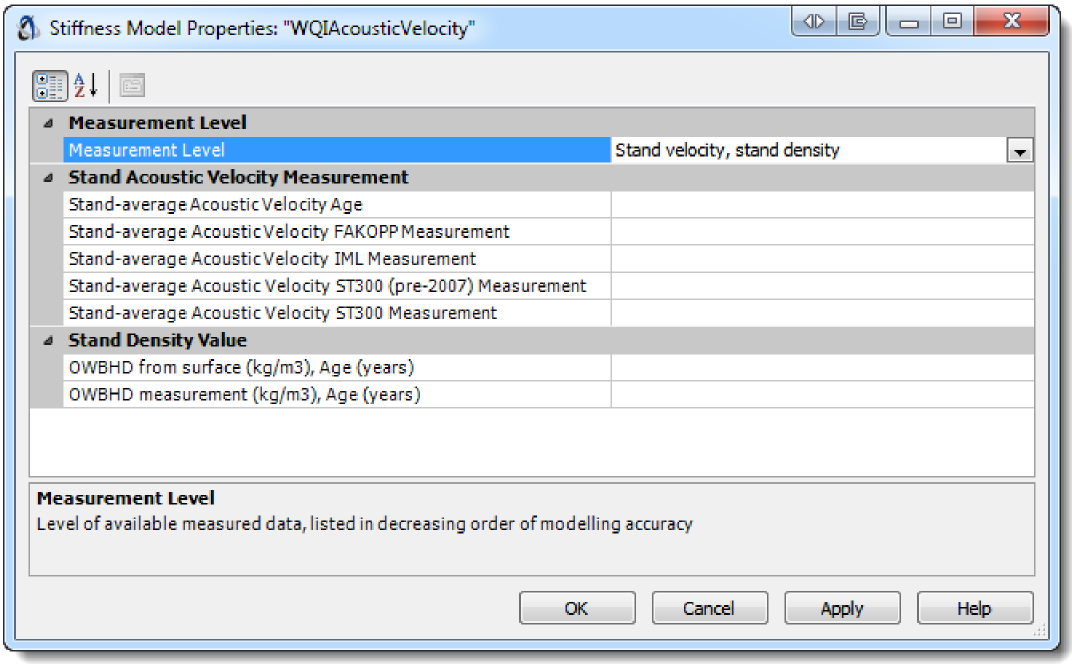
Stiffness Models Implemented

The currently available stiffness models are:

- **WQIAcousticVelocity**, which predicts stiffness in values of acoustic velocity [22]
- **FFRMOE**, which predicts stiffness in values of modulus of elasticity (MOE) [23]
- **None**, used when no modelling of stiffness is required.

Requirements

The WQIAcousticVelocity model uses stand-average measurements of density and/or standing tree velocity. The velocity measurements can be made with any one of a ST300, an IML or a FAKOPP instrument. For the ST300, the distinction between those models calibrated prior to 2007 and later models is made by specifying them as different instruments. Default, model-level values for stand-average measurements, along with their age of measurement, can be entered as properties to the acoustic velocity model via the functionSet maintenance form. Crop-specific values can be entered as crop properties via the crop maintenance form, and they will override any default model settings. If density values are required but no *measured* value is supplied, the model will use a density *index* value from the density index surface, appropriate for the selected site.



Model Properties for the WQIAcousticVelocity Stiffness Model

Property	Description
Measurement Level	The model predicts acoustic velocity using one of several equations, determined by the level and type of measured data available. The levels of measurement data that are currently supported (listed here in decreasing order of modelling accuracy) are: 1. **Stand velocity, stand density** - where there are values for both stand-average velocity and stand-average density. 2. **Stand velocity, no density** - where there is a value for stand-average velocity only. 3. **No velocity, stand density** - where there is a value for stand-average density only. One of these options must be selected from the dropdown picklist, and the relevant measurements should be specified in the following properties.
Stand-average Acoustic Velocity Age	Average age at which the stand-average velocity measurements were taken. If this value is specified, then an actual measurement should be specified for just one of the following four instrument types.
Stand-average Acoustic Velocity FAKOPP Measurement	Data measured using a FAKOPP instrument.
Stand-average Acoustic Velocity IML Measurement	Data measured using a IML instrument.
Stand-average Acoustic Velocity ST300 (pre-2007) Measurement	Data measured using a ST300 (pre-2007) instrument.
Stand-average Acoustic Velocity ST300 Measurement	Data measured using a ST300 instrument.
Outerwood Breast-Height Density	A measured value (starting point) of stand-average outerwood breast height basic density (kg/m^3)
Outerwood Breast-Height Density Age	The age at which the stand-average outerwood breast height density measurement was taken

The **FFRMOE** model requires no external properties to be specified, but from the specified crop and site it uses:

- Mean Minimum Autumnal Air Temperature, derived from the installed temperature surface using the site's location.
- Stand-level historic values of annual mean stem slenderness and annual mean stem ht.
- Stem-level historic values of annual DBH and annual ht.

Between-stem Variation

The **FFRMOE** model includes inter-stem variation based on the difference between the stem's slenderness and the stand's mean slenderness, and the **WQIAcousticVelocity** model also uses stem-level data (stem "fatness").

Outputs

When a Stiffness model is selected, where the model is within its valid range, the following values will be output in result tables:

Result Table	Values
LogTrace (values for each log)	Acoustic Velocity (**WQIAcousticVelocity** only) MOE (**FFRMOE** only)
LogSummary (values for each Log Product)	Mean Acoustic Velocity (**WQIAcousticVelocity** only) Mean MOE (**FFRMOE** only)
LogYield (values for each Log Product)	Acoustic Velocity – min, mean, max and standard deviation (**WQIAcousticVelocity** only) MOE – min, mean, max and standard deviation (**FFRMOE** only)

Mean log Acoustic Velocity can be used as a constraint within a log product definition (see Log Product Definitions), but should only be used when the **WQIAcousticVelocity** model is selected.

If StemPiece Details is selected in the Standard Charts tab of Report Options, the details of the predicted Acoustic Velocity values can be displayed in the StemPiece Viewer.

Microfibril Angle (MFA) Model

General

Microfibril angle is the angle of cellulose microfibrils in the S2 layer of softwood tracheids. It is important for the performance of solid timber because of its strong influence on stiffness, strength, shrinkage properties and dimensional stability.

MFA Models Implemented

The currently available microfibril angle models are:

- **FFRMFA**, The FFR microfibril angle model for radiata pine[37,39]. It predicts a value of microfibril angle at a point specified by its height up the stem (as a proportion of the stem's total height), and radially outwards from the pith (by ring number). This model is available only to members of the Radiata Management Theme of FFR.
- **None**, used when no modelling of microfibril angle is required.

Data Requirements

No other data is needed as input to the model, thus there are no Properties defined for the model.

Between-stem Variation

The **FFRMFA** model does not explicitly model any inter-stem variation, but does so implicitly, through the variation in the stems' DBH and height.

Outputs

When the **FFRMFA** model is selected, from the predicted point values, the following values are calculated for each log:

- a mean value of MFA (°)
- the percent of the log's volume for which the value of MFA is < 15°.

and the following values will be output in result tables:

Result Table	Value(s)
LogTrace (value for each log)	Mean microfibril angle Percent of volume that does not exceed the 15° threshold
LogSummary (value for each Log Product)	Mean of all logs' mean microfibril angle Mean of all logs' percent of volume not exceeding the 15° threshold
LogYield (values for each Log Product)	Min, mean, max and standard deviation of all logs' mean microfibril angle Min, mean, max and standard deviation of all logs' percent of volume not exceeding the 15° threshold

Spiral Grain Angle (SGA) Models

General

Spiral Grain Angle is the orientation of fibres (tracheids) with reference to the longitudinal axis of the tree stem. It is a very influential factor on end-product performance because low spiral grain is a leading cause of twisting in solid wood.

SGA Models Implemented

The currently available spiral grain angle models are:

- **FFRSGA**, The FFR spiral grain angle model for radiata pine[37,39]. It predicts a value of spiral grain angle at a point specified by its height up the stem (as a proportion of the stem's total height), and radially outwards from the pith (by ring number). This model is available only to members of the Radiata Management Theme of FFR.
- **None**, used when no modelling of spiral grain angle is required.

Data Requirements

No other data is needed as input to the model, thus there are no Properties defined for the model.

Between-stem Variation

The **FFRSGA** model does not explicitly model any inter-stem variation, but does so implicitly, through the variation in the stems' DBH and height.

Outputs

When the **FFRSGA** model is selected, from the predicted point values the following values are calculated for each log:

- a mean value of SGA (degrees)
- the percent of the log's volume for which the value of SGA is > 4°.

and the following values will be output in result tables:

Result Table	Value(s)
LogTrace (value for each log)	Mean spiral grain angle Percent of volume that exceeds the 4° threshold
LogSummary (value for each Log Product)	Mean of all logs' mean spiral grain angle Mean of all logs' percent of volume exceeding the 4° threshold
LogYield (values for each Log Product)	Min, mean, max and standard deviation of all logs' mean spiral grain angle Min, mean, max and standard deviation of all logs' percent of volume exceeding the 4° threshold

Density Models

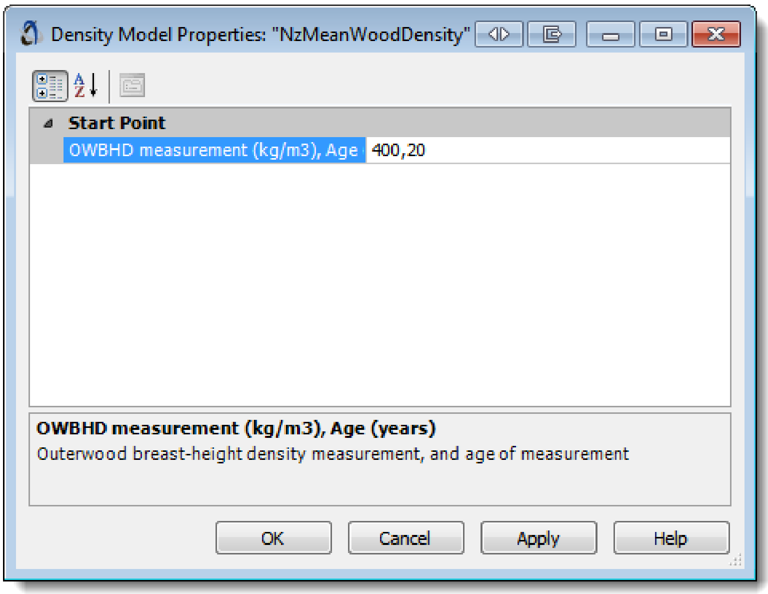
Density Models Implemented

The currently available wood density models are:

Model	Description
NzMeanWoodDensity	The New Zealand mean density model for radiata pine.
WQIBasicDensity1	The updated (2007) WQI density model for radiata pine [24]. This model is available only to members of the SWI.
KimberleyDFir2002	The New Zealand density model for douglas fir. This model is available only to members of the Diversified Species Theme of FFR.
FFRDensity2011	The FFR density model for radiata pine[31]. This model is available only to members of the Radiata Management Theme of FFR.
None	Selected if no density modelling is required.

Requirements

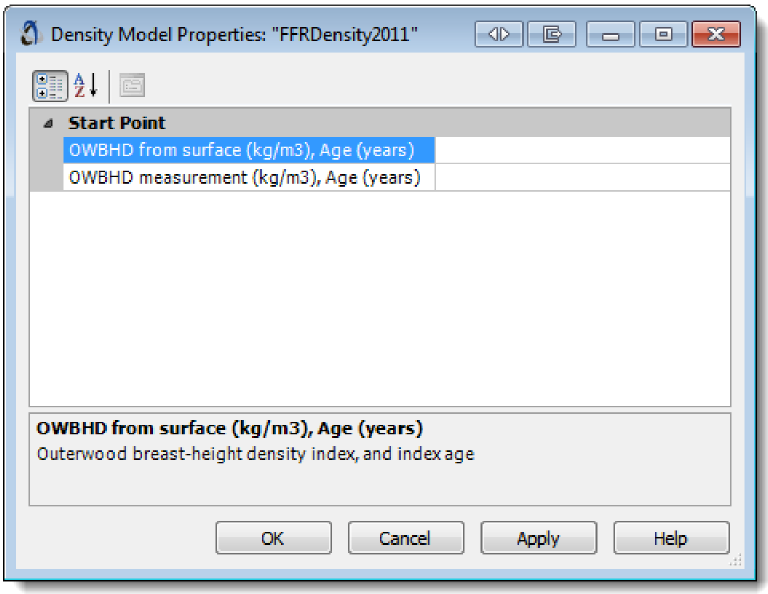
All density models model use a stand-average measurement of density, and the age at which the measurement was taken. These values are held in a single property which can be set on the selected model via the FunctionSet (see below), or on any Crop or Site. During an analysis, the models will use any crop-level values in preference to site-level values, and if neither are present then the model-level values will be used.



Property Name	Description
"OWBHD measurement (kg/m3), Age (years)"	A measured value of stand-average outerwood breast height basic density (kg/m^3), and the age at which the measurement was taken.

Note that in Forecaster v1.11, this property's name has been changed slightly to distinguish it from a density index value. All existing instances of the property (on existing Crops, Sites and FunctionSets, and those imported from CSV files) will have their names updated automatically.

The **FFRDensity2011** model can be used with either actual stand-average density measurements (as described above), or with a density index value looked up from the density index surface using the Site's location (see below, and under Spatial Site Selection). The density index value is automatically set as a property on all Sites, and should not be manually altered or deleted. This model uses measured values preferentially (whether set as properties on Crop, Site or FunctionSet), but if none are available then the Site's density index value is used. No default values are specified on the model via the FunctionSet.



Property Name	Description
"OWBHD from surface (kg/m3), Age (years)"	A density index value looked up from the density index surface, and the index age (always 20).

The **WQIBasicDensity1** model also uses the Site's altitude and NZMG northing.

Between-stem variation

The **WQIBasicDensity1** model incorporates variance among trees such that, for example, for a predicted stand-average disk basic density of 400 kg/m3, 95% of trees will have a basic density value of between 358.8 and 445.9 kg/m3, regardless of position on the tree, and before allowing for variation due to DBH.

The **FFRDensity2011** model also models inter-tree variation: "the wood density of trees within a stand is normally distributed with a coefficient of variation of 6.46%, and is not related to tree diameter."(31).

Outputs

When a Density model is selected, the following values will be output in result tables:

Result Table	Values
LogTrace (values for each log)	Mean Density
LogSummary (values for each Log Product)	Weight (oven-dried) per ha
LogYield (values for each Log Product)	Weight (oven-dried) per ha – min, mean, max and standard deviation

Minimum mean log density (a minimum threshold for the mean density value of a log) can be used as a constraint within a log product definition (see Understanding Log Product Definitions), but note that no such constraints should be used when the **None** model is selected.

If **StemPiece Details** is selected in the **Standard Charts** tab of Report Options, the details of the predicted density values can be displayed in the StemPiece Viewer.

Heartwood Models

Heartwood Models Implemented

The currently-available Heartwood models are:

- **FFR2008** *(9)*.
- **FFRWQI2009** *(10)*.
- **None**, chosen when no Heartwood model is required.

Neither model requires any external properties to be specified by the user, they use a stem's age and its site's location (NZMG Easting and Northing) to predict a heartwood value.

Between-stem variation

Neither model uses stem-specific data, but the **FFRWQI2009** model includes inter-stem variation using a randomized component.

Outputs

When a Heartwood model is selected, where the model is within its valid range, the following values will be output in result tables:

Result Table	Values
LogTrace (values for each log)	Heartwood volume Heartwood % volume Small-end Heartwood diameter Large-end Heartwood diameter Maximum Heartwood diameter
LogSummary (value for each Log Product)	Maximum Heartwood diameter – mean
LogYield (values for each Log Product)	Maximum Heartwood diameter – min, mean, max and standard deviation

Maximum heartwood diameter can be used as a constraint within a log product definition (see Understanding Log Product Definitions), but note that no such constraints should be used when the None model is selected.

If **StemPiece Details** is selected in the **Standard Charts** tab of Report Options, the details of the predicted Heartwood values can be displayed in the StemPiece Viewer.

Limitations

The **FFR2008** model distinguishes a stem's location simply as being in either the North Island or the South Island. For North Island sites, the model will only predict a value for stems with 19 ≤ age ≤ 37, and for levels below 25m. For South Island sites, the model will only predict a value for stems with 24 ≤ age ≤ 45, and for levels below 20m.

The **FFRWQI2009** model will only predict values for stems of age ≥ 10.

Carbon Model

Introduction

Carbon sequestration in plantations can be predicted over a particular period of time from stand measurements and models. One approach is to estimate allocation of biomass across various pools using the C-change model [(26)]. This model has been implemented into Forecaster from the Excel VBA version [(28)]. To run the C-change model within Forecaster, the model must be selected in the Carbon Models field of the FunctionSet.

As wood density is a key input when calculating carbon yield, C_change requires density to be modelled. While log density may be modelled using one of several log density models, density for carbon is most appropriately modelled using a sheath-based approach. Consequently, the mandatory density model to be used in conjunction with C_change is the PRADSheathDensity model[(30, 31)], which is selected automatically on selection of C_change (this model is used for all species other than Douglas fir, for which the Douglas fir sheath density model is automatically selected). This also ensures that the carbon predictions are consistent with the approach taken by the NZ Government for the Emissions Trading Scheme (ETS). A separate log density model may also be specified in the FunctionSet to model log density (see Density Models).

C-change works by estimating biomass in several pools:

- Above ground live
- Below ground live
- Dead woody litter
- Fine litter
- Shrub understorey

As part of the Forecaster simulation, a yield table of annual under-bark stem volumes is produced by a growth model (for example, GM300Index, PPM88, etc.) under the specified silvicultural regime.

The biomass estimates are made as a function of the total under-bark standing volume together with details of pruning and thinning. Stocking predictions are also required in order to calculate the volume lost to mortality. The predictions of wood density from a density model are used to derive the amount of carbon sequestered from the biomass estimates.

C-change predicts carbon sequestration across both the current rotation and the next rotation. The second rotation is assumed to be identical to the first in terms of the silviculture and volume yields, but starts with the carbon residue from the first rotation on the site.

C-change Parameters

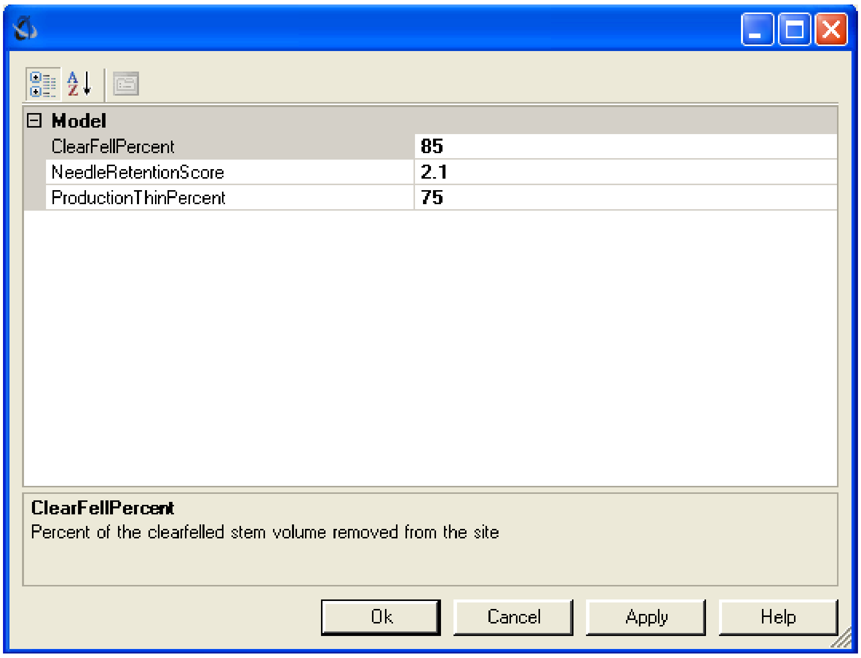
Three parameters can be specified for the C-change carbon model:

- ClearFellPercent. This is the percentage of the clearfelled stem volume that is removed from the site. By default this value is set to 85%. To adjust this to fit your own circumstances, an appropriate value could be derived from a representative sample, for example a pre-harvest inventory from a comparable area, simulated through a clearfell harvest event. Total Recoverable Volume divided by Total Standing Volume should provide a close estimate of this variable.

- NeedleRetentionScore. This is the mean number of years that needles are retained. By default this value is set to 2.1, which was estimated as an acceptable average by Kimberley & Beets (2008) (28). Note that this variable has a relatively minor effect on the total carbon – altering the variable allocates carbon differently between the foliage (in the above ground live biomass pool) and the fine litter pool (where it subsequently decays). To adjust this to fit your own circumstances, individual trees in a representative area could be scored for needle retention, and scores averaged for the stand – this is done by counting the number of more-or-less complete needle age classes retained in the lower third of the potential green crown (25) (i.e. if there are 2 years' worth of needles, then the score would be 2). Trees affected by Dothistroma (or other diseases affecting needle retention) have a lower needle retention score – perhaps down to around 0.5 for significant infection. Trees grown in drier regions tend to have a higher needle retention score (up to 3).

- ProductionThinPercent. This is the percentage of the thinned stem volume that is removed from the site during a production thinning. By default this value is set to 75%. To adjust this to fit your own circumstances, follow the same procedure as for Clear Fell percentage above (but where the simulated harvest event is a production thin).

The parameters are stored as properties of the model. To view or edit them, click on the **Properties** button next to the Carbon Model selection field in the FunctionSet form:



Modelling Carbon Sequestration for Other Species

The core components of carbon modelling are:

1. volume and density models, which define the amount of biomass produced throughout the rotation
2. allocation and decay functions, which control how that biomass is allocated throughout different parts of the tree and litter pools
3. the rate of decay of dead matter [(26)]

While the biomass allocation and decay functions within C_change are specific to radiata pine only, adjustment functions for Douglas-fir are implemented in order to account for the differences in allocation and decay of this species [need reference to latest Douglas-fir work here – currently unpublished MPI report]. These adjustments are applied to (and have been validated for use with) the DFNat500Index growth model and the Douglas-fir sheath density model.

When C_change is used for species other than Pinus radiata or Douglas-fir, then the model applies no adjustments, i.e. radiata pine biomass allocation and decay functions are assumed.

Reports

When Forecaster has completed a simulation, the results are available in two forms:

1. Charts. Within the Report Manager select **Graphs | Variable by Age | Rotation 1 Carbon** (or **Rotation 2 Carbon**) to view the time series of carbon sequestered either in each of the different pools or in total.

2. Data. Within the Report Manager select **Export | AnnualCropCondition Table** to export the data in tabular form. The following 12 columns contain the carbon information:

    R1TotalCarbon_t_per_ha
    R1AboveGroundLiveCarbon_t_per_ha
    R1BelowGroundLiveCarbon_t_per_ha
    R1DeadWoodyLitterCarbon_t_per_ha
    R1FineLitterCarbon_t_per_ha
    R1ShrubUnderstoreyCarbon_t_per_ha
    R2TotalCarbon_t_per_ha
    R2AboveGroundLiveCarbon_t_per_ha
    R2BelowGroundLiveCarbon_t_per_ha
    R2DeadWoodyLitterCarbon_t_per_ha
    R2FineLitterCarbon_t_per_ha
    R2ShrubUnderstoreyCarbon_t_per_ha

Note that R1 and R2 designate rotation 1 and rotation 2.

Contacts for Models

Scion www.scionresearch.com

Scion's mission is to improve the international competitiveness of the New Zealand forest industry and build a stronger bio-economy. We contribute to the sustainable economic development of New Zealand by focusing on four strategic goals:

Increase the profitability of New Zealand's forest industries
Ensuring that return on investment from the New Zealand forest industries increases in line with sector plans. Helping expand the sector in new, higher-value markets and taking advantage of the economic benefits offered by Environmental Services.

Optimise the value of marginal land
Helping inform land owners and policy makers through our science and decision-support tools about land-use options to extract multiple benefits from marginal land.

Accelerate the growth of the bioeconomy
Focusing on market-led opportunities which provide competitive advantage for lignocellulosic and biopolymer-based products, and ensuring appropriate support for bioeconomy strategies and frameworks through our active engagement with policy makers and key stakeholders.

Maximise the quality and impact of Scion's science
Fostering a culture of innovation by investing in high-performing individuals and teams, and providing a research environment that encourages collaboration. We actively engage with our local, national and international community through energising partnerships and active communication of our science.

With approximately 340 staff, Scion is headquartered in Rotorua, with satellite offices in Christchurch, Wellington and Auckland.

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ATLAS Technology www.atlastech.co.nz

ATLAS Technology is a software development business unit of Scion with a team of business analysts, software engineers, software testers, support and client service managers. ATLAS Technology has the vision and the capability to develop software tools spanning the entire forestry value chain.

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Future Forests Research Limited www.ffr.co.nz

Future Forests Research is an industry-controlled company established collaboratively by the forestry sector and Scion to improve the engagement between industry and research. Its objective is to raise the profitability and sustainability of the forestry sector by delivering research outcomes that are relevant to industry, are world class, and deliver value to FFR investors. FFR was established in 2007 and initially consolidated the activities of the former research cooperatives (Douglas fir, Eucalypt, Stand Growth Modelling, Site Management and Plantation Forest Management). At the same time environmental and harvesting research programmes were formed to put a renewed focus on these aspects of forestry sector research. FFR has a board of directors comprising industry and science representatives and is managed by a Chief Executive and a Business Support Manager. Scion, as the forestry sector's CRI, is the primary research provider to FFR.
Our research programmes are organised under four themes:

- Radiata Management
- Environment & Social
- Diversified Species and
- Harvesting & Logistics

Each of our themes is led by a Theme Leader and a Technical Steering Team comprising a good balance of industry and science skills. The role of the Technical Steering Team is to provide input, from a science and industry perspective, into the direction of the programme, ensure the programme is relevant and aligned with industry needs and to assist with the deployment and uptake of the research outcomes by the sector. A real success with this approach has been shaping the direction of research programmes, focusing on the outputs required by industry and increasing the amount of buy-in by industry members to the programme.

Solid Wood Innovation (SWI) www.wqi.co.nz

Solid Wood Innovation (SWI) is a research consortium that builds upon the initial research conducted by WQI. Shareholders cash injections are matched by NZ Government funding via the Foundation for Research, Science and Technology. The focus of SWI is to create value for it's shareholders (around 26 companies) in the area of solid wood processing. The value proposition for shareholders is in three areas:

- Increased manufacture of appearance related wood products targeted at export markets
- More efficient manufacturing through yield optimisation systems
- Greater energy efficiency and reduced water useage in wood drying

Our History

SWI commenced operation 1 May 2009. It was formed from the realignment of WQI Ltd, the first consortium established in NZ in Feb 2003 and which focused on the development of tools and technologies for segregating standing trees, stems,
logs and lumber based on wood quality features. WQI invested around $12 million NZD over 6 years and was considered a success by its investors/stakeholders and sustained a focus on radiata wood quality R&D in Australia and New Zealand. Having achieved much of what it set out to do, stakeholders in WQI supported a substantial shift in focus for the company and, with the introduction of new shareholders from the wood processing sector, SWI was formed.

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Regimes

Regimes are used to specify the timing and sequence of silvicultural events that are applied to a Crop. Regimes comprise a series of Commands, where each Command has two parts:

- A Condition - this defines when to carry out an event. A condition may consist of multiple conditions, all of which must be met simultaneously for the condition to be met (and the associated Events to be carried out).
- One or more Events - these define which stems will be treated, and what will be done to them

Several Clearfell events may be included in a regime, each of which can have more than one cutting strategy associated with it. In this way, the regime can represent many scenarios (see Understanding Projects), as in reality the crop can only be clearfelled at one age using one Cutting Strategy.

	Condition(s)	Event(s)
Command 1	MeanDOS > 180mm	1. Prune 450 stems/ha to 3m 2. Thin to 500 stems/ha
Command 2	1. MTH < 20m 2. BA > 25m^2/ha	Production Thin to 400 stems/ha using Cutting Strategy 'PT2010'

Note 1: Before Clearfell or Production Thinning Events can be defined in a Regime, a Cutting Strategy and associated Log Product Definitions must first be defined (see Cutting Strategies and Creating Log Product Definitions).

Note 2: In STANDPAK, Regime triggers were converted to fixed dates in the Treatments form. This is not the case in Forecaster, which allows Regimes to be shared. For example, if a Regime where pruning is triggered by MeanDOS is shared across stands which differ in productivity, the resultant pruning age for each pruning event will be unique to each stand.

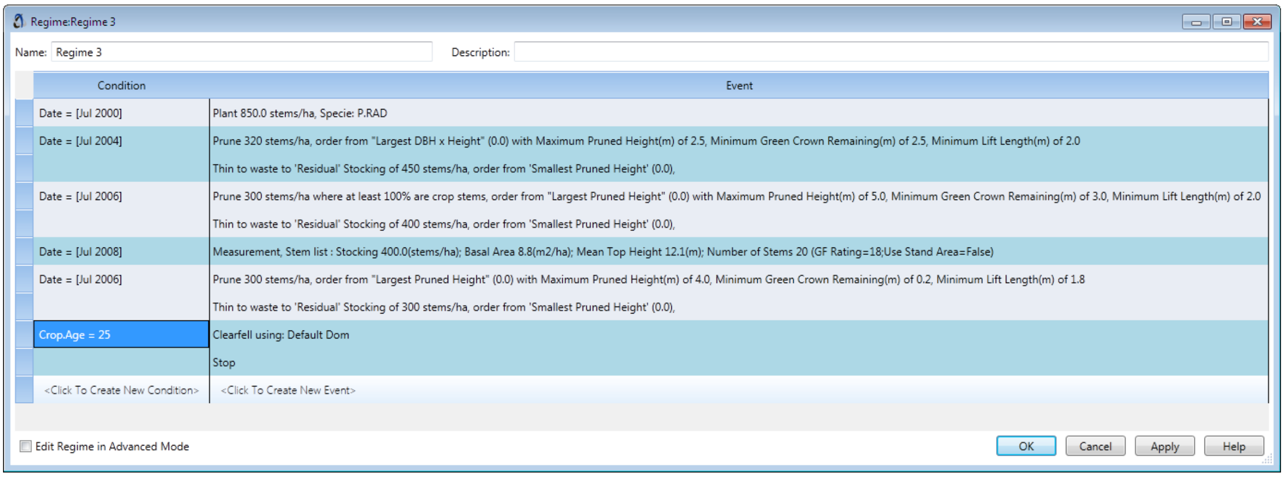
In this section

This section contains the following topics:

Regime Forms

Regime Form

The Regime form allows the conditions and events in a regime's commands to be added or changed. Each command is distinguished by an alternating background colour in the form's grid:



This grid is used to edit regimes in both Forecaster and Yield Generator. It is also used when editing a crop’s history in Forecaster, in which case only conditions containing a date or age can be specified.

Only a single condition or event can be selected at once. However, a whole row can be selected by clicking the row header – the blue cell immediately to the left of the row's condition cell. The widths of the columns can be changed by dragging the divider bar between the column headers.

The following table describes the fields and buttons in the Regime form, and their usage:

Field/Button	Function
Name/ Description	A Regime must have a Name which is unique within its containing folder. It may also have a Description, useful in helping users decide whether a Regime is appropriate for a particular simulation.
Condition	A Condition must evaluate to *true* for the Command's Event(s) to be executed (see below). As a simulation proceeds, the stand is grown forward in monthly steps. At each step, the Condition of the next Command in the Regime is evaluated, and if it evaluates to *true* then all the Events in that Command are executed in order.
Event	Supported Events include: • Plant • Measurement • Prune • Thin - either Waste Thin or Production Thin • Clearfell - a Clearfell event includes one or more Cutting Strategies, and will automatically create an age-range Condition whose ages are determined by the species in the Plant Event

Field/Button	Function
	• Stop - a Stop event is required to end the simulation, without a Stop event the simulation will proceed until the oldest age allowed by the growth model. **Note:** Selecting an event displays a popup that requires data to be entered or selected from a list.

Editing Conditions

To create a new condition, either click on the **<Click to Create New Condition>** cell in the last row of the grid, or double-click an empty cell. To edit an existing condition, double-click the cell containing the condition.

When not in advanced mode, conditions are entered by:

1. Selecting the variable to be scheduled from a drop-down list
2. Selecting (where appropriate) the operator, i.e. **=**, **>**, **<** or **<>** from a second drop-down list, and finally
3. Entering the value(s) of the variable in one or more text boxes.

Advanced mode allows more complicated conditions to be entered, and additional variables to be used in conditions. It is *Off* by default, but can be enabled via the **Edit Regime in Advanced Mode** check-box at the bottom of the form. When in Advanced Mode, conditions are entered directly into a text box.

Editing Events

To create a new event, click on the **<Click to Create New Event>** cell in the bottom row of the grid, then from the menu, select the type of event that you wish to create. An event-specific form will be shown in which the event's details can be entered.

To edit an existing event, double-click the cell containing the event.

Note that Plant events always appear at the top of the regime, and they cannot be moved or copied.

A context menu of relevant options can be displayed by right-clicking a condition or event cell. All options in the context menu are also available using keyboard shortcuts, shown to the right of each menu item.

Cut and Paste

A row or cell can be moved using Cut and Paste, i.e. by pressing Ctrl-X to cut the selected row or cell, and then pressing Ctrl-V to paste the row or cell which has been cut. Similarly, a row or cell can be copied rather than cut, by pressing Ctrl-C rather than Ctrl-X.

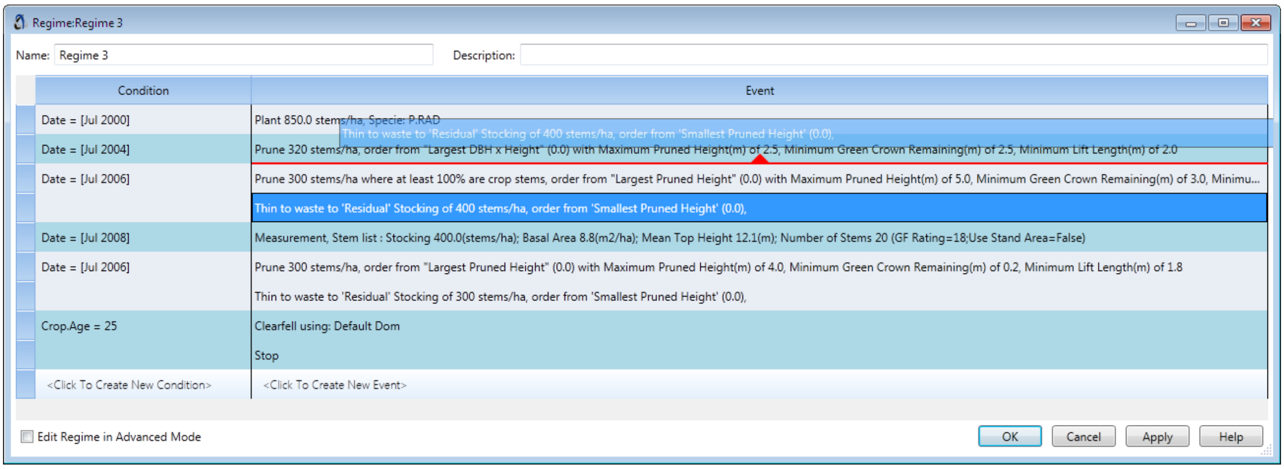
When pasting an event, it will be inserted immediately before the event in the selected cell, whereas pasting a condition will overwrite the condition in the selected cell. When pasting a row, it will be inserted immediately before the current row.

Drag and Drop

A row or cell individual can be copied or moved using **Drag and Drop**. This may be useful when the order of events within a command, or when the order of commands themselves, needs to be changed.

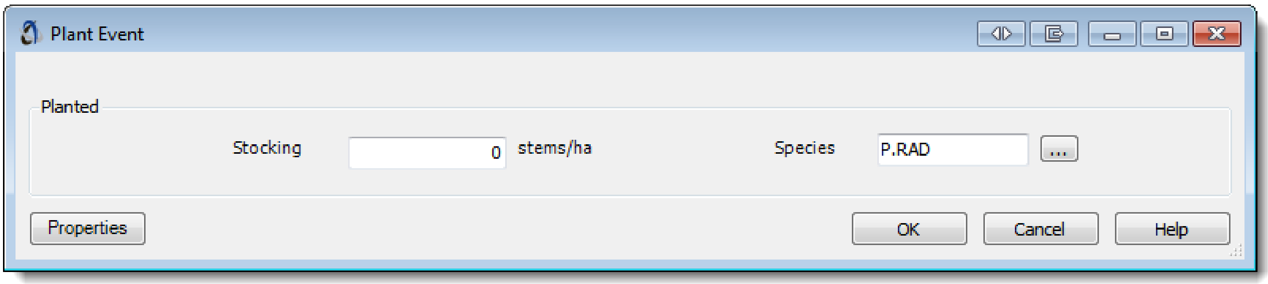
An item can be moved by placing the mouse pointer over the item, then dragging and dropping it on the destination location. The mouse pointer will change to indicate that a drag operation is in progress. If the item(s) being dragged may be dropped onto the item under the mouse pointer, then it will be highlighted, or a separator will be displayed to indicate either where the item being dragged will be inserted, or which item will be overwritten. If the item(s) being dragged may not be dropped on the item under the mouse pointer, then the mouse pointer will change into the "⦸" symbol.

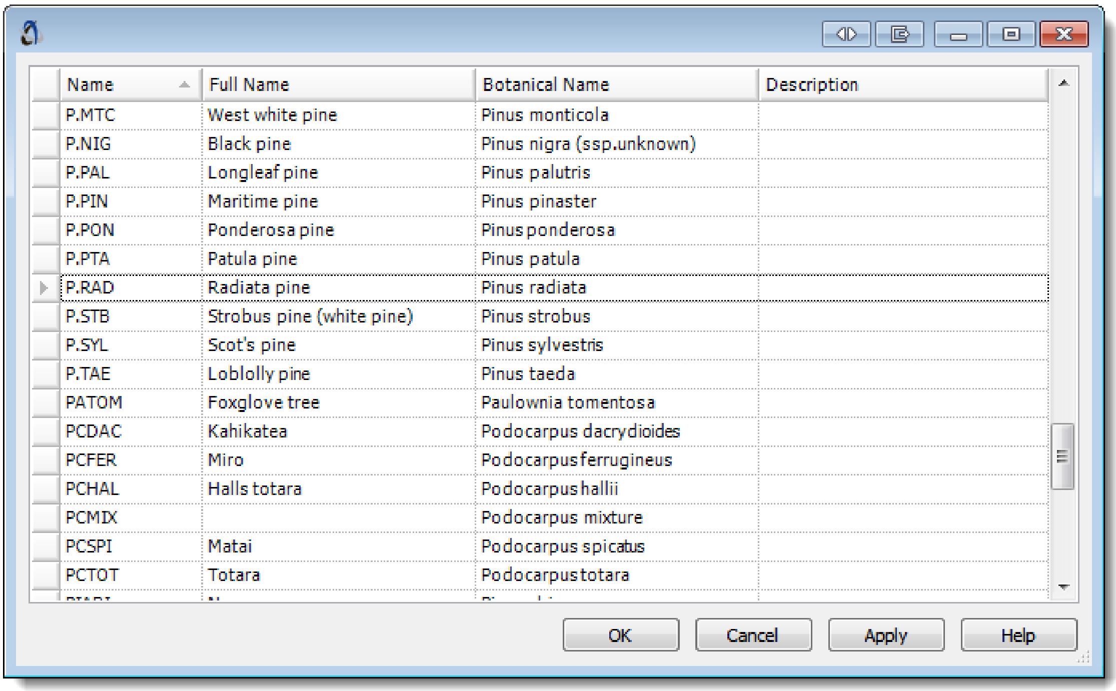
Note that when dragging and dropping an event, it will be inserted either before or after the event onto which it is dropped. A red line indicates the position at which the event will be inserted. An arrowhead in the middle of the line indicates which command the event will belong to when it is dropped. For example, in the screenshot below, a **Thin to Waste** event is being dragged. If it is dropped, it will be inserted into the same command as the first prune event, and after that event. This is indicated by the upwards-pointing arrowhead:



Plant Event

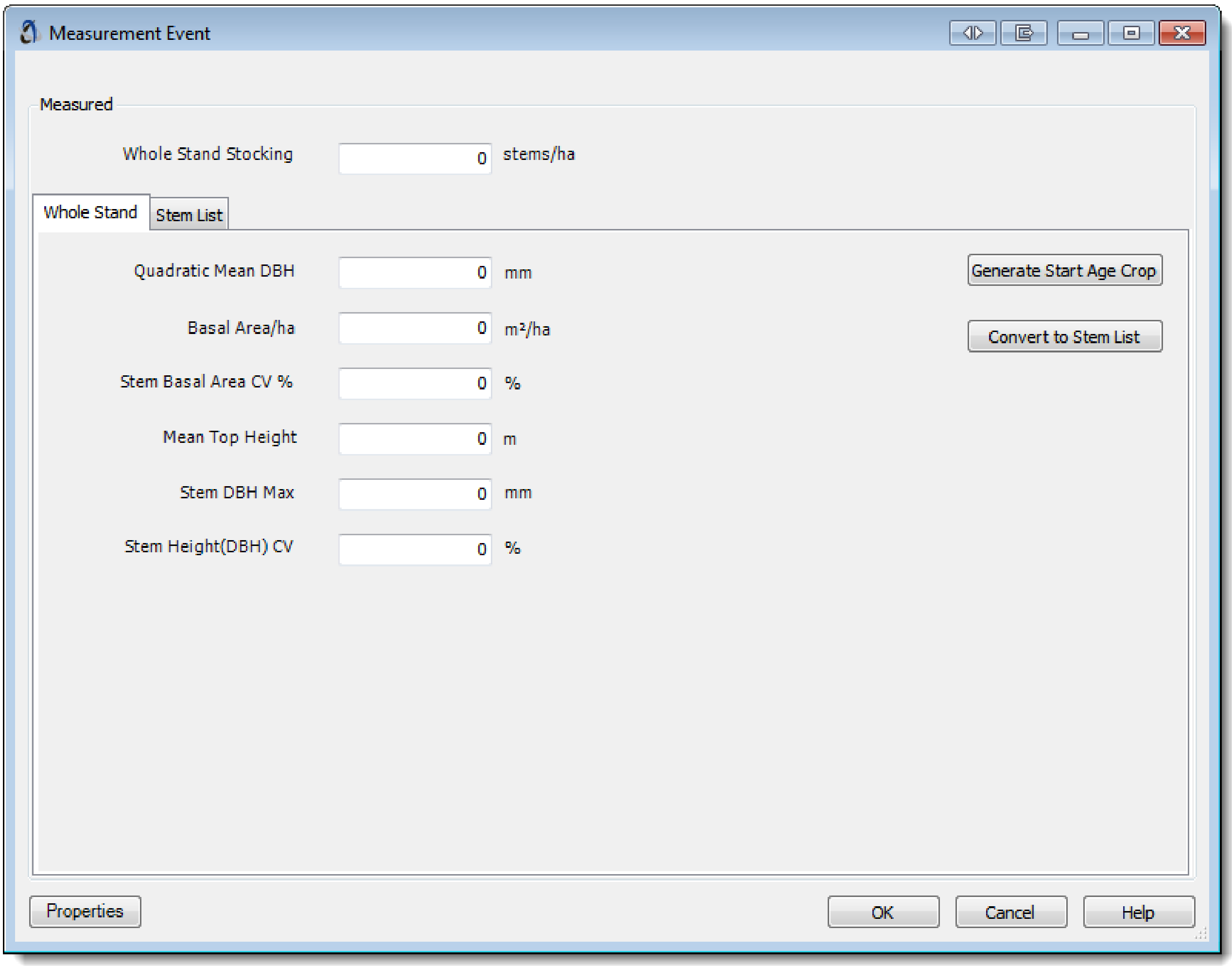
This is the Plant Event screen into which the starting conditions of the Crop are entered. Initial stocking must be specified, and the Species entered from the list:





Measurement Event

A Measurement Event represents the condition of a Crop at the start of the simulation. It can be based on a Stemlist Measurement, a Whole Stand Summary, or a Stand Subset Summary (see Crop Measurements):



Pruning Event

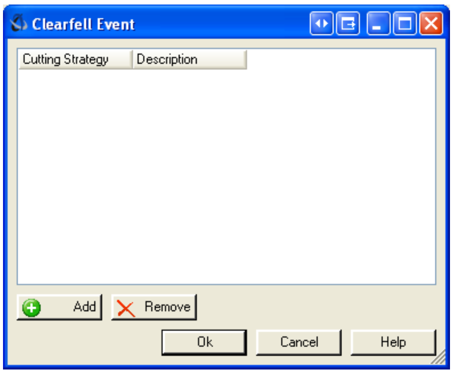
See Pruning topic for more detail.

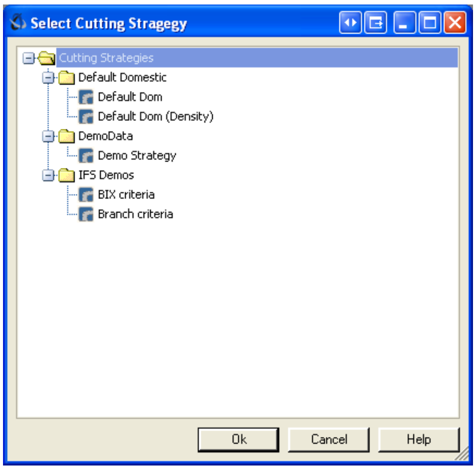
Thin Event

See Thin topic in this section.

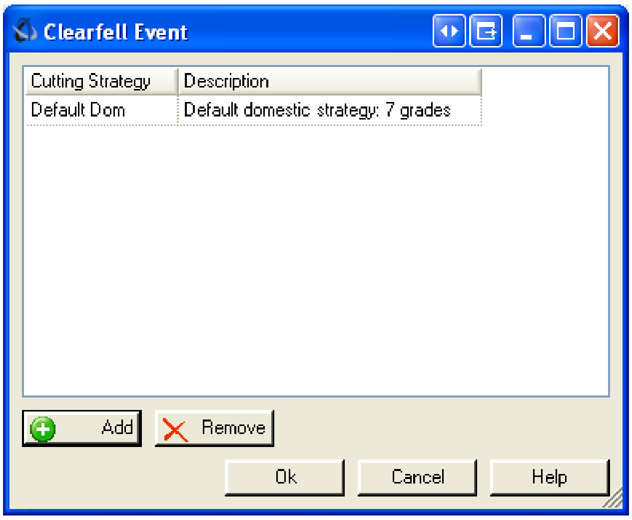
Clearfell Event

A Clearfell Event must specify at least one Cutting Strategy to be applied to the felled stems. Clicking the **Add** button displays the Select Cutting Strategy form, allowing nor or more Cutting Strategy to be defined.


Clearfell Event
Cutting Strategy
Description
Add
Remove
Ok
Cancel
Help


Select Cutting Stragegy
Cutting Strategies
Default Domestic
Default Dom
Default Dom (Density)
DemoData
Demo Strategy
IFS Demos
BIX criteria
Branch criteria
Ok
Cancel
Help

The selected Cutting Strategy is added to the Clearfell Event list:



Creating a New Regime

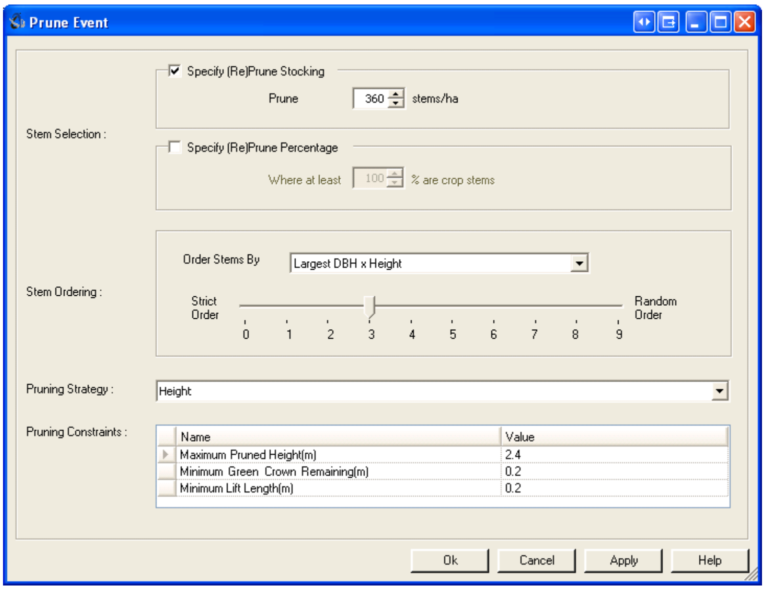
Follow these steps to create a new Regime:

<table>
<tr><th>Step</th><th>Action</th><th>Key Point</th></tr>
<tr><td>1</td><td>Create a new Regime</td><td>

- Select the required Regime folder in the Tree View Pane
- Right-click in the List View Pane
- Select New from the context menu, to display the New Regime form
- Enter a Name and Description for the Regime

Note that if any Clearfell or Production Thin Events are to be included in the Regime, then first ensure that any required Cutting Strategies and their Log Product Definitions have been defined.
</td></tr>
<tr><td>2</td><td>Add a Command</td><td>Select **+ Add Command** to display the New Condition form.</td></tr>
<tr><td>3</td><td>Specify the Command's Condition(s)</td><td>See the Conditions section for details.</td></tr>
<tr><td>4</td><td>Add an Event</td><td>Right-click on the *Event* field, select **Add**, and select the required Event type from the dropdown list.</td></tr>
<tr><td>5</td><td>Enter the Event's details</td><td>

For example, for a Pruning Event:



- Set the target pruned stocking, stem ordering, and randomness (see Pruning topic in this section)
- Nominate the *Pruning Strategy* (Height, Percentage of Stem, or Caliper)
- Select the Event's *Properties* (in this case prune to 2.4m, with no limit on Green Crown Remaining, or Minimum Lift Length)
- Click on the **OK** button
</td></tr>
</table>

Step	Action	Key Points
6	Add further Events for the same Command (if required)	Repeat steps 4 and 5 for each Event required
7	Add any further Commands required	Repeat steps 2 to 6
8	Finish setting up the Regime	• Ensure that a "Stop" Event is the last Event of the last Command. • Check that the order of Commands and Events is correct. • Click **Ok** to save all changes, and return to the main form.

Stem Ordering

Many silvicultural operations require a subset of the stems in a stand to be selected. These are the stems which are treated in the operation.
For example, pruning is usually applied to a selection of stems which are large, well-formed, evenly-spaced and vigorous to ensure that the value added by pruning is applied to the trees which can maximise the production of clearwood. Thinning often targets small, malformed or un-thrifty stems for removal, thus improving the quality of the residual crop.

Forecaster manages the selection of stems by first ordering the stemlist based on stem dimensions or other characteristics. The selection rules of the silvicultural operation are then applied to the stems in this order. When sufficient stems have been selected to meet the target, the operation is performed.

Stem ordering is specified as part of the operation. Forecaster simulates the selection of stems for a silvicultural operation as follows:

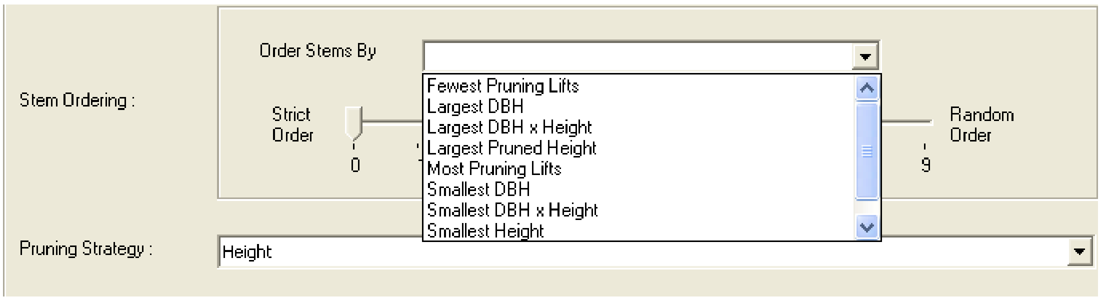
Step	Description
1	The stems are sorted into order, based on the stem variable(s) selected. When there is a tie during sorting based on pruned lift number or pruned height, this is resolved by comparing the DBHxHeight value of the two stems (The larger stem being selected).
1.1	The sort order is reversed if selection is from largest to smallest rather than smallest to largest.
1.2	The required variability of the ordering is then considered. If strict ordering is required no change is made, otherwise the position in the sorted list is considered the average position in a normal distribution of positions and a new position is sampled from this distribution. As the required variability increases so does the variance of the distribution.
1.3	As a special case, random ordering is handled separately by placing stems in the list at random.
2	The ordered stem list is used as the basis for considering candidates for the operation. For thinning events, the required number of stems to achieve the thinning target are selected from the ordered stem list – each of these stems are thinned out. For pruning events, the first stem in the ordered stem list is considered for pruning. If it can be pruned to meet the pruning constraints, then it is. If not, this stem is skipped, and the next stem in the order is then considered, until the target number of stems can be pruned.
3	If sufficient stems can be selected to exceed stand-level targets (eg. stocking or basal area) then the last stem selected is duplicated and its weighting apportioned between selected and unselected lists to represent the correct target value.

Simplified example

If 350 stems are selected for pruning:

Stem	Weighting	Stem	Weighting
1	100	1	100
2	100	2	100
3	100	3	100
4	100	4_1	50
5	100	Total pruned stocking	350 stems/ ha
6	100	4_2	50
		5	100
		6	100
Total Stocking	600 stems/ ha	Total unpruned stocking	250 stems/ ha

Pruning stem selection, for example:



Two options are available, Reprune currently pruned stems or select stems to meet a target stocking:

- The reprune option is useful for second and subsequent prunings when there is no attempt at reselection and there is no catch-up pruning. Reprune is likely to result in fewer stems being pruned in each subsequent operation, as the growth model's mortality calculations will reduce the stocking represented by the pruned stems in the list. In most cases this reduction in pruned stocking will be small.
- Prune to a target. Three values need to be set: The target stocking, the variable(s) used to order the stems and the variability of the ordering. Stems can be ordered on a number of variables including: number of pruning lifts, pruned height, DBH, height and DBHxHeight. The variability of the order can range from strict (0) to fully random order (9).

The effects of different ordering variability are illustrated in the Pruning Selection Examples that follow this topic.

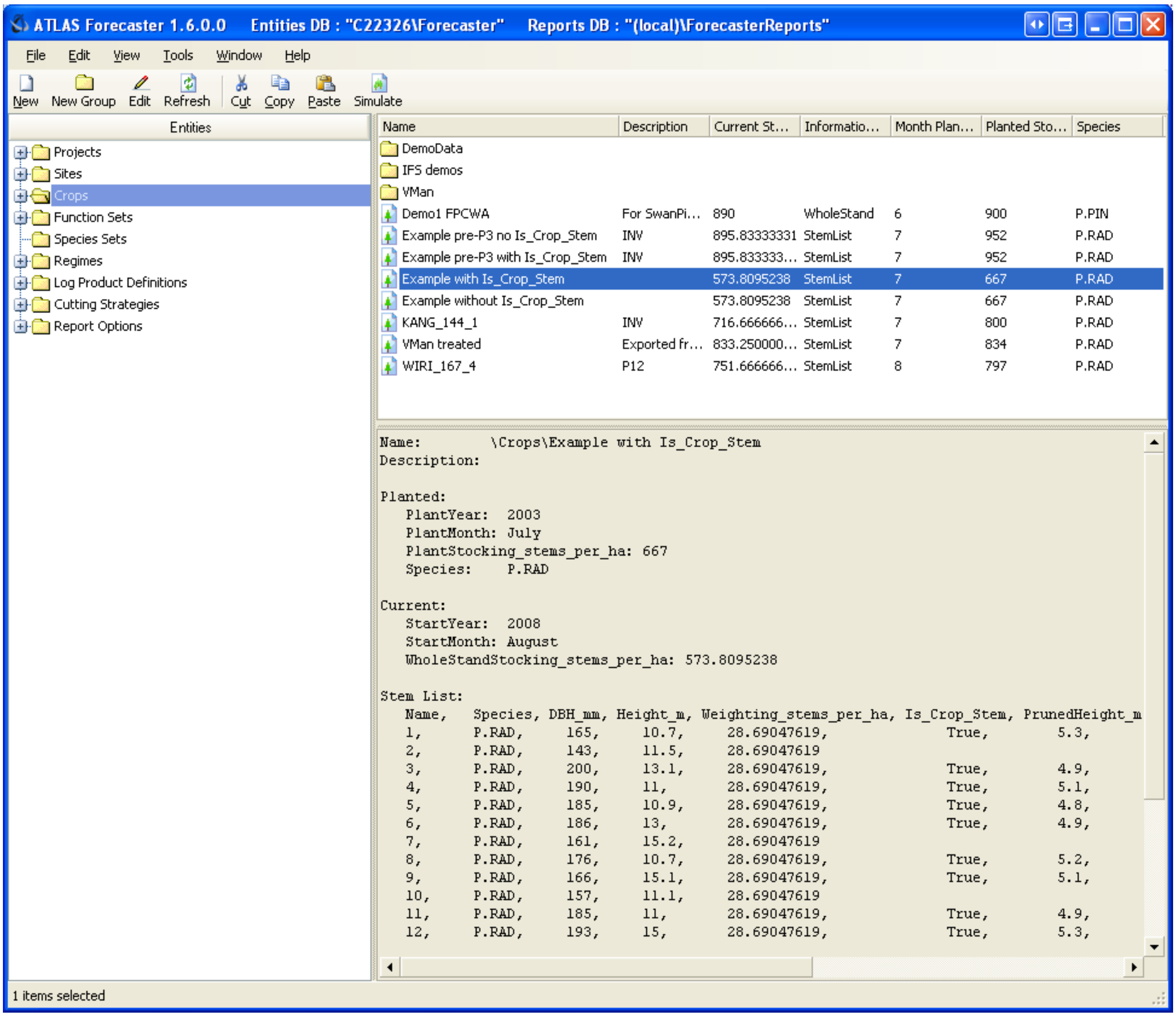
Thinning Coefficient

To assist users in easily determining whether a simulated thinning event (with a particular stem ordering and randomness setting) is realistic or not, for each thinning event Forecaster provides a Thinning Coefficient, which is is displayed in the Message Viewer that appears at the end of the simulation. The Thinning Coefficient is defined as the proportion of basal area relative to stocking that remains following a thinning, thus as the coefficient increases, more of the larger stems are thinned out. Analysis of historical radiata pine PSP data in New Zealand suggests the following average values (pers comm Mark Kimberley):

- 0.784 for waste thinning
- 0.823 for production thinning
- 0.56 is equivalent to natural mortality

Stem Selection Examples

These examples illustrate the effect of different stem ordering variability on the selection of stems for pruning or thinning.
The stem selection criteria is overruled if the Is_Crop_Stem variable is set to TRUE for any stems in the stem list (this only applies if the crops information level is set to Stem List and Is_Crop_Stem variable in the list is TRUE).
The "Is_Crop_Stem" attribute can be viewed in the main display by selecting the crop - the fields contained in the stem list file are shown in the preview pane as illustrated below:

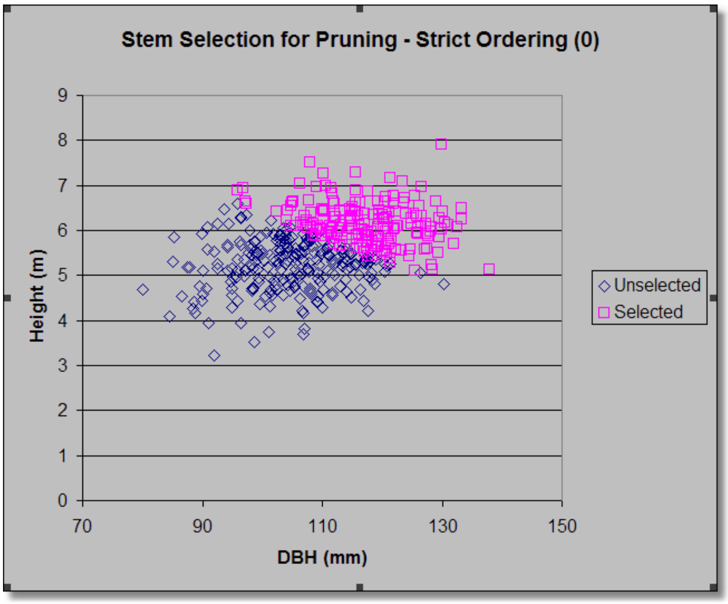


Forecaster holds only a limited set of characteristics for each stem. Malformations (sweep, lean, wobble, kink) are not modelled during silviculture. Apart from DBH and height, the vigour of a stem is not modelled directly in terms of crown density and health. Forecaster represents a stand as a stem list "growing" on a site. The list of stems does not include their spatial position, so except for aggregate measures such as number of stems per hectare and basal area per hectare, nothing is known of an individual stems placement or its neighbours. Details such as the condition of the leader and branching habit are also not considered by Forecaster when simulating silvicultural operations, though in reality they would be used as stem selection criteria by a silviculture crew. To model a more realistic selection of stems for thinning or pruning, the ordering variables and order variability can be set.

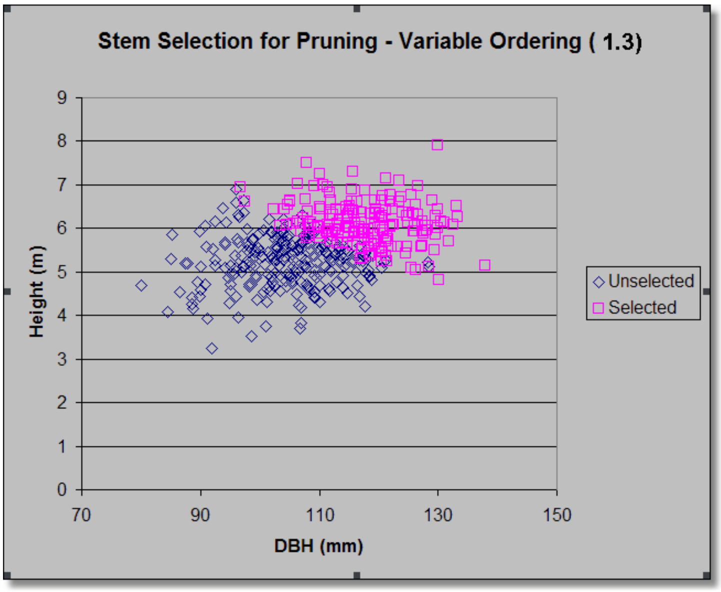
The example charts linked below show the stem list plotted as stem height over DBH. 360

stems per hectare are selected from 850, ordered from the largest DBHxHeight. The selected and unselected are identified as two series.

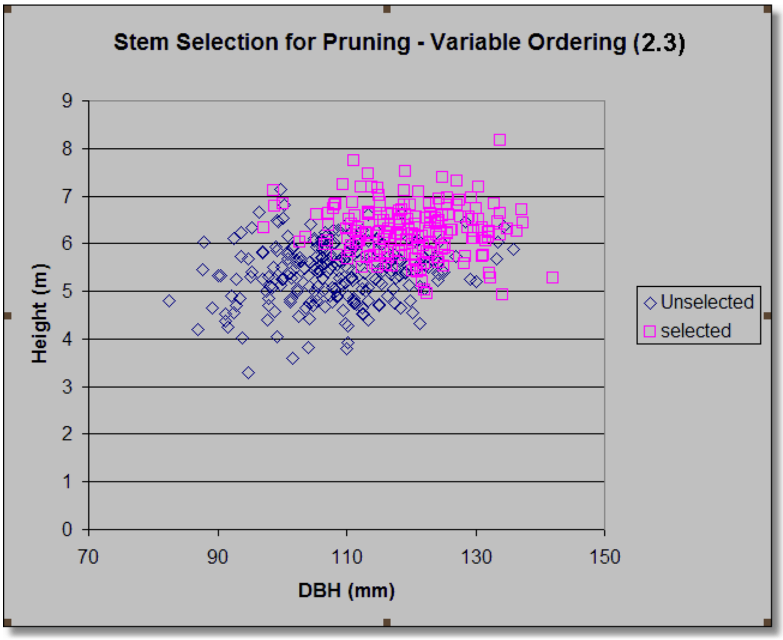
Note that the selection is the result of both the ordering and the pruning strategy because, even though a stem appears first in the list it will only be selected if it meets the "crown remaining" and "minimum lift" constraints.



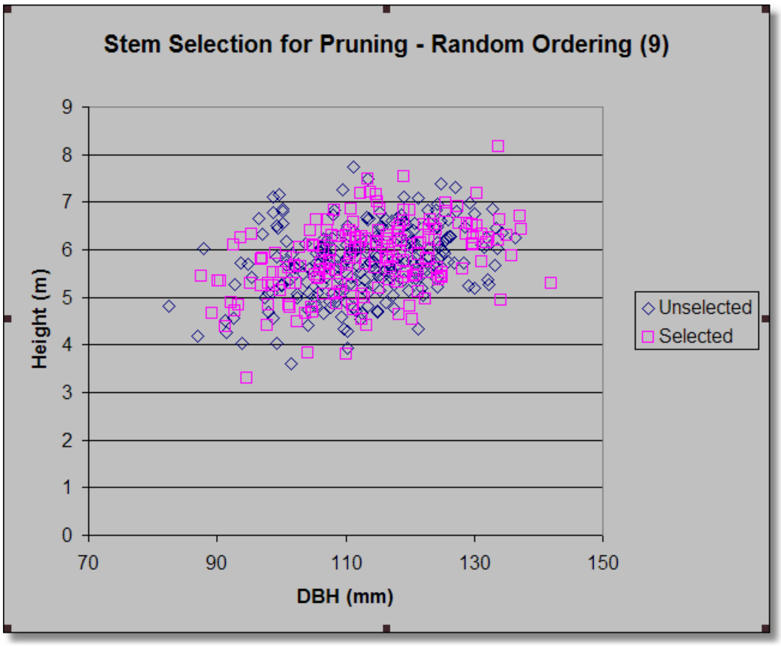
In an ideal stand (evenly spaced, straight stems of equal vigour) the final crop should be selected from the largest / tallest stems. This can be modelled in Forecaster by ordering the stems from the largest DBHxHeight with strict ordering.



With slight ordering variability some large stems are not selected and a few small stems have been selected.



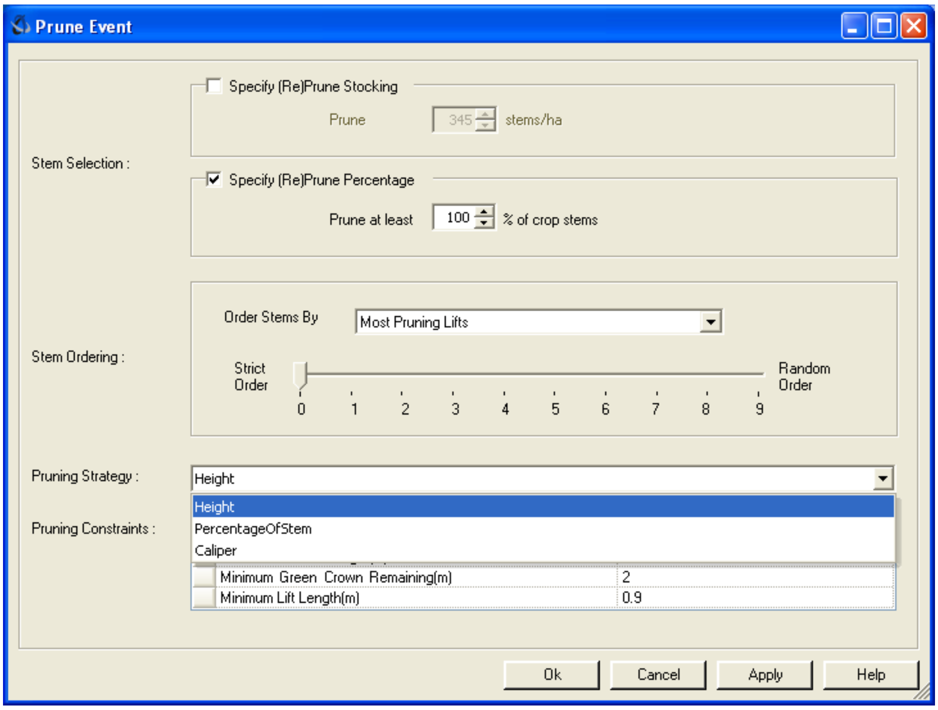
Increasing the variability further results in a mix of selected / unselected stems of average height and DBH.



In a patchy stand with uneven establishment and considerable malformation, the pruning selection can be modelled by applying random ordering (9). With fully random ordering there is no relationship between a stem's size and the order it is considered in, as a candidate for pruning.

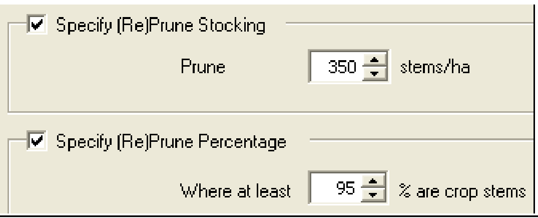
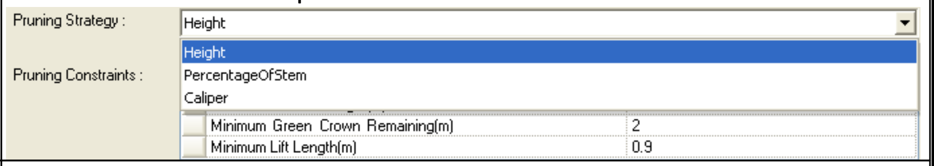
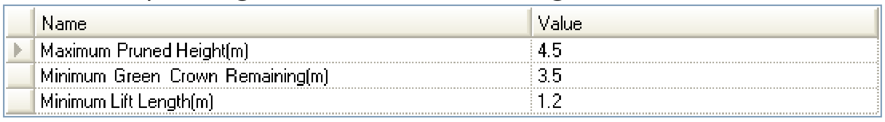
Pruning Events

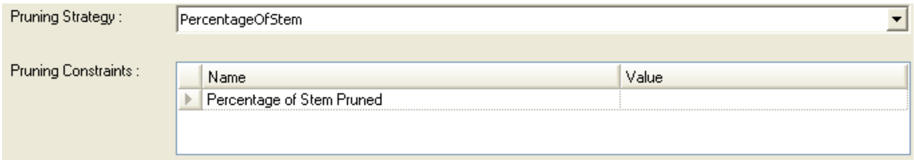
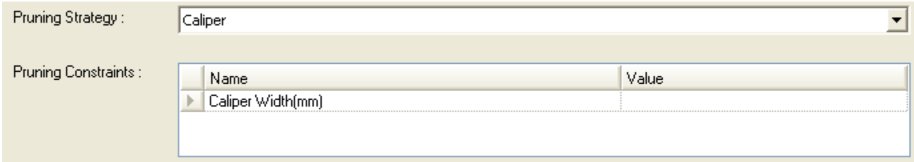
The Prune Event form is used to set up or modify a pruning event:



The following table describes the functions of the fields and buttons in the Prune Event form:

Field/Button	Function
Specify (Re)Prune Stocking	The user enters the stocking (number of trees per hectare) which they wish to prune (or reprune, if it is a 2nd or subsequent pruning lift).
"Specify (Re)Prune Percentage"	The "Specify (Re)Prune Percentage" field allows the user to specify a minimum percentage of the crop stems which must be pruned. A "crop stem" is defined as: • any stem which has the Is_Crop_Stem attribute set to TRUE, or; • where the Is_Crop_Stem attribute is not present, any stem which was pruned in the previous pruning event. The "Specify (Re)Prune Percentage" field is combined with the "Specify (Re)Prune Stocking" field in two slightly different ways: • Where the "Specify (Re)Prune Stocking" option is unchecked, then the "Specify (Re)Prune Percentage" means that the specified percentage of the crop stems will be pruned (at a minimum). The form is displayed as below:

Field/Button	Function
	• Where the “Specify (Re)Prune Stocking” option is checked, then the “Specify (Re)Prune Percentage” means that at least that percentage of the pruned stems must be crop stems. The form is displayed as below: 
Stem Ordering	Select from drop down list and adjust variability with slider. Refer to Regimes > Stem Ordering for an explanation of the use of this field.
Pruning Strategy	Selected from the drop down list. 
Pruning Constraints - Height	This is the pruning constraints list for height.  Prune a minimum lift of x metres and to a maximum height of y metres, subject to a green-crown remaining of z metres. At least one of the three values must be specified. Lift length is the new pruned height minus the old pruned height. If the minimum lift is unspecified then this strategy functions as a simple prune to height with a green-crown remaining constraint. If the green-crown remaining constraint is unspecified then maximum height will be applied up to the height of the stem. By not specifying a minimum lift, and setting a large maximum height with a realistic green-crown remaining constraint, this becomes "pruning to a green-crown remaining". If the minimum prune lift and minimum green-crown remaining constraint cannot both be met, then the stem is not pruned. On the first pruning, the minimum lift is the minimum pruned height as it is assumed that an unpruned stem is branched from ground-level up. This pruning strategy is implemented in four steps: 1. Check whether the current prune height plus the minimum lift will leave at least the minimum green crown. If not, then don't prune. 2. Check whether the current prune height plus the minimum lift will exceed the maximum prune height. If it will, then don't prune. 3. If pruning to the maximum prune height will leave at least the

Field/Button	Function
	minimum green crown, then prune to the maximum prune height. 4. Otherwise, prune to a height that will leave at least the minimum green crown.
Pruning Constraints - Percentage of Stem	 Prune to x percent of the total height of the stem. If, on second and subsequent lifts, the calculated prune height is not greater than the current prune height, then the tree is not pruned.
Pruning Constraints - Caliper	 Prune all branches below the height at which the stem over-bark diameter is equal to the caliper width (usually 90 to 100 mm). If the stem is currently pruned to, or beyond, the caliper height then the stem is not pruned. Stems with over-bark diameter at 0.8m that are smaller than the caliper diameter are not pruned.

In this section

Topics
Pruning Behaviour
Using Forecaster to Manage Pruning Behaviour

Pruning Behaviour

The "Is_Crop_Stem" attribute is also considered as a result of the flexibility allowed by the Prune Event form explained in the previous topic.

How the different combinations of the fields in the Prune Event form and the "Is_Crop_Stem" attribute is handled are explained in the following tables:

For the first pruning event

Is_Crop_ Stem[1]	Prune Stocking[2]	Prune %[3]	Behaviour	Reason
✓	✗	✓	At least X% of stems marked with Is_Crop_Stem = TRUE must be pruned.	X<100 prevents small rogue stems from delaying the pruning event.
✓	✓	✗	**Error:** Pruned stocking cannot be specified when Is_Crop_Stem attribute is present on stemlist.	Is_Crop_Stem designation is intended as the definitive factor in selecting stems.[4]
✓	✓	✓	**Error:** Pruned stocking cannot be specified when Is_Crop_Stem attribute is present on stemlist.	Is_Crop_Stem designation is intended as the definitive factor in selecting stems.[4]
✗	✗	✓	**Error:** Pruned percentage cannot be entered as crop stems are unknown.	% of crop stems is meaningless as crop stems are unknown.
✗	✓	✗	N stems will be pruned.	This is the current basic behaviour. Followers might be pruned at the expense of stems pruned in prior lifts.
✗	✓	✓	**Error:** Pruned percentage cannot be entered as crop stems are unknown.	% of crop stems is meaningless as crop stems are unknown.

Notes

1. Some stems have the Is_Crop_Stem attribute set to TRUE on the crop's stemlist
2. Prune N stems/ha is specified on the Prune Event form
3. (Re)Prune at least X% of crop stems is specified on the Prune Event form

4. Behavior is to ignore the pruned stocking and prune those stems where Is_Crop_Stem = TRUE.

For subsequent pruning events

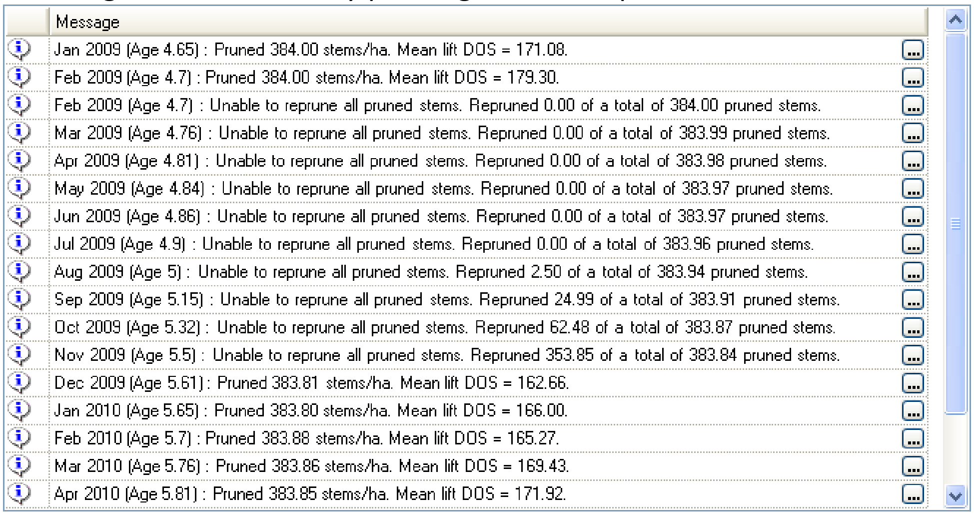
In this case, at least one pruned event has already occurred, either in the crop's history or during simulation through the regime. Crop stems can always be identified (they were pruned in the last pruning event) regardless of whether Is_Crop_Stem attribute has been set on the stemlist:

Is_Crop_ Stem[1]	Prune Stocking[2]	Prune %[3]	Behaviour	Reason
✓	✗	✓	At least X% of stems marked with Is_Crop_Stem = TRUE must be repruned.	X<100 prevents small rogue stems from delaying the pruning event.
✓	✓	✗	**Error:** Pruned stocking cannot be specified when Is_Crop_Stem attribute is present on stemlist.	Is_Crop_Stem designation is intended as the definitive factor in selecting stems.[4]
✓	✓	✓	**Error:** Pruned stocking cannot be specified when Is_Crop_Stem attribute is present on stemlist.	Is_Crop_Stem designation is intended as the definitive factor in selecting stems.[4]
✗	✗	✓	At least X% of stems pruned in previous prune event must be repruned.	X<100 prevents small rogue stems from delaying the pruning event. User won't know exact prune stocking.
✗	✓	✗	N stems will be pruned.	This is the current basic behaviour. Followers might be pruned at the expense of stems pruned in prior lifts.
✗	✓	✓	N stems will be pruned, with at least X% of the stems pruned to come from those stems pruned in the previous prune event. Where X% of the target pruned stocking (N) exceeds the available crop	This prevents followers from being pruned immediately after the previous prune event.

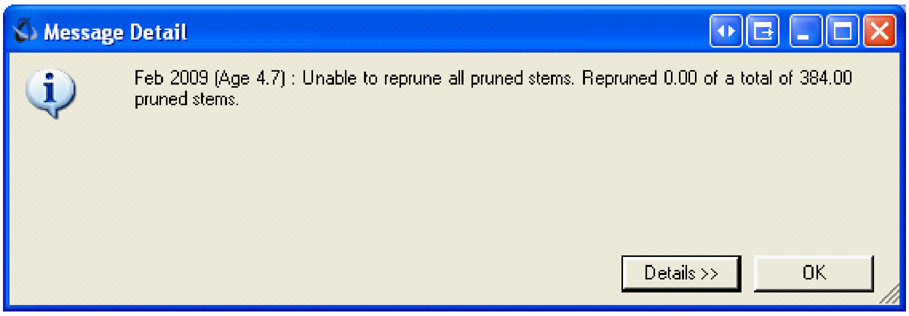
Is_Crop_ Stem[1]	Prune Stocking[2]	Prune %[3]	Behaviour	Reason
			stems, an error will indicate this to the user.	

Using Forecaster to Manage Pruning Behaviour

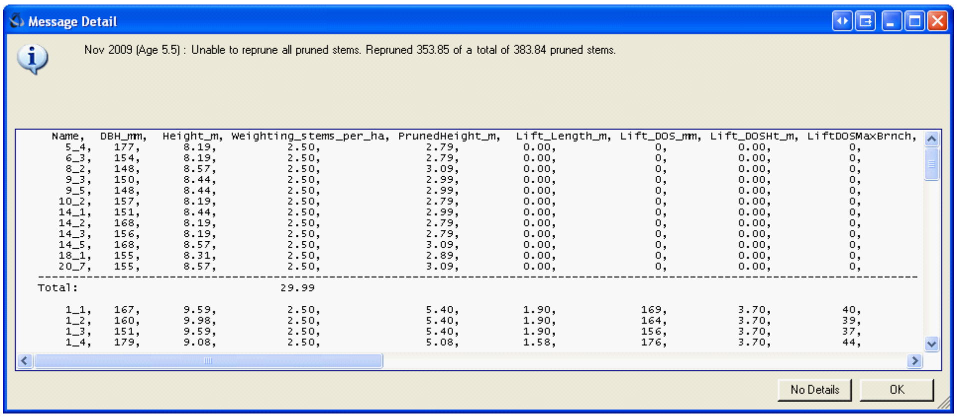
When new prune events are added to a regime, it is recommended that the (Re)Prune % initially be set at 100%. If the timing of the pruning seems to be unrealistically delayed, then the (Re)Prune % can be lowered. Whether or not the pruning has been delayed can be identified from the Message Viewer following simulation. Information-level messages are displayed indicating when the dummy pruning was attempted:



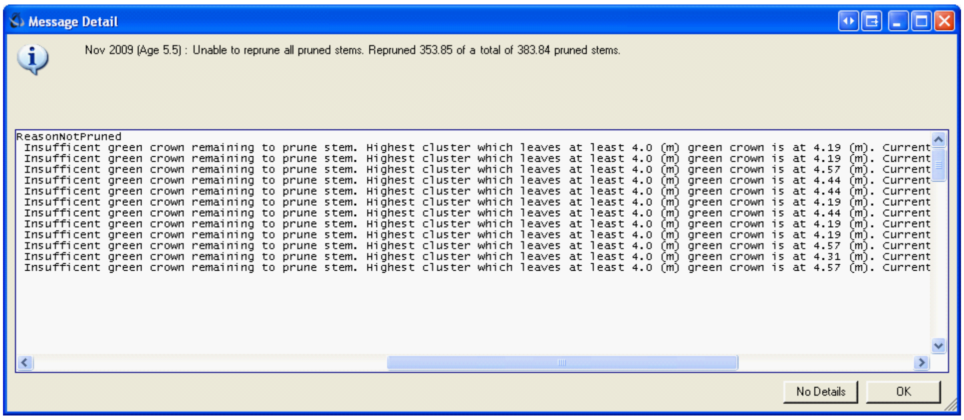
To view more details on why the pruning was not able to be successfully completed for any given month, first press the button, and then the **Details >>** button on the following dialog:



The stem list is displayed, and shows the stems which are not able to be pruned in the dummy pruning event, as well as those that can be (including their resulting pruned height, lift length, DOS, etc.):



Scrolling out to the right will show why those stems could not be pruned:



Some stems might not be able to be pruned because they haven't yet grown enough to meet the pruning constraints. In the following months, as these stems grow, they will eventually be able to pruned and satisfy all constraints. However, in some cases the location of a particular cluster on a stem (in relation to the current pruned height, and the pruning constraints) may cause this delay to be unduly extended. Where only a small number of individual stems are unduly holding up the pruning event (after the majority of the stems have been able to be successfully pruned for some time), then the user should consider setting the pruned percentage to a value less than 100%.

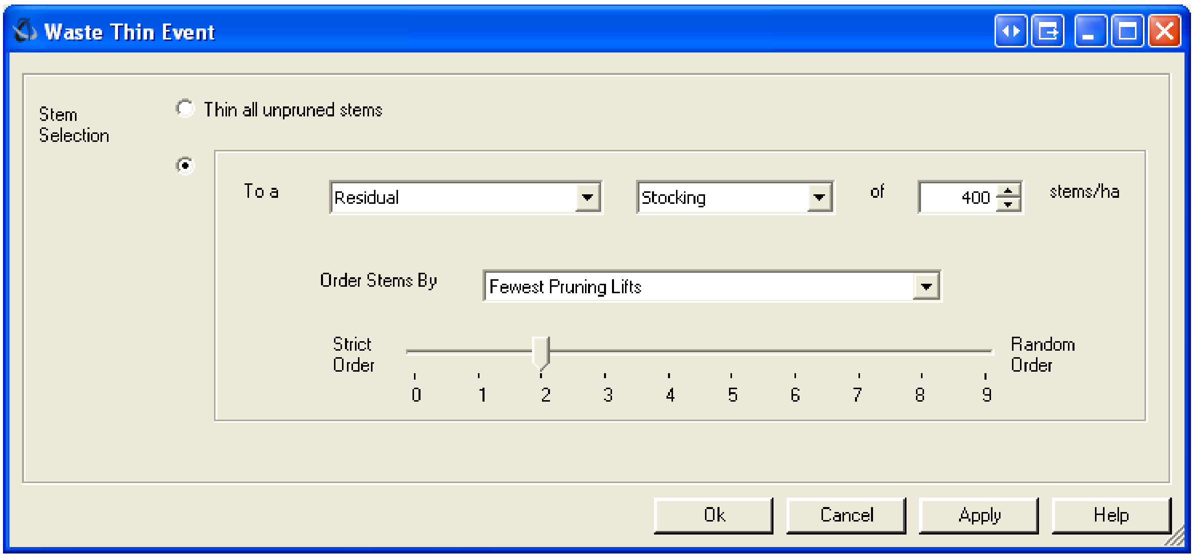
Thinning Events

Two types of Thinning Events are available: Waste Thin and Production Thin.

Waste Thin Event

The Waste Thin Event form is used to specify the extent of the thinning, and which stems are to be thinned. If any stems in the stem list have been pruned then the simplest option may be to thin all unpruned stems, otherwise a thinning target must be specified, along with the stem order (see Stem Ordering process). Available target types are:

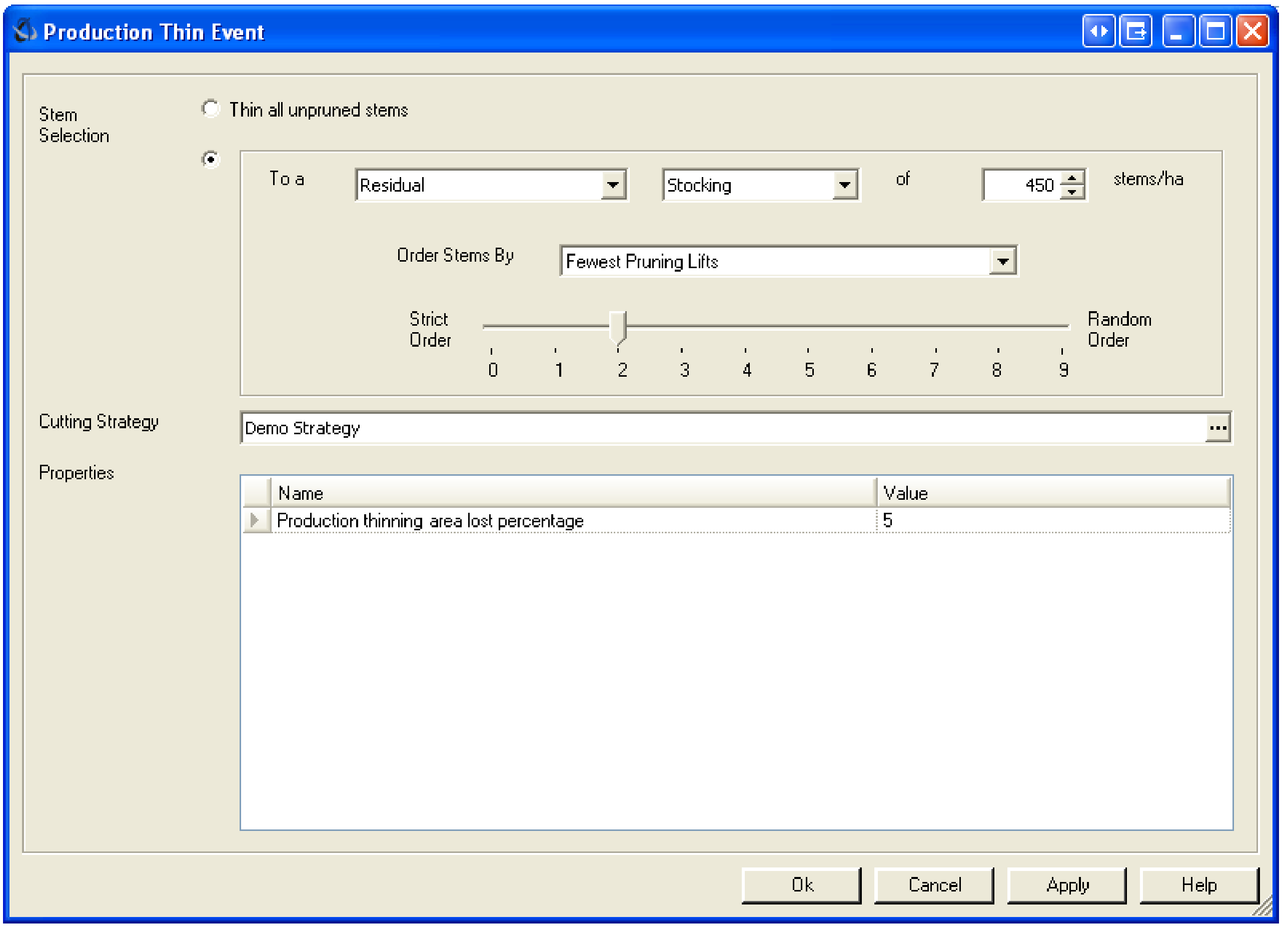
- Removed Stocking
- Removed Basal Area
- Residual Stocking
- Residual Basal Area



Field/Button	Function
Thin all unpruned stems	Click to have *all* unpruned stems in the stemlist thinned.
To a	For the first two fields, select an options from the drop down list: either Residual or Removed, and either Stocking or Basal Area. In the last field, enter the required target value in either stems/ha or m^2/ha.
Order stems by	Select required ordering option from dropdown list (see Stem Ordering)
Strict - Random Order	Set the position of the slider to specify the required degree of Randomness used by the simulation to determine the application of stem ordering.

Production Thin

In addition to stem selection criteria (as for a Waste Thinning, above), a Production Thinning Event must specify a Cutting Strategy:



Field/Property	Usage
Cutting Strategy	Select a Cutting Strategy by browsing the tree of all defined Cutting Strategies.
Production thinning area lost percentage	Specify the amount of net stocked area lost due to roads and skid sites (as a percentage: 0-100). This area loss is assumed to be permanent i.e. for the rest of the rotation.

Log Product Definitions

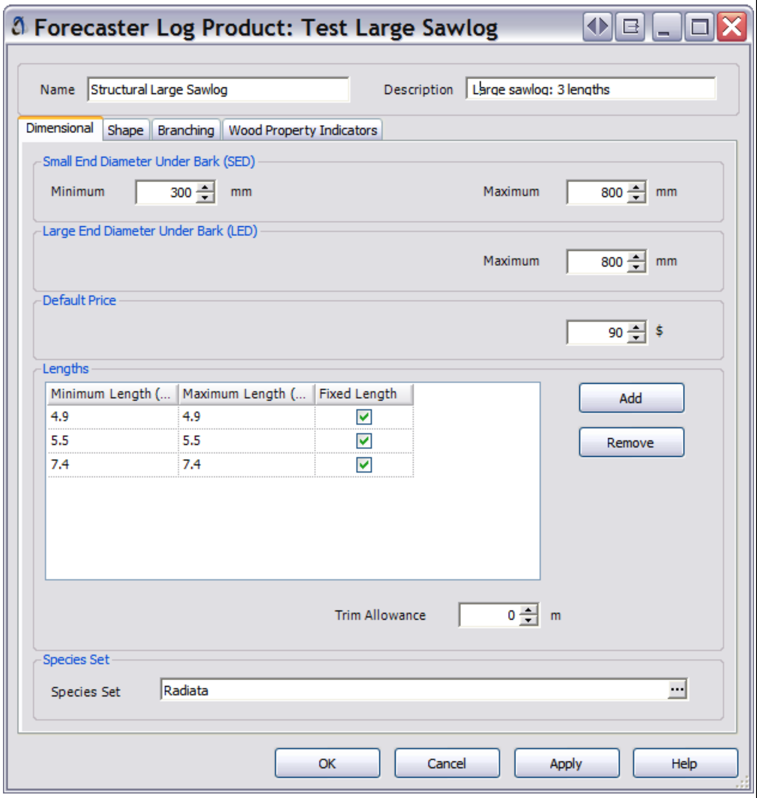
Understanding Log Product Definitions

Log product definitions define the criteria to be used when bucking (cross-cutting) stem pieces into logs and grading them. A number of standard log product definitions are available (based on New Zealand examples).

Creating a Log Product Definition

Log Product Definitions will usually be set up in separate folders. For example, you may have several folders, such as Domestic and Export in which you would place each of your sets of log grades, e.g. pruned, sawlog, industrial grade and pulp.

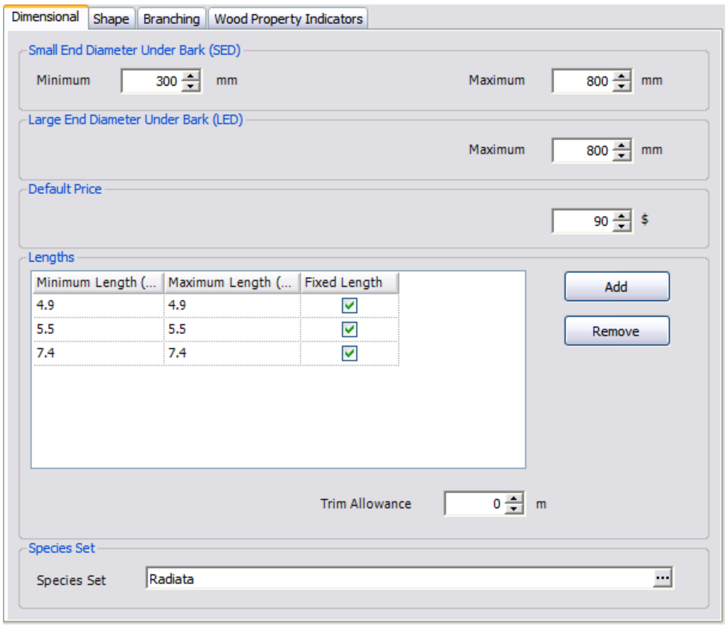
Follow these steps to create a new Log Product Definition:

Step	Action	Key Point
1	Open the Log Product Definition form	• Right-click on the appropriate folder or sub-folder • Select **New** - a new form is opened with the default name "New Log Product Definition": 
2	Enter a Name and Description	The name must be unique for the folder containing the Log Product Definition. The optional description is a short phrase describing the log product.

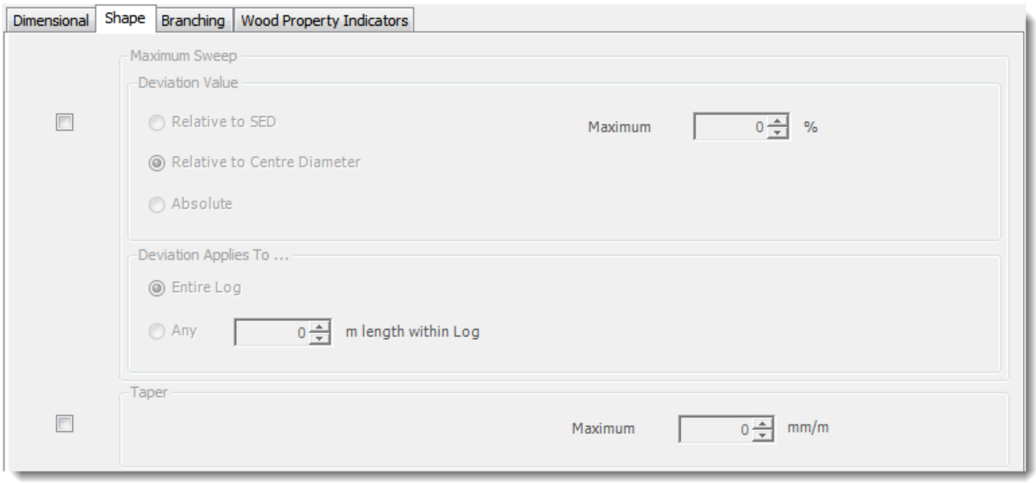
<table>
<tr><th>Step</th><th>Action</th><th>Key Point</th></tr>
<tr><td>3</td><td>Enter constraint data</td><td>There are four constraint-type tabs in which you can constrain your log grade characteristics:
Dimensional
Shape
Branching
Wood property indicators
Refer to the next table (Constraint Information) for details of each constraint.

Once all values have been entered, click OK to accept. The system will warn you of any mandatory fields that have been left blank, or any other inconsistencies.</td></tr>
</table>

Constraint Information

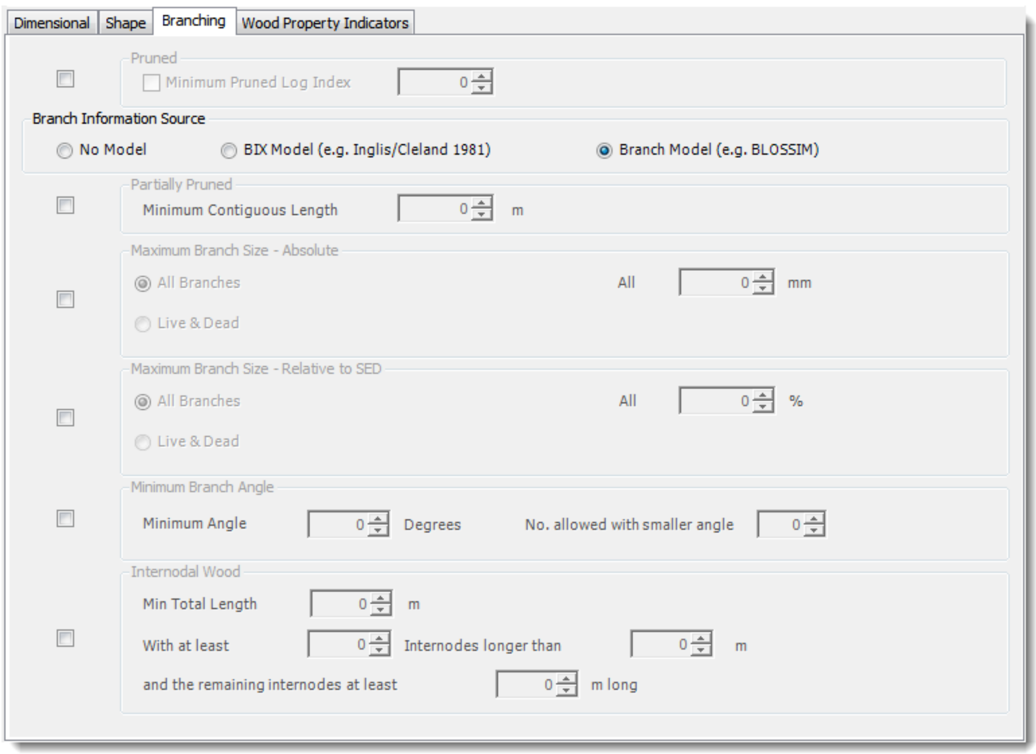
<table>
<tr><th>Tab Heading</th><th>Description</th></tr>
<tr><td>Dimensional</td><td>


The Dimensional tab (see picture above) is used to specify the minimum and maximum small end diameter (SED), and maximum large end diameter (LED) for the log grade, along with a default price, and allowable lengths.
To enter a new log Length, click Add. Entered lengths can be revised or deleted using Edit and Remove buttons.
A Trim Allowance may be entered, specified to the nearest centimetre. The bucking process will cut logs using "gross" lengths (a specified log length plus the trim allowance), but will use and report values calculated from the logs' "net" (specified) lengths.
A Default Price must be entered, and the form requires the allowable species to be defined by selection of an appropriate Species set.</td></tr>
</table>

<table>
<tr><th>Tab Heading</th><th>Description</th></tr>
<tr><td></td><td></td></tr>
<tr><td>Shape</td><td>


The Shape tab is where the maximum allowable sweep is defined, measured as the maximum deviation of the log's centreline from a line joining the centres of the log's ends. The deviation can be specified as either:

1. an absolute value,
2. a percentage of the log's SED, or
3. a percentage of the diameter at the log's midpoint

In addition, it may be specified as applying to the full length of the log, or to a section of a specified length occurring anywhere along the log.
A maximum allowable taper can also be specified.
</td></tr>
<tr><td>Branching</td><td>


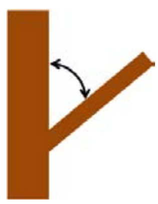
</td></tr>
</table>

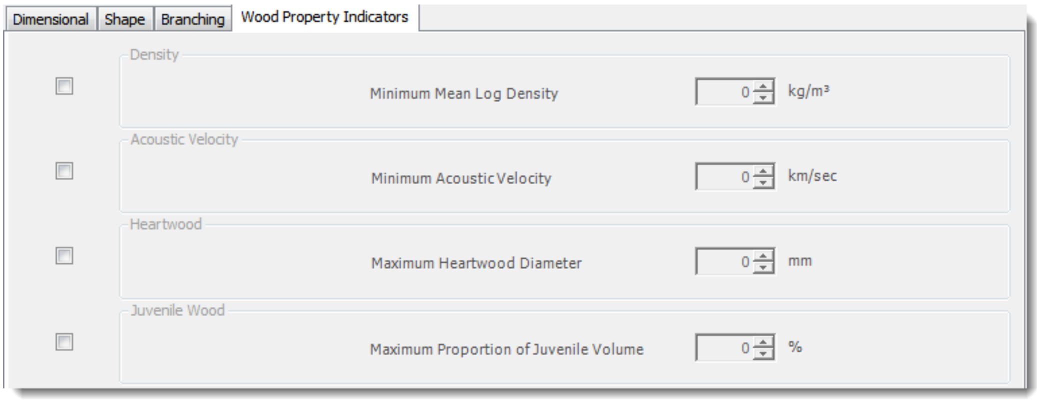
<table>
<tr><th>Tab Heading</th><th>Description</th></tr>
<tr><td></td><td>
The Branching tab allows constraints to be specified in terms of pruning and branching characteristics.
Pruned Log
If the log product being defined is a pruned log, the Pruned checkbox at the top of the tab can be checked. A Pruned Log Index constraint can be specified by also checking the Pruned Log Index checkbox, and entering a minimum allowable PLI value.
If the Pruned checkbox is checked, the rest of the tab will be disabled, as it is not relevant for pruned logs.
Branch Information Source
Branching information can be sourced from three places:

No Model - branching constraints cannot be specified.
BIX Model - only maximum branch size information is available and can only be applied for all branches - no distinction is possible between live and dead branches.
Branch Model - all branch specification sections are available due to the richness of the modelled branching information.

Partially-pruned Log
For Partially-pruned logs, the minimum contiguous length of pruned material must be specified.
Maximum Branch Size
The maximum allowable branch size can be specified in 2 ways:

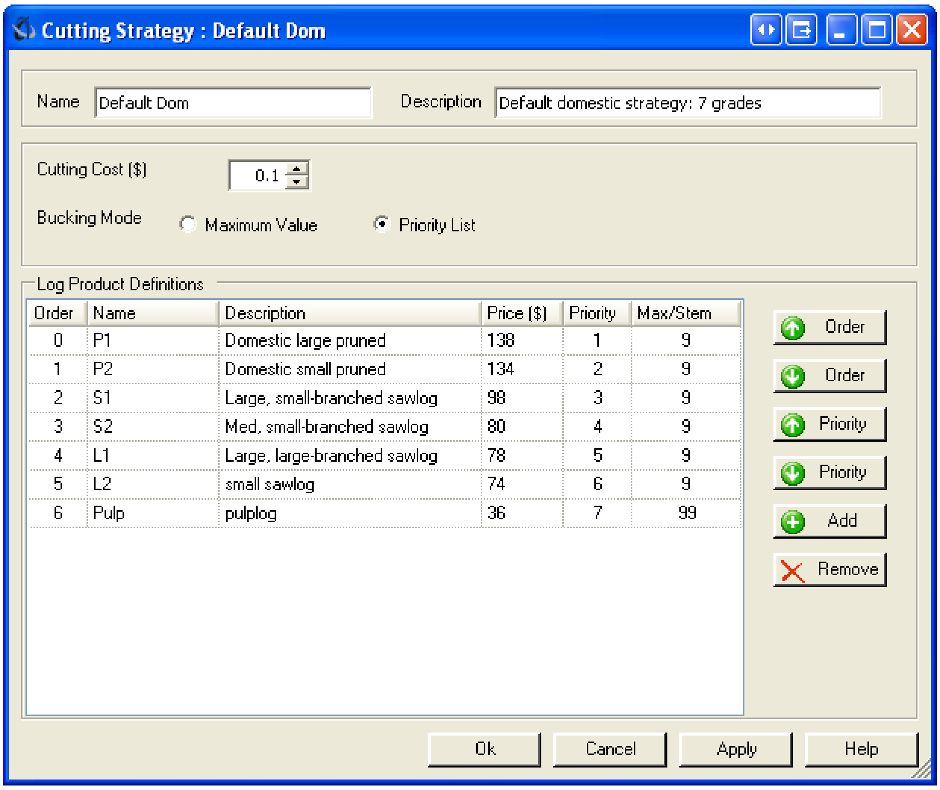
as an absolute value (mm), or
as a % of log SED

If the branch information source is set to branch model, then both these methods can have different branch size limits applied for live or dead branches.
Minimum Branch Angle
In order to avoid spike branches, a minimum branch angle constraint can be set. The angle is measured from the branch to the upper side of the stem:

If some spike branches are allowed in a particular log specification, then a maximum number of branches with a smaller angle may be specified.
Internodal Wood
</td></tr>
</table>

Tab Heading	Description
	The Internodal Wood fields describe the log's constraints based on internodal clearwood sections. It requires the specification of: • the minimum total length of all internodes, • a number of internodes to be of at least a certain length, and • another length that all of the other internodes must exceed This phrasing is intended to read like a sentence, for example: "a valid log must have a minimum total length of 4.0 m of internodal material, with at least 2 internodes longer than 1.0 m, and all of the remaining internodes being at least 60 cm long".
Wood Property Indicators	 It is also possible to constrain the log in terms of minimum mean density, minimum acoustic velocity, maximum heartwood diameter, and/or maximum percentage of juvenile core volume. In these cases (except for juvenile core volume, which is always calculated), an appropriate model must be selected in the Function Set, and any required model properties must also be specified there.

Cutting Strategies

A Cutting Strategy contains a number of log products (grades) that are considered for production when the strategy (cutting pattern) is applied to the stand. This simulates the cross-cutting instructions that a harvesting crew uses when producing logs from felled stems.



Fields and Buttons on the Cutting Strategy Form

Field/Button	Function
Name/Description	A name and description for the Cutting Strategy.
Cutting cost ($)	The cost of making a sawcut. This is indicative only, but can be useful in forcing the bucker to favour cutting long logs over shorts of the same product.
Bucking Mode	Two types of bucker are available: • The Maximum Value bucker optimises the set of logs cut from each stemPiece to return the maximum possible value. • The Priority List bucker behaves as a log-maker on the skid would - it will cut as many logs of a product as it can (up to the maximum specified), before moving onto the product of next lower priority. Towards the end of the stem, some look-ahead is used to avoid wasting potential low priority logs (similar to how a log-maker would assess the remaining length of the stem). **Bucking Modes in other systems**

<table>
<tr><th>Field/Button</th><th>Function</th></tr>
<tr><td></td><td>The Priority List mode was implemented in STANDPAK, MARVL used the optimising mode, and ATLAS Cruiser has both modes available.</td></tr>
<tr><td>Log Product Definitions</td><td>This is the list of Log Product Definitions to be used for this Cutting Strategy. Further products can be added using the Add button, and existing products can be removed using the Remove button.
When a product is added, its Name, Description and Price columns are populated from the selected Log Product Definition. The value used for Price is the Default Price defined for the Log Product Definition, but it can be overridden in this Cutting Strategy maintenance form. Note that any such changes are stored only in the current Cutting Strategy, and a change to the actual Default Price must be done in the Log Product Definition itself.

Priority List bucking

For each log product, a priority must be set using the Priority buttons, and the maximum number of logs that can be cut from a stem must also be specified, in the Max/Stem field. For example, for the following values:
<table><tr><th>Log Type</th><th>Priority</th><th>Max/Stem</th></tr><tr><td>Pruned</td><td>1</td><td>1</td></tr><tr><td>Sawlog</td><td>2</td><td>3</td></tr><tr><td>Pulp</td><td>3</td><td>99</td></tr></table>
the Priority List bucker would try to first cut one Pruned log from the stem, then up to three Sawlogs, then as many Pulp logs (up to 99) as it can.</td></tr>
<tr><td>Order ⇑
Order ⇓</td><td>These buttons change the order of the selected log product as displayed in reports.</td></tr>
<tr><td>For Priority List bucking:
Priority ⇑
Priority ⇓</td><td>These buttons change the priority of the selected log product. This sets the order in which the bucker tries to cut each log product from a stem - see Bucking Mode above.</td></tr>
</table>

Standard Cutting Strategies

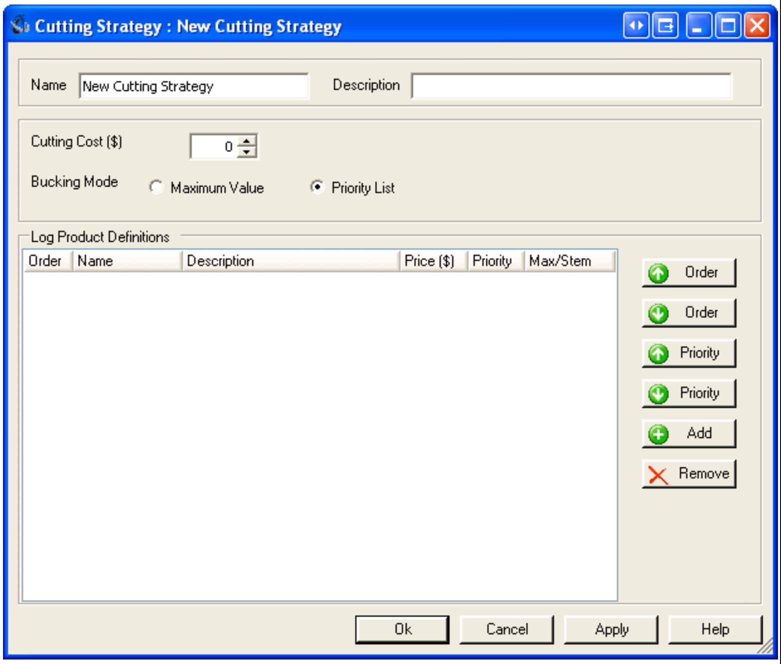
Some standard cutting strategies are available, based on the standard (New Zealand-based) Log Product Definitions.

Creating a New Cutting Strategy

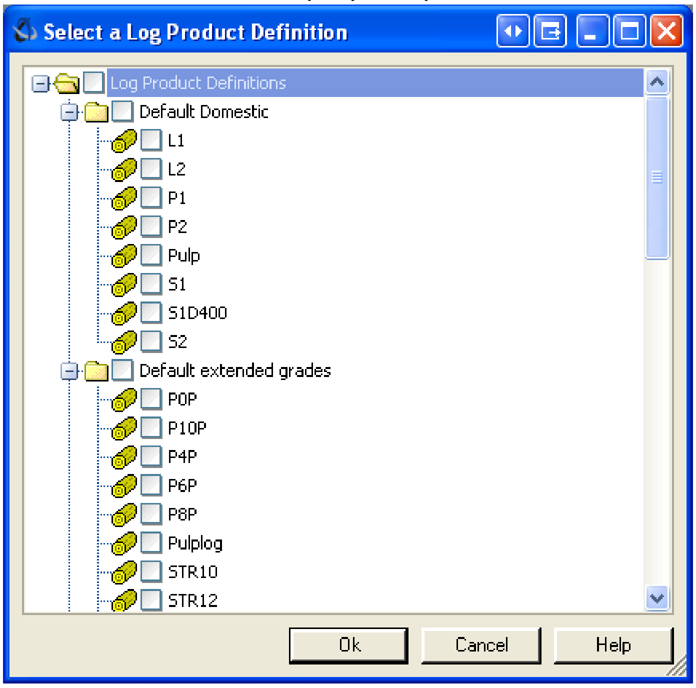
<table>
<tr><th>Step</th><th>Action</th><th>Key Point</th></tr>
<tr><td>1</td><td>Check for Log Product Definitions</td><td>Have the required Log Product Definitions been created yet? If not, refer to Log Product Definitions.</td></tr>
<tr><td>2</td><td>Create a new Cutting Strategy</td><td>

- In the Tree View Pane, select the folder (under the Cutting Strategies sub-tree) in which the new Cutting Strategy is to be created.
- Select **New** from the **File** menu or main toolbar, or right-click in the List View Pane and select **New** from the context menu.

This creates a new Cutting Strategy, and opens the maintenance form for
content:



</td></tr>
<tr><td>3</td><td>Enter a Name and Description</td><td>Enter a name and description for the new strategy. Note that the name can be changed at any stage from within the List View Pane.</td></tr>
<tr><td>4</td><td>Enter a Cutting Cost</td><td>Enter a value representing the cost of making a sawcut ($).</td></tr>
<tr><td>5</td><td>Enter the Bucking Mode</td><td>The Bucking Mode can be set to either Maximum Value (optimising) or Priority List.</td></tr>
</table>

<table>
<tr><th>Step</th><th>Action</th><th>Key Point</th></tr>
<tr><td>6</td><td>Add the required Log Product Definitions</td><td>• Click Add, which will display the product selection form:


• Select one or more Log Product Definitions.
• Click Ok to add the selected products.</td></tr>
<tr><td>7</td><td>Set the Print Order for each product</td><td>Use the paired Order buttons to make any changes to the selected product's Print Order setting.</td></tr>
<tr><td>8</td><td>For Priority List bucking only:
set the Priority and log limit for each product</td><td>Use the paired Priority buttons to make any changes to the selected product's Priority setting.
In the product's Max/Stem field, enter the maximum number of logs of this product that can be cut from any stem.</td></tr>
<tr><td>9</td><td>Save changes</td><td>Click Ok to save all changes and exit to the Forecaster GUI, or click Apply to save changes and stay in the maintenance form.</td></tr>
</table>

Report Options

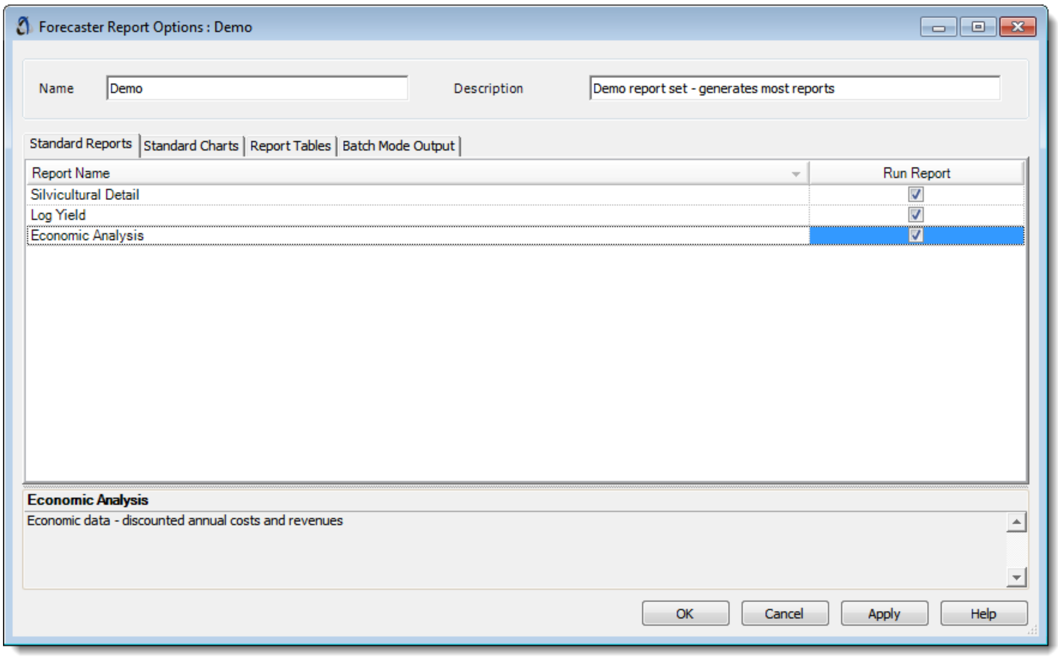
Because Forecaster models a large amount of information, the information about the crop as its growth is simulated is not retained unless it is needed. This approach helps to improve the performance of the system by producing only the information that the user needs to compile yield tables, schedule silvicultural events or compare different regimes.

Each set of report options describes the types of information that will be produced from one simulation, that is, when a project is analysed (see Projects). Within the simulation, results for one or more scenarios are generated, and all the information is keyed by the scenario ID.

- Simulation reports are available from within the Report Manager following a successful simulation.
- Basic information about each scenario is published in the Scenario Detail Table.
- Pruning events are covered by the Silvicultural Detail Table.
- Standard Reports and Standard Charts are produced in PDF format.

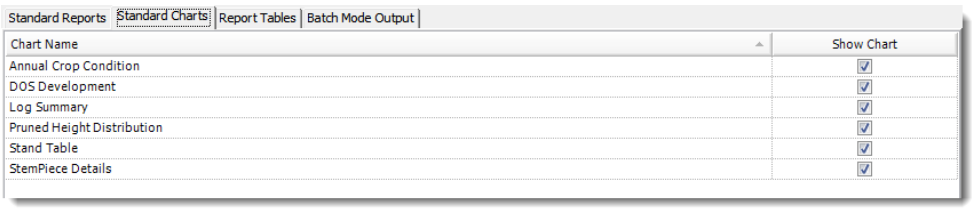
Report tables will be automatically created where they are required to generate the standard reports and charts that have been selected. Additional report tables can also be selected for generation.

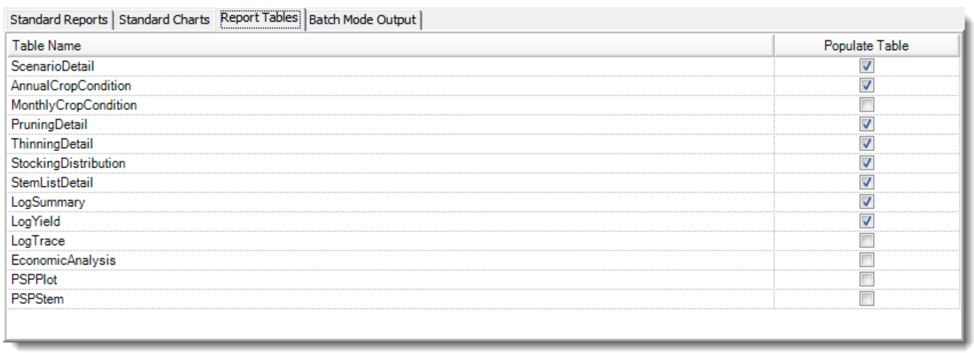
Report Options - Main form



Field/function

The following table describes the fields and tabs in the Report Options form:

<table>
<tr><th>Field/Tab</th><th>Function</th></tr>
<tr><td>Name/Description</td><td>A set of report options must have a name.
A description is useful so that users can more easily decide whether reports are appropriate for a particular simulation.</td></tr>
<tr><td>Report/Chart/Table Name</td><td>The name of the pre-configured report, chart or table</td></tr>
<tr><td>Standard Reports tab</td><td>Lists a small number of standard reports that are available in PDF format:
• Silvicultural Details Report
• Log Yield Report
• Economic Analysis Report
The reports are only available if their corresponding tables have also been selected in the Report options.
See Available Standard Reports for examples.</td></tr>
<tr><td>Standard Charts tab</td><td>Lists available standard charts. See Available Standard Charts for examples:


Log Summary activates Log Yield Graph in the Report Manager.</td></tr>
<tr><td>Report Tables tab</td><td>Lists available report tables. See Available Report Tables for examples:


Note: The Scenario Detail table is always produced, even when that option is not selected.</td></tr>
<tr><td>Batch Mode Output tab</td><td>Refer to Batch Mode Output later in this section.</td></tr>
</table>

Minimum Chart and Report Selection

If no charts or reports are selected then the following are still produced:

- Scenario Detail report

- Log Yield table - provided there is a clearfell event.

In this section

This section contains the following topics:

Available Standard Reports

At the end of a simulation, a number of standard reports are available in PDF format via the Report Manager **Reports** menu:

- Silvicultural Details Report
- Log Yield Report
- Economics Analysis Report

The reports are only available if the appropriate tables have been selected in the Report Options entity associated with the simulated project.

Silvicultural Details Report

This PDF report summarises pruning and thinning events. Under the pruning section, reported information includes a summary of the scheduling/prescription, and metrics relating to each pruning event (up to 4 lifts), as well as charts of DOS distribution and pruned height distribution. Under the thinning section, relevant metrics relating to pre-thin, post-thin, and the removed element are presented for up to 4 thinning events, as well as charts of DBH distributions (pre- and post-thinning), and stocking through time.

The charts included in this report are also available via the Charts menu option in the Report Manager.

This report will only be available if both the Pruning and the Thinning Details Tables have been selected in the Report Options entity associated with the simulated project:

Silvicultural Details Report

FFR Forecaster

Silvicultural Details Report

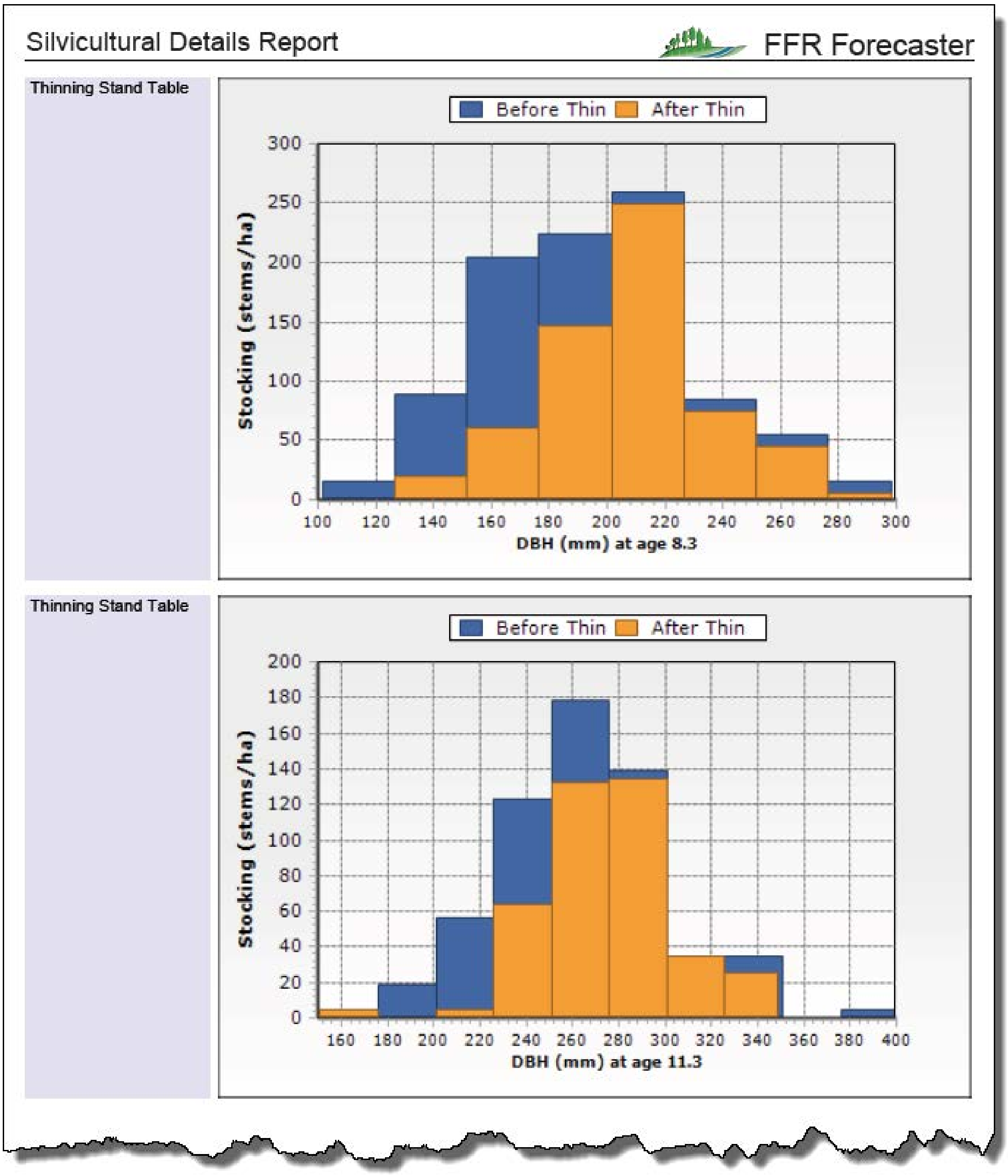
ScenarioID	7c8ba758-20d1-4020-8dd4-7d69bc347c89	**Simulation Start Time**	8-Oct-2013 1:16:33 p.m.
Project	\Projects\Framing multi-thin		
Crop	\Crops\FFR Q Silv Workshop\WAKA 1000		
Site	\Sites\FFR Q Silv Workshop\Whakarewarewa Forest		
Regime	\Regimes\FFR Q Silv Workshop\Framing\Testing Multi-thin\No CF\Framing - multi-thin		
Function Set	\Function Sets\Regional Function Sets\Central_North_Island		

Site Productivity Indices

Height (Site) Index (m)	34.0
300 Index (m3/ha/annum)	28.0

Thinning Details

	Thin 1	Thin 2	Thin 3	Thin 4
Month Year	October 2021	October 2024		
Age (years)	8.3	11.3		
Scheduled On	Crop.Age = 8.5	Crop.Age = 11.5		
Thin Type	WasteThin	WasteThin		
Stem Selection	Residual Stocking 600	Residual Stocking 400		
Stem Ordering	SmallestDbhxHeight(2.4)	SmallestDbhxHeight(3.0)		
Stocking (stems/ha)	945 - 345 = 600	596 - 196 = 400		
Basal Area (m2/ha)	28.87 - 8.33 = 20.54	33.37 - 9.30 = 24.07		
Q M Diam Before (mm)	197	267		
Q M Diam Removed (mm)	175	246		
Q M Diam After (mm)	209	277		
M Height Before (m)	12.7	19.0		
M Height After (m)	13.1	19.3		
M Top Height Before (m)	14.0	19.8		
M Top Height After (m)	13.7	19.7		
Thinning Coefficient	0.749	0.819		
Area Lost (%)	0.0	0.0		
Stems DBH >200mm (s/ha)	40	176		


Silvicultural Details Report
FFR Forecaster
Thinning Stand Table
Before Thin
After Thin
Stocking (stems/ha)
300
250
200
150
100
50
0
100 120 140 160 180 200 220 240 260 280 300
DBH (mm) at age 8.3
Thinning Stand Table
Before Thin
After Thin
Stocking (stems/ha)
200
180
160
140
120
100
80
60
40
20
0
160 180 200 220 240 260 280 300 320 340 360 380 400
DBH (mm) at age 11.3

Log Yield Report

This PDF report summarises log-making information, including log product yields (both gross and net) and value (derived from the net volume and the price stored in the cutting strategy). This report will only be available if the Log Yield Table has been selected in the Report Options entity associated with the simulated project.

Log Yield Report FFR Forecaster

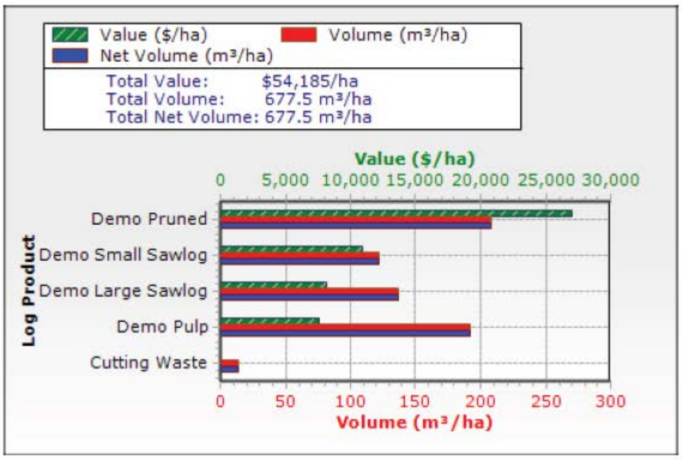
Log Yield Report

ScenarioID	89c0b666-1245-4b0e-a5cf-036b5435c045	**Simulation Start Time**	12/11/2012 9:59:55 a.m.
Project	\Projects\Demo Project		
Crop	\Crops\DemoData\Demo1		
Site	\Sites\Demodata\BoP Medium		
Regime	\Regimes\DemoData\Demo1		
Function Set	\Function Sets\Public Domain Demo Data\Demo 1		
Cutting Strategy	\Cutting Strategies\DemoData\Demo Strategy		

Clearfell at Age 30

	Volume		Net Volume		Value		Logs	Log Volume	Log SED	Log Length
	m³/ha	%	m³/ha	%	$/ha	%	logs/ha	m³/log	mm	m
Demo Pruned	208.8	32	208.8	32	27,141	50	307	0.7	367	5.5
Demo Small Sawlog	122.5	18	122.5	18	11,023	20	280	0.4	268	6.2
Demo Large Sawlog	138.2	21	138.2	21	8,294	15	222	0.6	313	6.9
Demo Pulp	193.2	29	193.2	29	7,727	14	552	0.4	242	5.8
Total Recovered Vol	662.7	100	662.7	100	54,185	100	1,361			
Total Recovered Vol	662.7	87	662.7							
Trim Allowance Waste			0.0							
Cutting Waste	14.8	2	14.8							
Total Extracted Vol	677.5		677.5							
Felling Waste	85.9	11	85.9							
Total Standing Vol	763.3	100	763.3							

Clearfell at Age 30.00



Forecaster v1.12.0.1028 Page 1 of 1 Prepared by snookj at 12/11/2012 10:11 a.m.

Economic Analysis Report

The Economic Analysis Report presents the results of an economic analysis in several different summarised forms:

- A Financial Summary, which lists the NPV, IRR (if calculable), LEV, Stumpage, and Break-even Log Price for each clearfell age at the base discount rate
- A Cash-flow Analysis, which lists the various cash-flow items, the age(s) at which they were applied, and the resulting discounted and undiscounted amounts. The Harvesting-related costs and revenues are grouped by clearfell age, and relevant values are totalled.
- A Sensitivity Analysis, which lists the NPV, IRR (if calculable), LEV, Stumpage, and Break-even Log Price for combinations of clearfell age, discount rates (the base rate ± any variation specified), and cost/price variations.

Economic Analysis Report

FFR Forecaster

Simulation Start Time	16-Nov-2012 1:56:09 p.m.
Project	\Projects\Demo Project
Crop	\Crops\DemoData\Demo1
Site	\Sites\Demodata\BoP Medium
Regime	\Regimes\DemoData\Demo1
Function Set	\Function Sets\Public Domain Demo Data\Demo 1
Economic Settings	\Economic Settings\Demo
Cutting Strategy	\Cutting Strategies\DemoData\Demo Strategy
Clearfell Age(s)	25, 30, 35, 40

Summary Information

Earliest Age of Stand Management	-1 years	**Area in Addition to Planted Area**	0.10 ha/ha
Base Discount Rate	7.0%	**Initial Land Value**	$1,980/ha
Carbon Discount Rate	7.0%	**Final Land Value (at Cutover)**	$1,980/ha

Financial Summary

Clearfell Age (years)	Discount Rate (%)	NPV ($/ha)	IRR (%)	LEV ($/ha)	Stumpage ($/ha)	Breakeven Price ($/m^3)
25	7.0	-441.69	6.56	-533.57	40298.77	89.98
30	7.0	-482.42	6.60	-549.94	54185.44	90.69
35	7.0	2144.98	8.46	5131.64	66169.70	67.13
40	7.0	1213.67	7.79	2903.57	77884.29	80.39

Economic Analysis Report

FFR Forecaster

Cashflow Analysis

Category	Item	Age (years)	Cost ($/ha)	Disc. Cost ($/ha)	Revenue ($/ha)	Disc. Revenue ($/ha)	Quantity	Units	Price per Unit ($)
General	Fencing	-1	150.00	150.00					
Land	Initial Land Value	-1	1980.00	1980.00					
General	Animal Control	0	3.00	2.80					
General	Spot Spray	0	50.00	46.73					
Planting	Planting	0	250.00	233.64					
General	Animal Control	1	3.00	2.62					
General	Animal Control	2	3.00	2.45					
General	Animal Control	3	3.00	2.29					
General	Animal Control	4	3.00	2.14					
General	Dothi	4	50.00	35.65					
General	Animal Control	5	3.00	2.00					
General	Dothi	5	50.00	33.32					
Pruning 1	Pruning - Lift 1	5	900.00	599.71					
Waste Thinning 1	Thinning 1	5	200.00	133.27					
General	Dothi	6	50.00	31.14					
Pruning 2	Pruning - Lift 2	6	800.00	498.20					
General	Dothi	7	50.00	29.10					
Pruning 3	Pruning - Lift 3	8	1250.00	679.92					
Totals:				**4464.97**		**0.00**			
Clearfell at 25 yrs									
Clearfell	Demo Pruned	25			23610.59	4065.64	181.6	m^3/ha	130.00
Clearfell	Demo Small Sawlog	25			6033.74	1038.98	67.0	m^3/ha	90.00
Clearfell	Demo Pulp	25			8657.39	1490.76	216.4	m^3/ha	40.00
Clearfell	Demo Large Sawlog	25			1997.05	343.88	33.3	m^3/ha	60.00
Clearfell	Felling & Extraction	25	7688.29	1323.89			512.6	m^3/ha	15.00
Clearfell	Transport	25	4612.98	794.33			512.6	m^3/ha	9.00
Clearfell	Logging Overhead	25	1537.66	264.78			512.6	m^3/ha	3.00
Clearfell	Roading	25	1500.00	258.29					
Annual	Forestry	-1 to 25	1296.00	615.64					
Land	Final Land Value	25			1980.00	340.95			
Totals:				**3256.93**		**7280.21**			
Clearfell at 30 yrs									
Clearfell	Demo Pruned	30			27141.49	3332.24	208.8	m^3/ha	130.00
Clearfell	Demo Small Sawlog	30			11023.17	1353.35	122.5	m^3/ha	90.00
Clearfell	Demo Pulp	30			7726.94	948.66	193.2	m^3/ha	40.00
Clearfell	Demo Large Sawlog	30			8293.84	1018.26	138.2	m^3/ha	60.00
Clearfell	Felling & Extraction	30	9484.52	1164.44			677.5	m^3/ha	14.00
Clearfell	Transport	30	6097.19	748.57			677.5	m^3/ha	9.00

Forecaster v1.12.0.1075 Page 2 of 5 Prepared by clementb at 16-11-2012 2:01 p.m.

Economic Analysis Report

FFR Forecaster

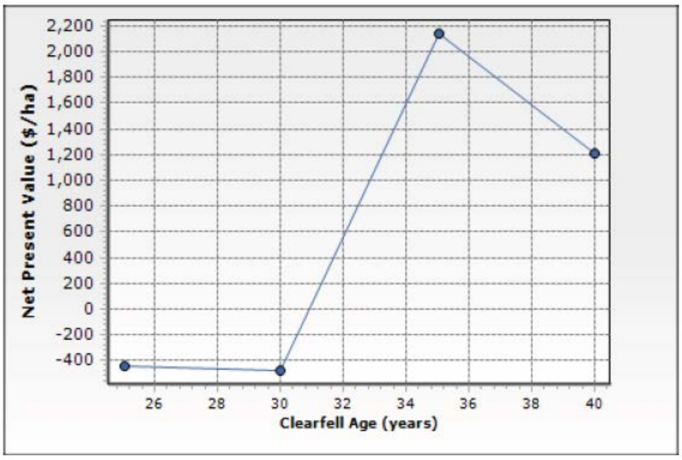
Sensitivity Analysis

		Sensitivity Analysis Variations										
Clearfell Age (yrs)	Disc. Rate (%)	Carbon Price (%)	Log Prices (%)	Gen. Costs (%)	Ann. Costs (%)	Event Costs (%)	Harv. Costs (%)	NPV ($/ha)	IRR (%)	LEV ($/ha)	Stumpage ($/ha)	Brkeven Price ($/m³)
25	4.0	0.0	0.0	0.0	0.0	0.0	0.0	3956.89	6.56	6189.31	40298.77	62.82
25	4.0	0.0	-3.0	0.0	0.0	0.0	0.0	3520.83	6.33	5507.23	39089.81	62.82
25	4.0	0.0	3.0	0.0	0.0	0.0	0.0	4392.95	6.77	6871.39	41507.73	62.82
25	7.0	0.0	0.0	0.0	0.0	0.0	0.0	-441.69	6.56	-533.57	40298.77	89.98
25	7.0	0.0	-3.0	0.0	0.0	0.0	0.0	-649.87	6.33	-785.05	39089.81	89.98
25	7.0	0.0	3.0	0.0	0.0	0.0	0.0	-233.51	6.77	-282.08	41507.73	89.98
25	10.0	0.0	0.0	0.0	0.0	0.0	0.0	-2312.94	6.56	-2524.78	40298.77	140.14
25	10.0	0.0	-3.0	0.0	0.0	0.0	0.0	-2414.38	6.33	-2635.51	39089.81	140.14
25	10.0	0.0	3.0	0.0	0.0	0.0	0.0	-2211.50	6.77	-2414.06	41507.73	140.14
30	4.0	0.0	0.0	0.0	0.0	0.0	0.0	5348.00	6.60	7601.55	54185.44	57.53
30	4.0	0.0	-3.0	0.0	0.0	0.0	0.0	4866.08	6.43	6916.57	52559.88	57.53
30	4.0	0.0	3.0	0.0	0.0	0.0	0.0	5829.91	6.77	8286.54	55811.00	57.53
30	7.0	0.0	0.0	0.0	0.0	0.0	0.0	-482.42	6.60	-549.94	54185.44	90.69
30	7.0	0.0	-3.0	0.0	0.0	0.0	0.0	-682.00	6.43	-777.45	52559.88	90.69
30	7.0	0.0	3.0	0.0	0.0	0.0	0.0	-282.85	6.77	-322.43	55811.00	90.69
30	10.0	0.0	0.0	0.0	0.0	0.0	0.0	-2622.99	6.60	-2767.15	54185.44	160.73
30	10.0	0.0	-3.0	0.0	0.0	0.0	0.0	-2707.68	6.43	-2856.50	52559.88	160.73
30	10.0	0.0	3.0	0.0	0.0	0.0	0.0	-2538.30	6.77	-2677.81	55811.00	160.73
35	4.0	0.0	0.0	0.0	0.0	0.0	0.0	12254.24	8.46	45502.38	66169.70	26.71
35	4.0	0.0	-3.0	0.0	0.0	0.0	0.0	11770.53	8.36	43706.29	64184.61	26.71
35	4.0	0.0	3.0	0.0	0.0	0.0	0.0	12737.94	8.56	47298.47	68154.79	26.71
35	7.0	0.0	0.0	0.0	0.0	0.0	0.0	2144.98	8.46	5131.64	66169.70	67.13
35	7.0	0.0	-3.0	0.0	0.0	0.0	0.0	1971.21	8.36	4715.92	64184.61	67.13
35	7.0	0.0	3.0	0.0	0.0	0.0	0.0	2318.75	8.56	5547.36	68154.79	67.13
35	10.0	0.0	0.0	0.0	0.0	0.0	0.0	-1325.47	8.46	-2484.52	66169.70	166.15
35	10.0	0.0	-3.0	0.0	0.0	0.0	0.0	-1389.69	8.36	-2604.89	64184.61	166.15
35	10.0	0.0	3.0	0.0	0.0	0.0	0.0	-1261.26	8.56	-2364.15	68154.79	166.15
40	4.0	0.0	0.0	0.0	0.0	0.0	0.0	11729.26	7.79	43553.02	77884.29	27.75
40	4.0	0.0	-3.0	0.0	0.0	0.0	0.0	11261.30	7.71	41815.41	75547.76	27.75
40	4.0	0.0	3.0	0.0	0.0	0.0	0.0	12197.21	7.87	45290.63	80220.82	27.75
40	7.0	0.0	0.0	0.0	0.0	0.0	0.0	1213.67	7.79	2903.57	77884.29	80.39
40	7.0	0.0	-3.0	0.0	0.0	0.0	0.0	1067.84	7.71	2554.69	75547.76	80.39
40	7.0	0.0	3.0	0.0	0.0	0.0	0.0	1359.49	7.87	3252.44	80220.82	80.39
40	10.0	0.0	0.0	0.0	0.0	0.0	0.0	-1901.60	7.79	-3564.44	77884.29	228.46
40	10.0	0.0	-3.0	0.0	0.0	0.0	0.0	-1948.53	7.71	-3652.41	75547.76	228.46
40	10.0	0.0	3.0	0.0	0.0	0.0	0.0	-1854.67	7.87	-3476.47	80220.82	228.46

Economic Analysis Report

FFR Forecaster

Net Present Value

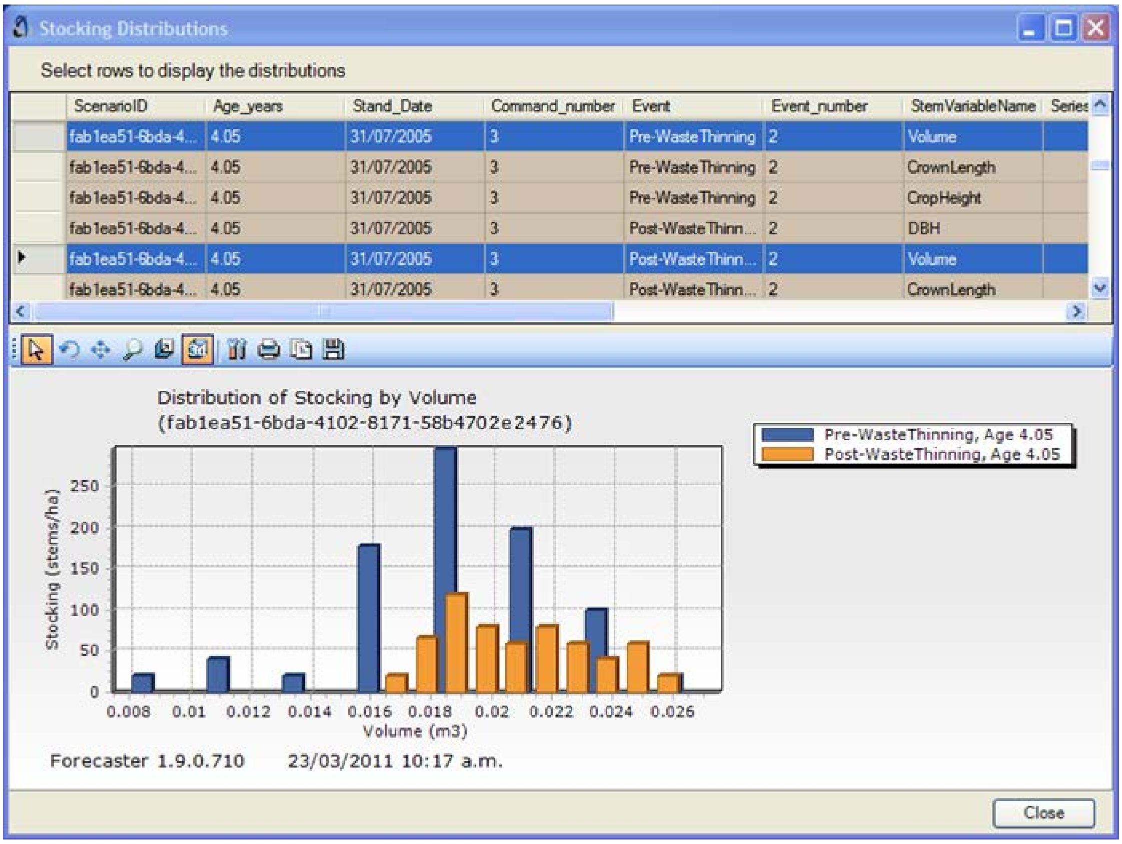


Available Standard Charts

At the end of a simulation, a number of on-screen graphs are available via the Report Manager **Graphs** menu:

Stocking Distributions Graph

The **Graphs | Stocking Distributions** menu command is available if the stocking distributions report table contains information for the selected scenarios. Selecting this menu item will open a report window showing the rows in the report table with histograms of the selected distributions below it:



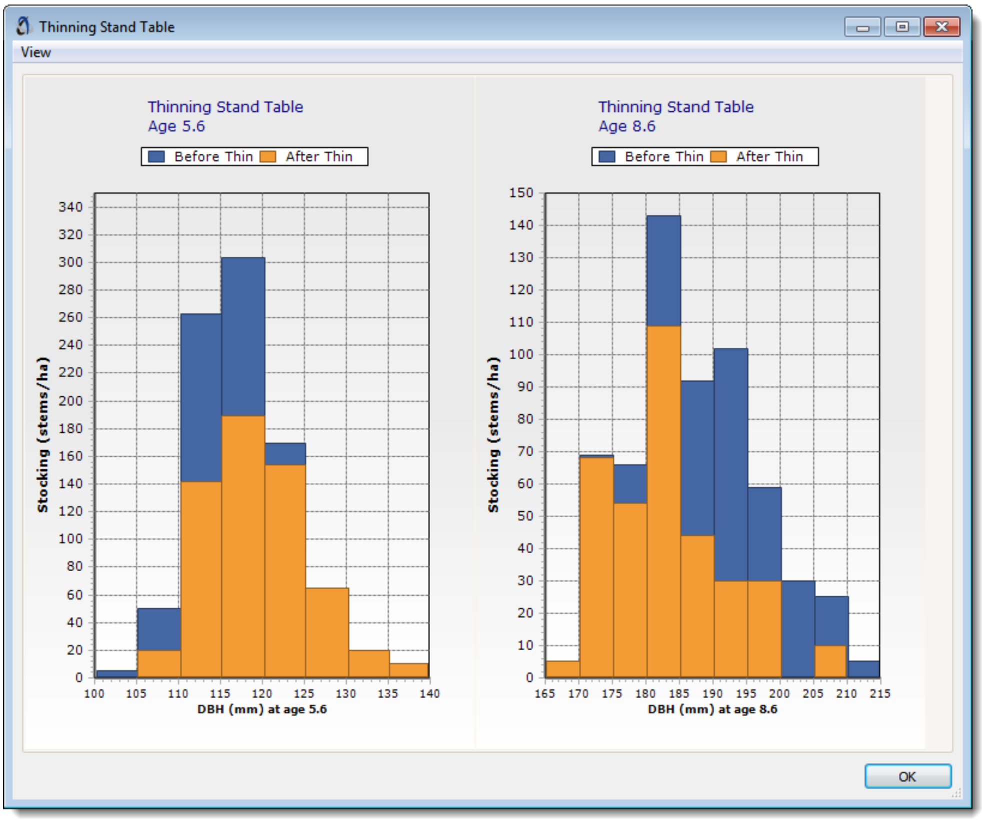
The distribution of stocking can be viewed by stem variables such as DBH, stem Volume, height as well as pruning variables. Rows can be selected by a single click anywhere in the row (use **Ctrl-click** or **Shift-click** to select several rows). Note that only one variable at a time can be used to classify stocking. In a selection of rows containing several variables, those which do not match the first row are ignored. For example, pressing **Ctrl-A** to select all rows will show all the DBH distributions in the report table. Each histogram (vertical bar series) is keyed by colour, and the legend on the right lists the corresponding events and ages.

Holding the mouse over a bar on the report will pop-up the X,Y values of the item. Clicking and dragging from top, left to bottom, right will zoom to the selected rectangle. The reverse gesture will un-zoom.

The tool-bar above the chart can be used to change the style of the report, and to print, copy and save.

Thinning Stand Table

A specific sub-set of the options available in the Stocking Distributions Graph, the Thinning Stand Table illustrates the distribution of stocking across DBH classes at the time of each thinning event. In the example below, the crop remaining after thinning is represented by the gold bars, while the blue and gold together represent the crop prior to thinning. These charts are useful to examine which part of the stemlist is being thinned out. In the example below, the first thinning targets the smallest stems, while the second thinning (following 2 further pruning lifts) removes the unpruned stems, which have now outgrown the pruned stems and so make up the large end of the DBH distribution:

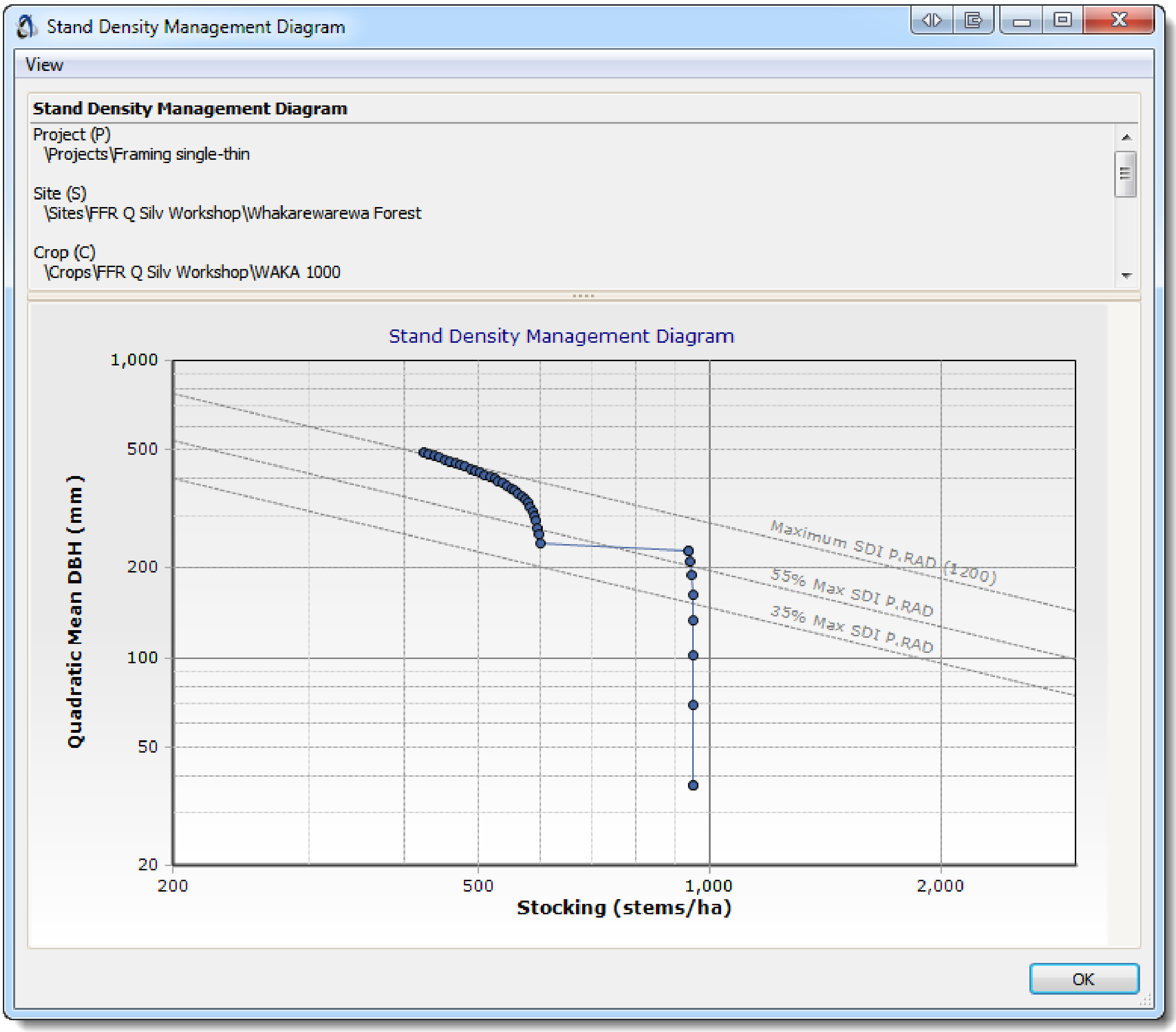


Stand Density Management Diagram

The Stand Density Management Diagram[(32)] illustrates the development of a stand through time represented as a plot of stand density (stocking) against quadratic mean DBH, on a log-log scale.

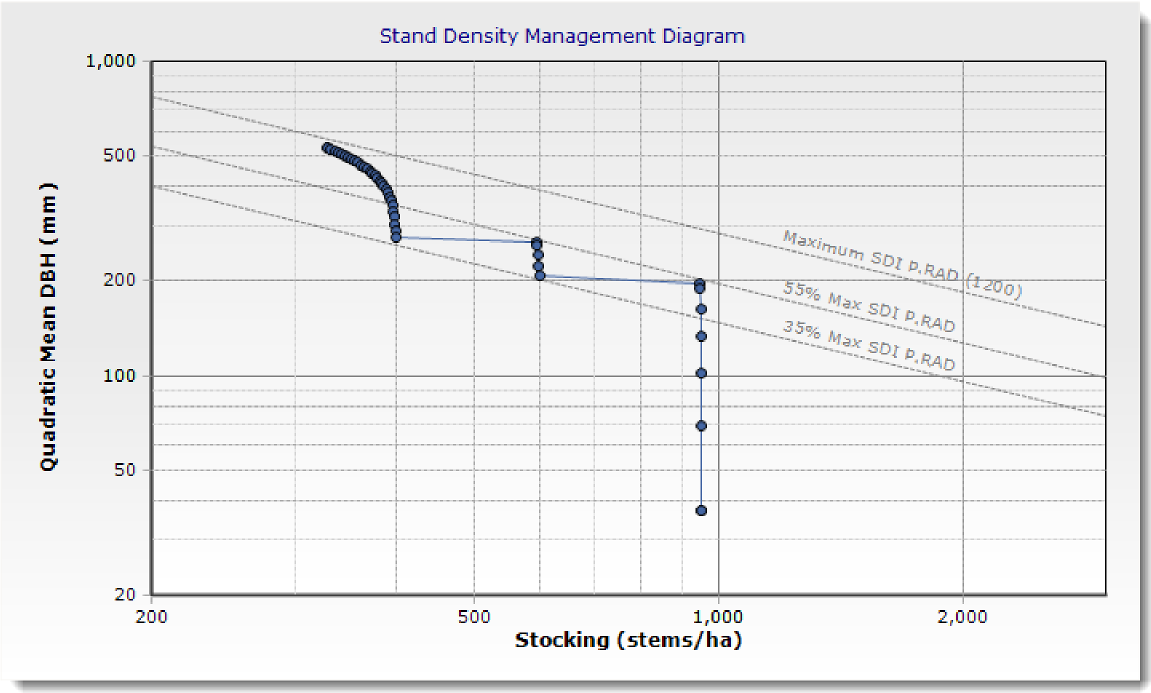
Stand age is not explicitly illustrated, but is represented by the progress of the plot upwards and to the left of the plot area. Thus, the development of the stand can be followed by starting at the bottom of the plot, where stocking is closest to the planted stocking, and average DBH very small. As the average tree size increases, eventually the trees begin to compete with each other for resources which introduces mortality, so the stocking begins to decrease, shown by the plot tipping towards the left.

An upper limit on the size-density relationship has been observed (and frequently published for a multitude of species across the world), which essentially means that for any given stocking there is a maximum stem size which can be supported by the site's resources. This introduces an asymptote to the SDMD, which is represented by the "Maximum SDI" diagonal line, and relates to a maximum Stand Density Index, shown to be about 1200 for NZ-grown Pinus radiata (J. Moore, unpublished). As the stand continues to develop, the plot will approach this line, but competition-induced mortality will keep it from exceeding the maximum SDI. Note that in some cases (on fertile ex-farm sites, for example) the maximum SDI has been observed to be up to 1500, though 1200 is the norm in most cases.



Thinning events are easily interpreted, as they cause a sudden jump to the left, indicating an instantaneous reduction in stocking. The direction of the line indicates the type of thinning undertaken - when the line moves upward (as in the example below), the thinning is from below i.e. the smaller stems have been removed, thus increasing the average stem diameter. A horizontal line indicates a random thinning across the diameter range, while a downward line would indicate that the average stem diameter decreased as a result of the thinning (such thinning-from-above may occur in a clearwood regime where the pruned stems have been out-grown by the followers, or in production thinning regimes).

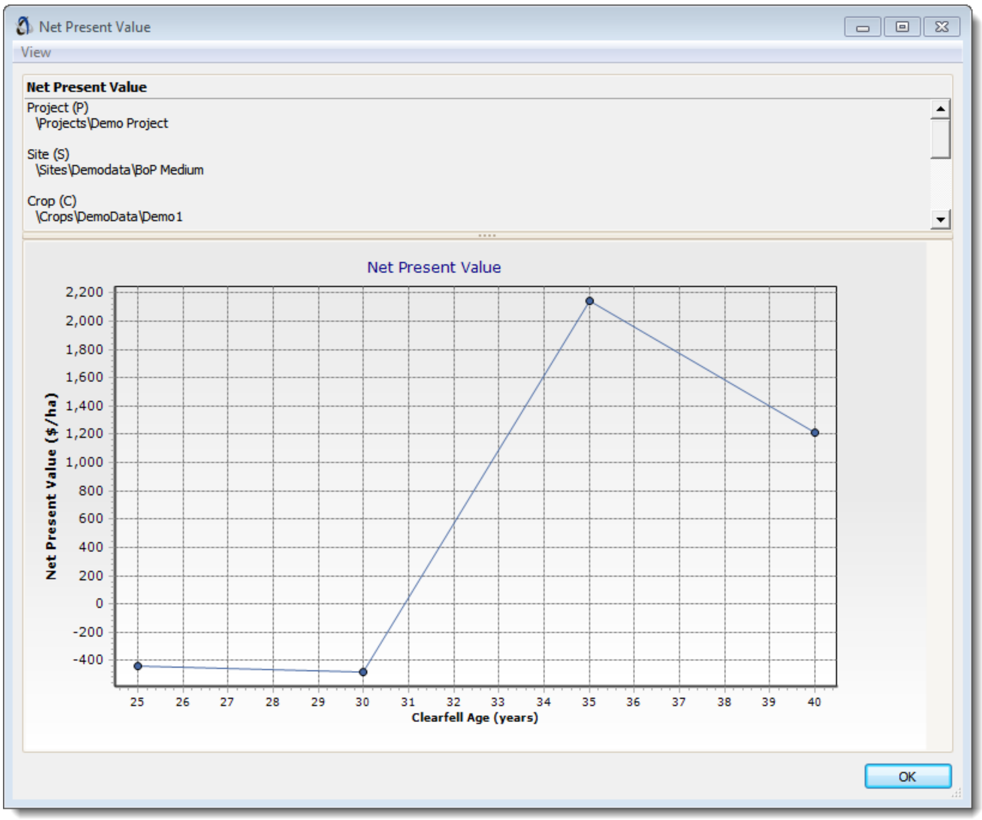
Managing the trade-off between individual tree vigour and competition-induced mortality requires knowledge of the size-density relationship, hence the SDMD can be used by foresters to help understand whether the stand is under- or over-stocked. When the SDI is between 35% and 55% of the maximum, the level of between-tree competition is ideal for promoting individual tree growth. When the SDI is lower than 35%, the stand is not taking full advantage of the site's resources. Above 55% and competition-induced mortality begins to increase much more rapidly. As such, thinning events can be timed to keep the stand within 35-55% of maximum SDI - a range known as the "management zone", and represented on the SDMD by 2 further dotted lines. Below is an example of a stand thinned to maximise time spent in the "management zone".



Net Present Value (NPV) Graph

This graph, accessed via **Graphs | NPV Graph**, is available for a simulation that includes an economic analysis. It displays values of NPV vs clearfell age for one or more scenario "groups", where a group is a number of scenarios with the same set of entities, but differing in clearfell age (typically from a regime with multiple clearfell ages). Each scenario group will produce a separate line on an NPV graph. Note that when selecting scenarios for an NPV graph, only one scenario from any group need be selected – all other available scenarios from that group will be automatically included in the graph.

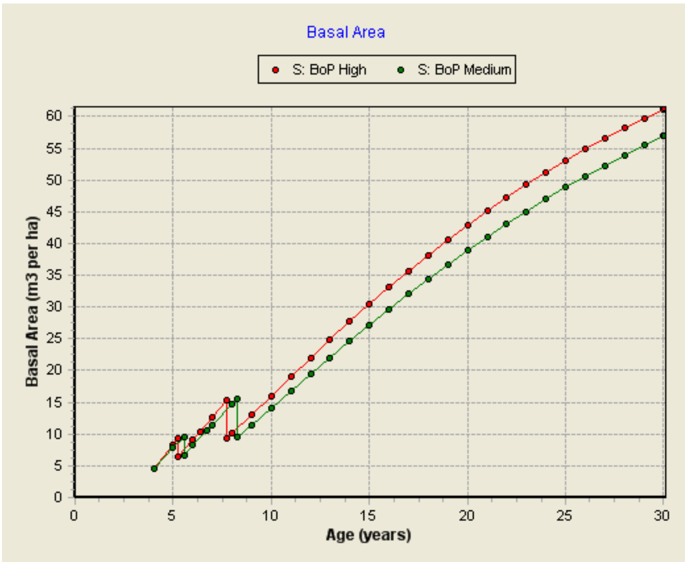
Note that when interpreting differences between the NPV curves of different regimes, users should be aware that the stochastic methods used throughout the modelling process can influence the final outcome of any simulation. To evaluate the impact, the random seed should be changed (see System Settings) and the simulation re-run. Repeating this 4-5 times should provide an indication of whether the differences are real or merely caused by these random effects. Doing this may show that the "lead" (in terms of NPV) changes between more than one regime under evaluation, which means that any differences between them cannot be quantified within Forecaster.



Variable-by-Age Graphs

A number graphs are available to display various stand-level measures throughout the period of the project's simulation, they are accessed via Report Manager's **Graphs | Variable By Age** menu item.

They can be used to compare results across different scenarios – to view more than one scenario on the same chart, select each of the scenarios in Report Manager before selecting the graph type. The following example compares the Basal Area growth of two sites:



StemPiece Details Chart

Refer to [StemPiece Details Chart] topic later in this section.

Available Report Tables

The following report tables can be exported in Excel or CSV formats:

Category	Table	Detail Level
Crop and Event Details	Stem List Detail	Stem
	Annual Crop Condition	Stand
	Monthly Crop Condition	Stand
	Silvicultural Detail	Stand
	Thinning Detail	Stand
	Stocking Distribution	Stand
Log Product Details	Log Trace	Log
	Log Yield	Stand
	Log Summary	Stand
	Yield Table	Stand
Scenario Details	Scenario Detail	Scenario
Economic Analysis	Economic Analysis	Stand

An example report table follows.

Annual Crop Condition

This table is intended to provide information about the growing stock (stocking, BA, volume, height measures, DBH, DOS, crown length). One record is written after every event and annually during a simulation.
This is a summary of the stem information in the Stem List Detail table.

By convention, fields that are prefixed "Min", "Q1", "Mean", "Q3", "Max" or "CV", refer to the minimum, first quartile, mean, third quartile, maximum and coefficient of variation of the named variable respectively. Numeric fields are suffixed with their units.
The ScenarioID field contains a unique label for the scenario that can be used as a foreign key to records in other tables. The combination of ScenarioID and Stand_Date is a unique key to each record. The fields are:

Field
ScenarioID
Site_Name[1]
Crop_Name[1]
Regime_Name[1]
FunctionSet_Name[1]
Age_years
Stand_Date
Event
Event_number
Stocking_stems_per_ha
MeanTopHeight_m
MeanHeight_m

Field
BasalArea_m2_per_ha
MeanTopDBH_mm
Stand_Volume_m3_per_ha
Mean_Annual_Increment_m3_per_ha_per_year
QMeanDBH_mm
Current_Annual_Increment_m3_per_ha_per_year
HeightDiameterRatio
MeanTopDos_mm
RelativeSpacing
MeanStemDBH_mm
MeanStemHeight_m
MeanStemCrownLength_m
MeanStemDos_mm
MeanCropHeight_m
MinStemDBH_mm
Q1StemDBH_mm
Q3StemDBH_mm
MaxStemDBH_mm
CVStemDBH
MinStemHeight_m
Q1SternHeight_m
Q3StemHeight_m
MaxStemHeight_m
CVStemHeight
MinStemCrownLength_m
Q1StemCrownLength_m
Q3StemCrownLength_m
MaxStemCrownLength_m
CVStemCrownLength
MinStemDos_mm
Q1StemDos_mm
Q3StemDos_mm
MaxStemDos_mm
CVStemDos
MinCropHeight_m
Q1CropHeight_m
Q3CropHeight_m
MaxCropHeight_m
CVCropHeight
SiteHeightIndex_m
Site300Index_m3_per_ha_per_year
Site400Index_m3_per_ha_per_year
Site500Index_m3_per_ha_per_year
Site1000Index_m3_per_ha_per_year
ThinningCoefficient
R1TotalCO2_E_t_per_ha

Field
R1AboveGroundLiveCO2_E_t_per_ha
R1BelowGroundLiveCO2_E_t_per_ha
R1DeadWoodyLitterCO2_E_t_per_ha
R1FineLitterCO2_E_t_per_ha
R2TotalCO2_E_t_per_ha
R2AboveGroundLiveCO2_E_t_per_ha
R2BelowGroundLiveCO2_E_t_per_ha
R2DeadWoodyLitterCO2_E_t_per_ha
R2FineLitterCO2_E_t_per_ha
R1ShrubUnderstoreyCO2_E_t_per_ha
R2ShrubUnderstoreyCO2_E_t_per_ha
ReinekesStandDensityIndex[2]

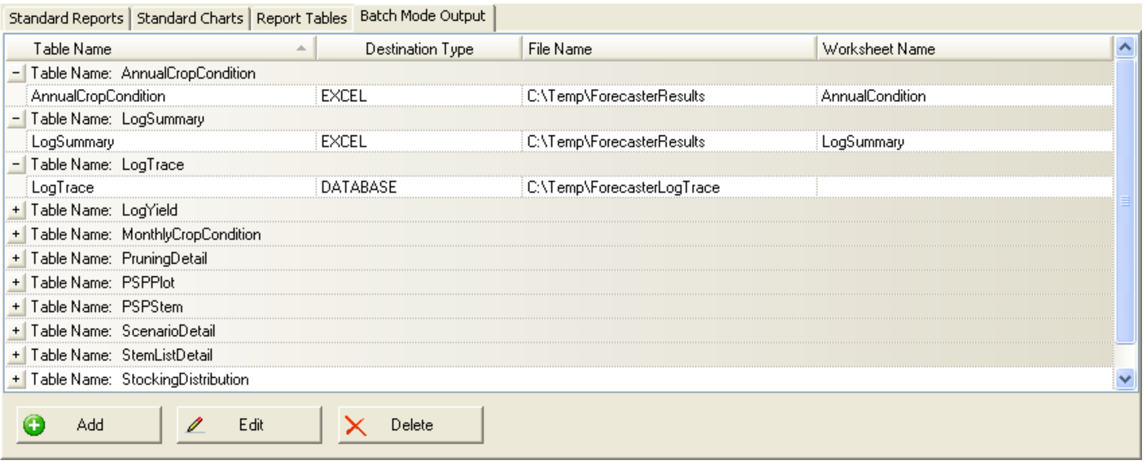
1. When “Export Entity Names” is checked in Report Manager

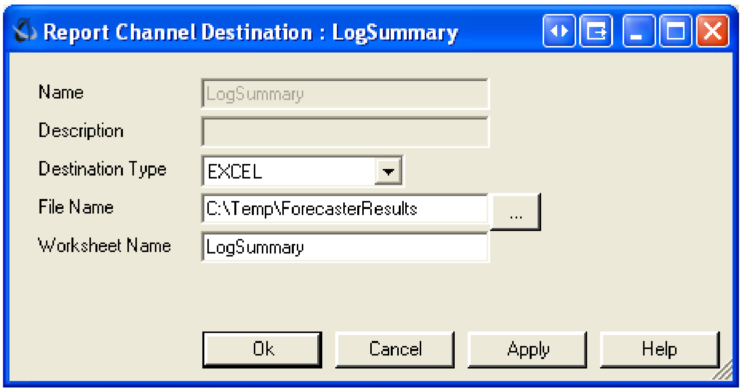
2. Reineke's Stand Density Index (RSDI) is a measure of site occupancy of a stand, which can be used to infer the level of competition, and also the biological potential of the stand. It can be thought of as converting both the stocking and BA to determine the "equivalent number of 10-inch stems per hectare", using the formula:

RSDI = Stocking × (Quadratic Mean DBH / 25.4) ^ 1.605 (where DBH is in cm)

Batch Mode Output

The Batch Mode Output option is used when Forecaster is run from a command line. For each selected table, output can be written to either a CSV file or an Excel file (if the latter, the worksheet name can be specified). The tables cannot yet be written to a database, and standard reports are not yet available in batch mode.



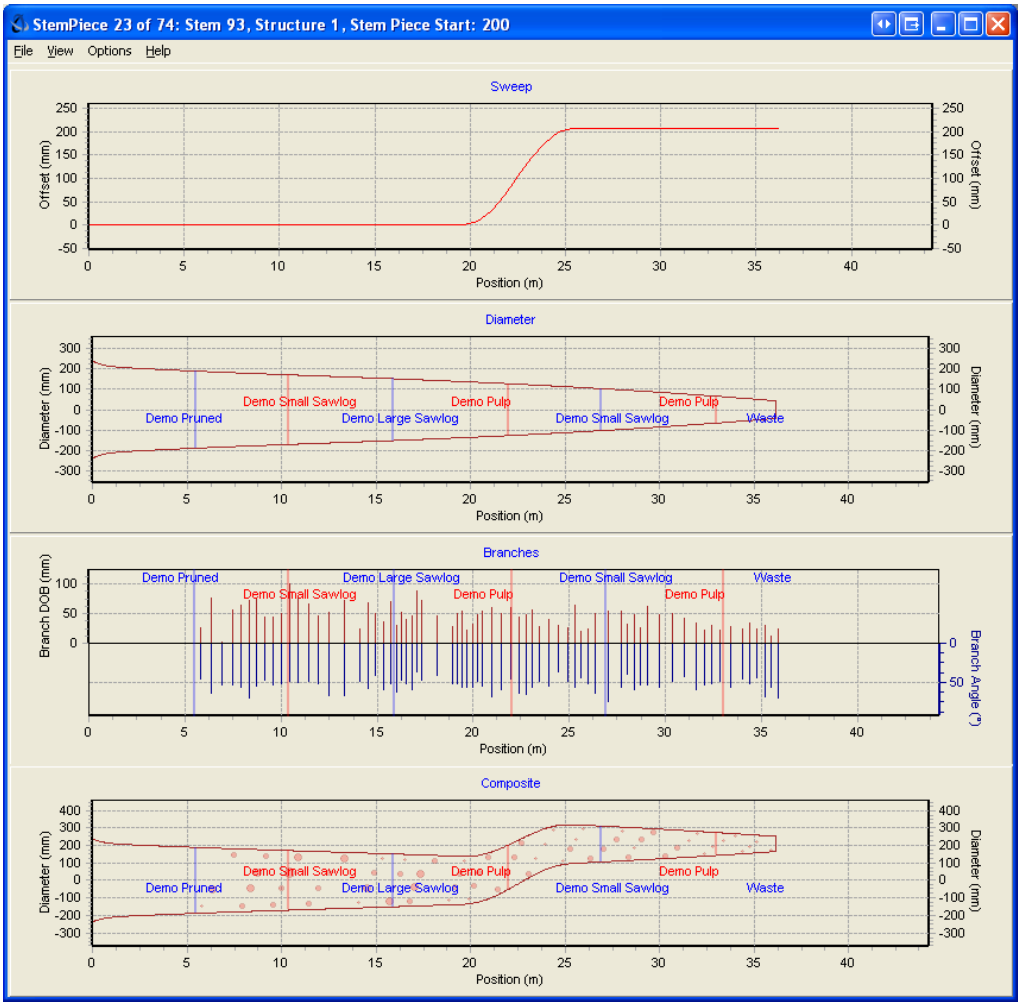
<table>
<tr><th>Field/Button</th><th>Function</th></tr>
<tr><td>Add button</td><td>Adds a blank line which can then be edited</td></tr>
<tr><td>Edit button</td><td>Displays the Report Channel Destination Form for the selected Table (also accessible by double clicking in the white line for the Table):


Complete the fields and click Ok.</td></tr>
<tr><td>Delete button</td><td>Deletes the Destination information for the selected selected Table.</td></tr>
</table>

StemPiece Details Chart

This chart requires the separate application, StemPiece Viewer, to be installed.

Selecting StemPiece Details Chart from the Report Manager opens the StemPiece Viewer application. The viewer displays stem-level information (on stem shape and size, branching and wood quality attributes) for the stempieces resulting from the currently selected scenario. This tool is especially useful for determining reasons for the distribution of volume among log products.

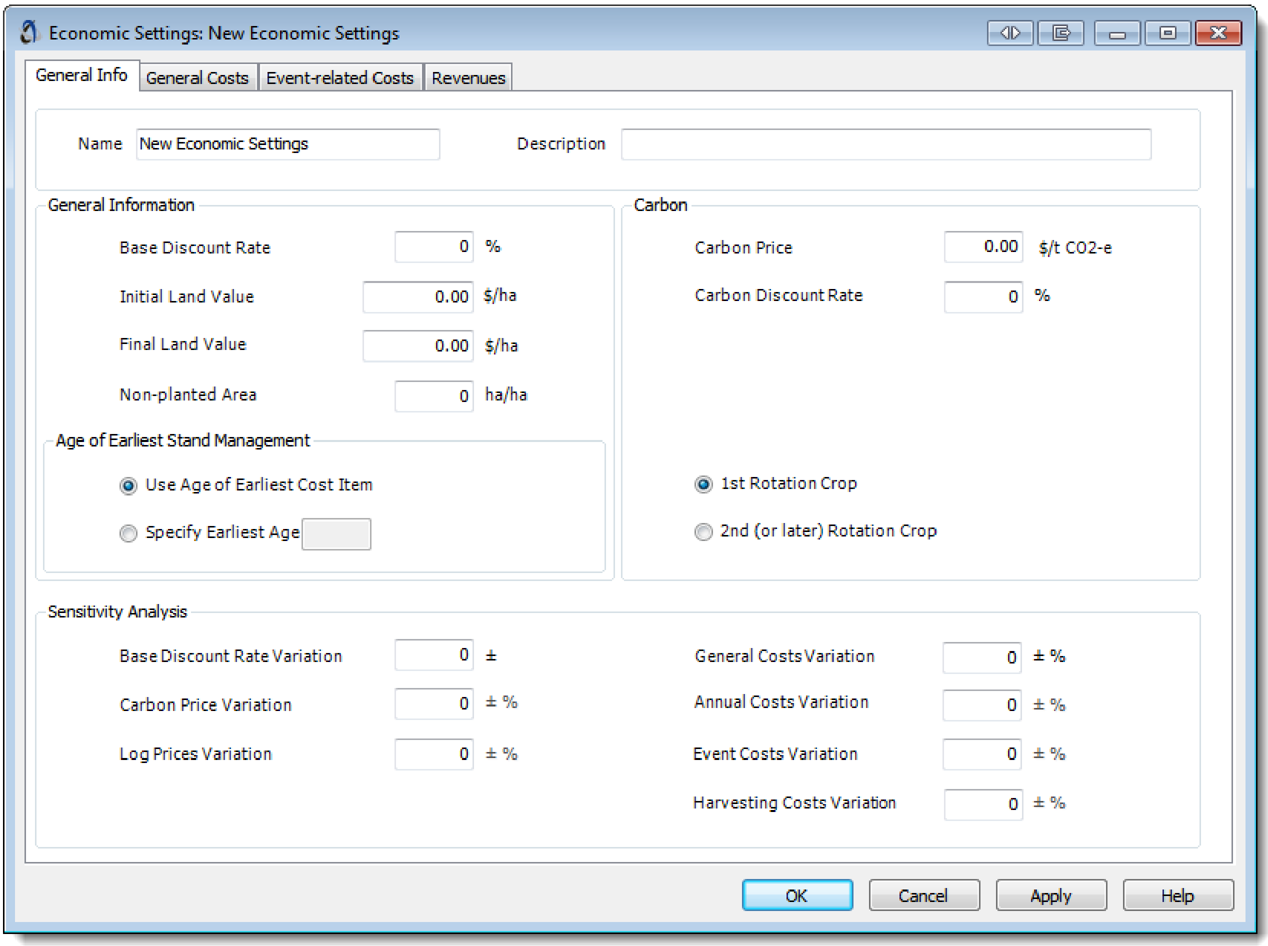


Economic Analysis

By associating an Economic Settings entity with a Project, the simulations using that Project can include an economic analysis.

Economic Settings Entity

An Economic Settings entity consists of a number of base settings, and several collections of cash flow items - costs and revenues. These are all entered and edited via the Economic Settings form:



General Information

Base Discount Rate

This is the rate at which all costs and revenues (except for Carbon, which has its own discount rate, see below) will be discounted back from the age at which they apply to the starting age.

Initial and Final Land Values

The planting and harvesting of a crop of trees will affect the condition of the land, changing its value between pre-planting and post-harvest. To cater for this, the land is effectively "bought" at the start of an economic analysis, and then "sold" when the crop is clearfelled. This avoids the problems of discount rates for the land and other costs differing, and of separating out the value of "improvements".

The initial land value is applied as a cost at the age of earliest stand management, and the final value as a revenue at the age of latest stand management (see below). To model lease-hold land, set the initial and final land values to zero, and enter land rental costs as an annual cost.

Non-planted Area

This is to allow for unplanted land, such as roads and fire-breaks. It is expressed as a proportion of the planted area, and is applied to the initial and final land values to increase them by the specified proportion, in order for the initial land cost and final land revenue to represent the total land area, i.e. both productive and non-productive. For example, if the non-planted area is 0.05 (5%) of the planted area, then the actual initial and final land values used in the economic analysis will be 105% of those specified in the Economic Settings.

Age of Earliest Stand Management

This is the age to which all cost and revenue items are discounted. It can be specified directly, or can be derived from other settings i.e. the earliest age of all General costs and any Planting-related costs (including any offset). If there are no such costs defined, a value of 0 will be used.

Note that the **latest** age of stand management is also derived - it is the latest of all General and Clearfell costs (including any offset).

Carbon

Where a simulation has included the modelling of carbon sequestration, its economic analysis will include the consequent costs and revenues. The sequence of modelled annual values of total biomass (as appear in the AnnualCropCondition table) are used to derive an annual increment - the difference between this year's value and last year's. Typically, that increment will be positive, and an instance of revenue is applied at that age. But when the increment is negative (for example, when there has been a production thinning or a clearfell event), then a cost is applied at that age.

Carbon Discount Rate

This is the rate at which all carbon costs and revenues will be discounted back from the age at which they apply to the starting age.

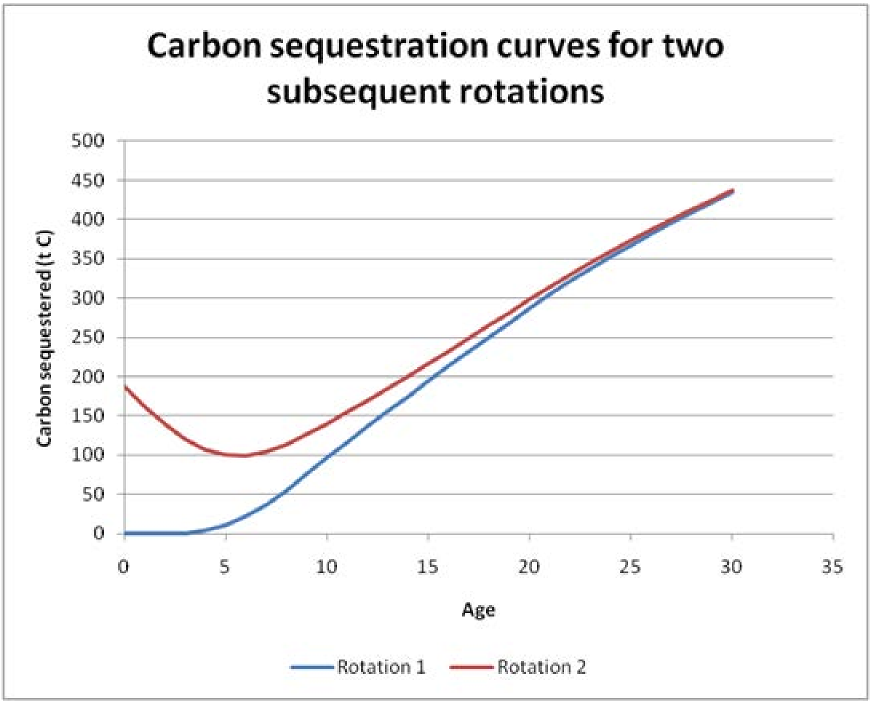
Note that if the Carbon Discount Rate has a different value from the Base Discount Rate, it is not possible for an Internal Rate of Return (IRR) to be calculated (because no single solution can be reached when solving IRR for more than one discount rate). In such cases the IRR column in the Economic Analysis table will be blank.

Carbon Price

This value is used to determine the value of an item of carbon cost or revenue from the the corresponding annual increment of modelled biomass.

Crop Rotation

The Rotation setting determines what initial carbon value should be used, i.e. at age 0. For a first rotation (where the land has been converted from pasture or scrub) the carbon value is presumed to start at zero, whereas for any subsequent rotation (where the land is is continuous forestry cover) the initial carbon value is significantly higher, owing to the residue from the previous rotation:



At a clearfell, regardless of the rotation, the net carbon volume removed (and thus treated as a cost) is the difference between the carbon sequestered pre-clearfell, and the initial carbon value for the start of the next rotation. Note that the amount of material removed during either a clearfell or a production thinning are set as parameters to the Carbon model (see C-Change Parameters).

Sensitivity Analysis

It is possible to vary a number of the base settings to determine the manner in which the overall economic outcome is affected. The settings that can be changed in this way are those labelled as "variations" in the Sensitivity Analysis box.

Leaving the value of any variation at zero means that no variation will be applied for that setting, but entering a value will cause the data to be analysed with that setting at 3 different values:

- The original value
- The original value plus the specified variation
- The original value minus the specified variation

For example, if the Base Discount Rate is set at 5.5%, and the Base Discount Rate Variation is set to 1.5, then analyses will be run for discount rates of 5.5%, 4.0% and 7.0%.

When more than one variation type is specified, not all combinations are analysed. For each variation of the Base Discount Rate, each of the other variations is separately applied in turn, i.e. with all of the other settings at their base values. For example, if the Base Discount Rate and its variation are set as above, and the Log Prices Variation is set to 3%, and the Harvesting Costs Variation is set to 5%, then the following analyses will be run:

Base Discount Rate %	Log Prices Variation %	Harvesting Costs Variation %
5.5	0	0
7.0	0	0
4.0	0	0
5.5	-3	0
7.0	-3	0
4.0	-3	0
5.5	+3	0
7.0	+3	0
4.0	+3	0
5.5	0	-5
7.0	0	-5
4.0	0	-5
5.5	0	+5
7.0	0	+5
4.0	0	+5

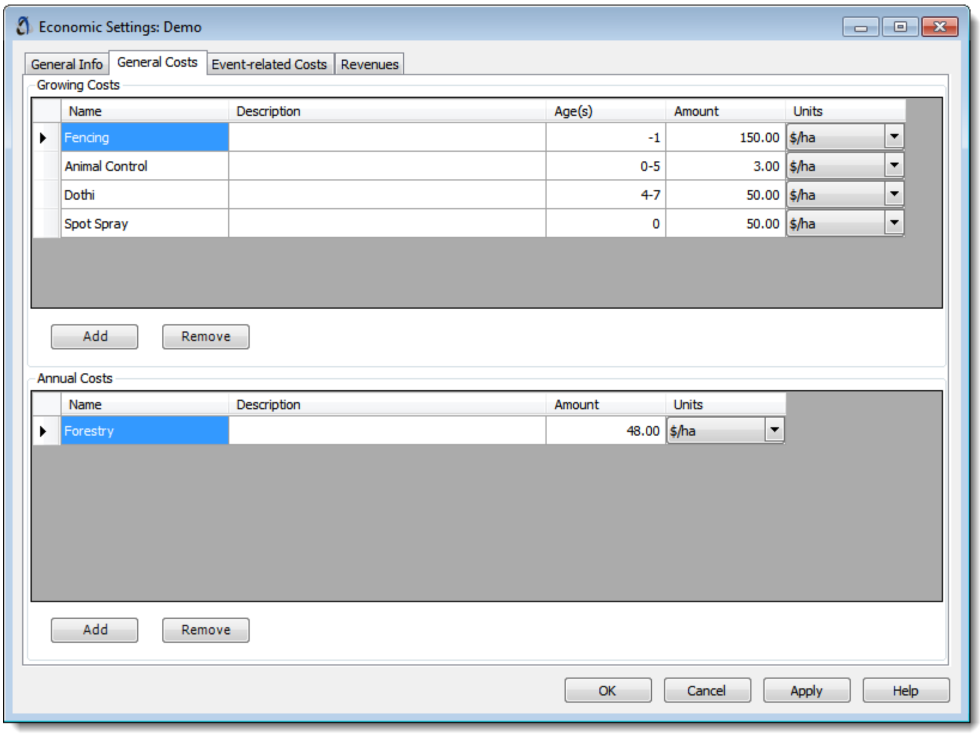
Costs and Revenues

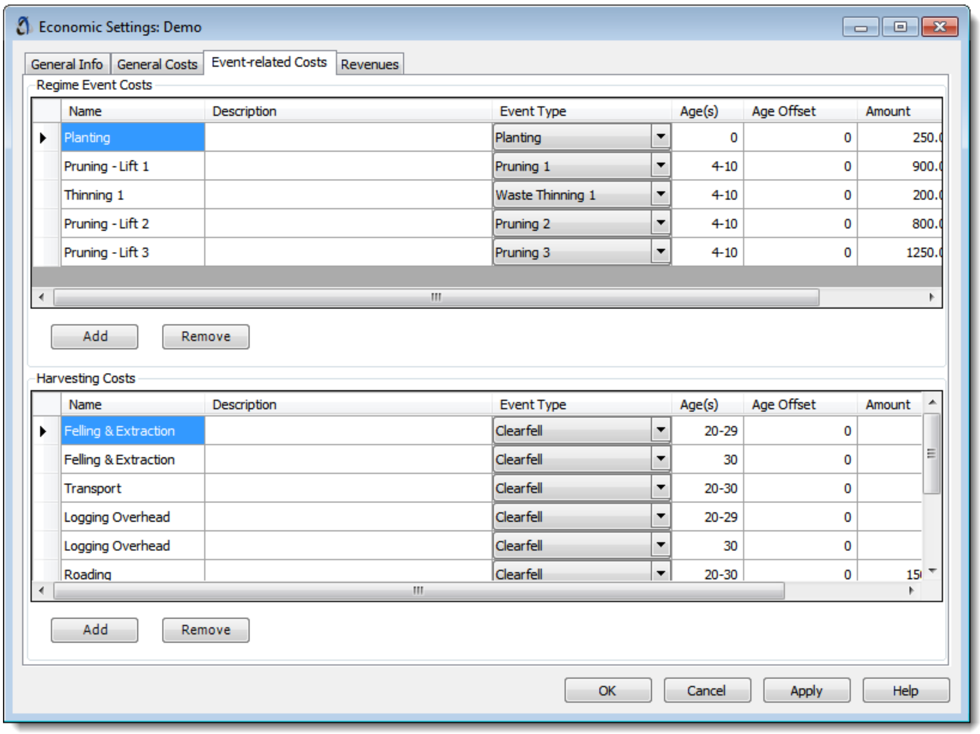
The cash-flow items of cost and revenue are managed in groups, with each group accessible via its own grid on the form.

For most types of costs and revenues, an age (or a set of ages) must be specified. This determines the age(s) at which the cost or revenue will apply. In some cases an age is irrelevant, for example for Annual Costs which are simply applied every year from the earliest until the latest age of stand management. In other cases, the ages can be used to specify alternatives, for example for Regime Event costs there could be multiple items for the same event but with different ages, allowing different costs to apply for the same event type, depending on when it actually occurs. A set of ages is a comma-separated list of age specifications, each of which is either a single age or an age range. For example, "1,3,5" represents the ages 1, 3 and 5; "2-5" represents the ages 2, 3, 4 and 5; "2,5-7" represents the ages 2, 5, 6 and 7. All ages should be specified as integers (whole numbers).

The units for each cash-flow item must also be specified - the default units are \$/ha, but some Harvesting Costs can meaningfully be expressed in \$/m³, and some Event costs (e.g. Planting and Thinning) in \$/stem.

The actual amount of a cost or revenue item can be negative.


Economic Settings: Demo
General Info
General Costs
Event-related Costs
Revenues
Growing Costs
Name
Description
Age(s)
Amount
Units
Fencing
-1
150.00
$/ha
Animal Control
0-5
3.00
$/ha
Dothi
4-7
50.00
$/ha
Spot Spray
0
50.00
$/ha
Add
Remove
Annual Costs
Name
Description
Amount
Units
Forestry
48.00
$/ha
Add
Remove
OK
Cancel
Apply
Help


Economic Settings: Demo
General Info
General Costs
Event-related Costs
Revenues
Regime Event Costs
Name
Description
Event Type
Age(s)
Age Offset
Amount
Planting
Planting
0
0
250.
Pruning - Lift 1
Pruning 1
4-10
0
900.
Thinning 1
Waste Thinning 1
4-10
0
200.
Pruning - Lift 2
Pruning 2
4-10
0
800.
Pruning - Lift 3
Pruning 3
4-10
0
1250.
Add
Remove
Harvesting Costs
Name
Description
Event Type
Age(s)
Age Offset
Amount
Felling & Extraction
Clearfell
20-29
0
Felling & Extraction
Clearfell
30
0
Transport
Clearfell
20-30
0
Logging Overhead
Clearfell
20-29
0
Logging Overhead
Clearfell
30
0
Roading
Clearfell
20-30
0
Add
Remove
OK
Cancel
Apply
Help

To add a new item, click the **Add** button under the relevant costs or revenue pane. A new row will appear in the pane, allowing the item's values to be entered.

To edit an existing item, click on the cell that is to be changed, and change its value.

To remove one or more items, select the item(s) to be removed by clicking on its row header (the left-most column), and click the **Remove** button. Use **Ctrl-click** or **Shift-click** to more easily select multiple items for removal.

General Costs

These costs are simply applied at each of the specified age(s).

Annual Costs

These costs are applied every year from the earliest age of stand management to the latest age of stand management (inclusive).

Regime Event Costs

Each of these costs is associated with a particular type of Regime event, such as a Planting or a Waste Thinning, which is selected from the dropdown list in the Event Type field. The cost will be applied only when such an event occurs AND if the cost’s specified age(s) includes the age at which the event actually occurs.

An age offset can also be specified so that the cost is applied, not at the actual age of the event's occurrence, but offset from that age by the number of years specified (either positive or negative). For example, a site establishment cost could be entered against the Planting Event but with an age offset of -1 years, indicating that it would occur one year prior to planting.

Some costs, such as Planting, can be specified in units of $/stem.

Note that these costs are applied at the truncated (integer) form of the age at which the event occurs, for example if a Waste Thinning occurs at age 7.3 years, then any costs associated with that event will be applied at age 7 (plus any offset specified).

Harvesting Costs

These costs are applied only when a Harvesting Event occurs. The cost is applied when the event occurs AND if the cost's specified age(s) match the age at which the event occurs. These costs may also have an offset specified.

General Revenues

It is also possible to specify other revenues that might be generated, such as firewood sales. For each, the age(s) at which the revenue is to be applied must be specified.

Harvesting Revenues

These are not specified in the Economic Settings, but are automatically generated whenever a Production Thinning or Clearfell occurs. The revenues ($/ha) are derived from the harvested log products' volumes (m^3/ha) and their associated prices ($/$m^3$ from the relevant Cutting Strategy).

Note that the Economic Analysis requires each scenario to include a Clearfell event.

The Economic Analysis Process

The Analysis Process

To enable an economic analysis[8], the EconomicAnalysis table should be checked on the Report Tables tab of the simulation's Report Options, and an Economics Settings entity must be selected in the Project form.

The analysis will calculate the following summarising values for each scenario, and they will appear in both the Economic Analysis table and the Economic Analysis report:

Net Present Value

For each combination of variations analysed, a Net Present Value (NPV) is calculated as the sum of all discounted costs and discounted revenues.

Internal Rate of Return

The analysis includes the calculation of an Internal Rate of Return (IRR) value. The IRR is the value of the discount rate for which the NPV equals zero.

Note that since there is a distinct discount rate for carbon data, an IRR value can be meaningfully calculated only either when there is no carbon data present, or when the carbon discount rate is equal to the base discount rate being used (taking into account any variation on the base discount rate). In all other cases, there will be no value of IRR produced, and a warning message will be published.

Note too, that in the case where the sum of all undiscounted costs exceeds the sum of all undiscounted revenues, no value of IRR can be calculated (since no matter what discount rate is selected, the total discounted revenues can never match the total discounted costs). When this occurs, a warning message will be published, and the analysis will continue with no value for IRR for that scenario.

Land Expectation Value

This is effectively the NPV of a regime in perpetuity, i.e. assuming replanting the same regime over and over again, with the same costs, revenues, etc.

$LEV = NPV1 \times ((1 + i) ^\wedge t / (((1+i) ^\wedge t) - 1)$ where:

$NPV1$ = the single rotation NPV
i = the discount rate
t = the interval between rotations - the (economic) rotation length plus the regeneration lag

Stumpage

The stumpage is calculated as the sum of all log product revenues at clearfell ($/ha).

Break-even Log Price

The break-even log price – the average log price required to "break even" – is calculated as the sum of all discounted costs / TRV, where TRV is the sum of all log product volumes, excluding waste.

The Economic Analysis Table

At the completion of a simulation, the Report Manager will appear, allowing the Economic Analysis Report Table to be exported, as either a CSV file or an Excel file. The table has a number of sections, one for each of the variations defined for the sensitivity analysis. Within each of these there is one row for each cost or revenue cash flow item that has been applied, and columns for each of the defining inputs and resulting outputs, including NPV, IRR, Land Expectation Value, Stumpage, and Breakeven Price.

The Economic Analysis Report and Graph

Also available via the Report Manager at the completion of an Economic Analysis is a graph of NPV vs clearfell age, and an Economic Analysis Report. For both of these, the scenarios used are "grouped" such that scenarios with the same set of entities but differing only in clearfell age are treated as a group, and constitute the basis of the report, or a line on the graph. To ease the selection of groups in the Report Manager in these cases, only one scenario from any group need be selected, and all other scenarios in that group will automatically be used.

Practical Advice

Overview

This feature is available only to members of the Radiata Management Theme of Future Forests Research Limited (FFR).

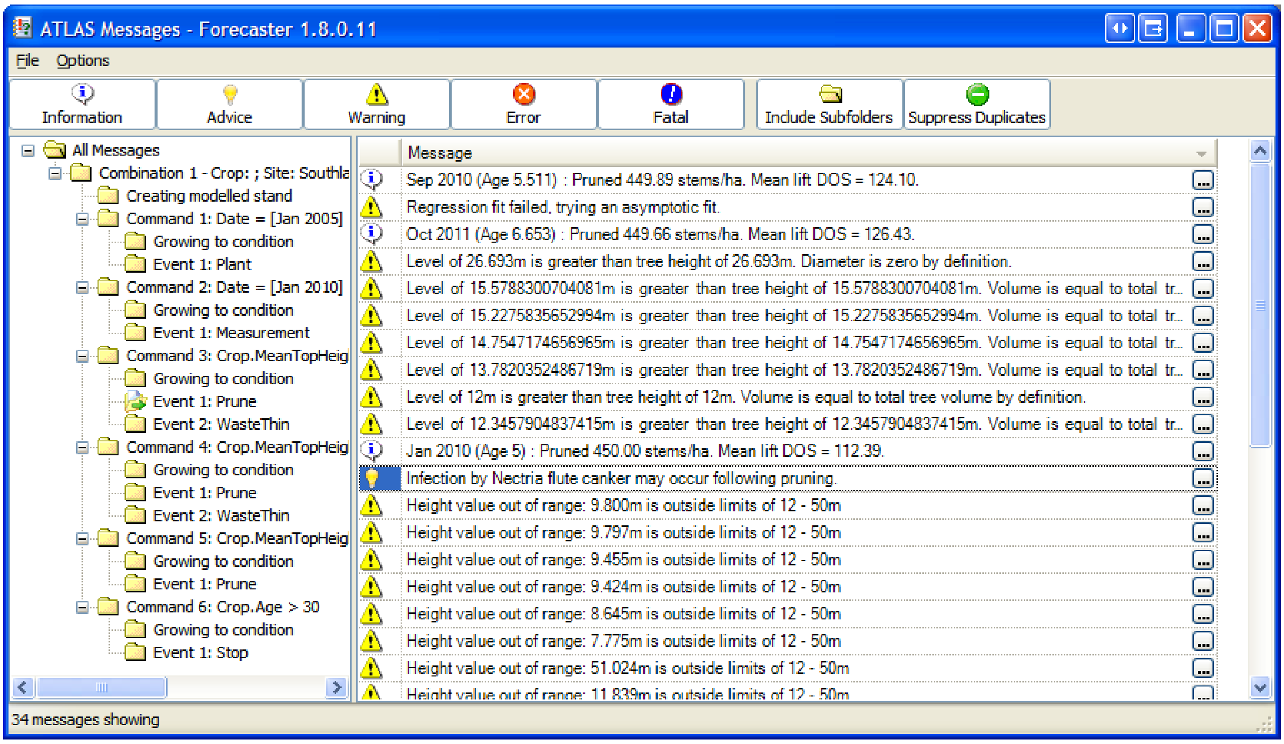
The Practical Advice module has been implemented to bring to the attention of users those issues that should be included in their decision making but aren't directly modelled by Forecaster. For example, a Forecaster simulation may suggest that a heavy thinning produces the highest Net Present Value, which may encourage a change to silvicultural regimes. However it can't tell you if the site is prone to high winds, and that subsequently windthrow is likely following heavy thinning.

This sort of contextual knowledge which guides the decision-making process will build up over time, and can often be one of a company's greatest assets. However, this valuable institutional knowledge is often not captured anywhere except in the memory of staff, and consequently can be lost with staff turnover. The Practical Advice module provides a means of storing and making available such non-modelled advice.

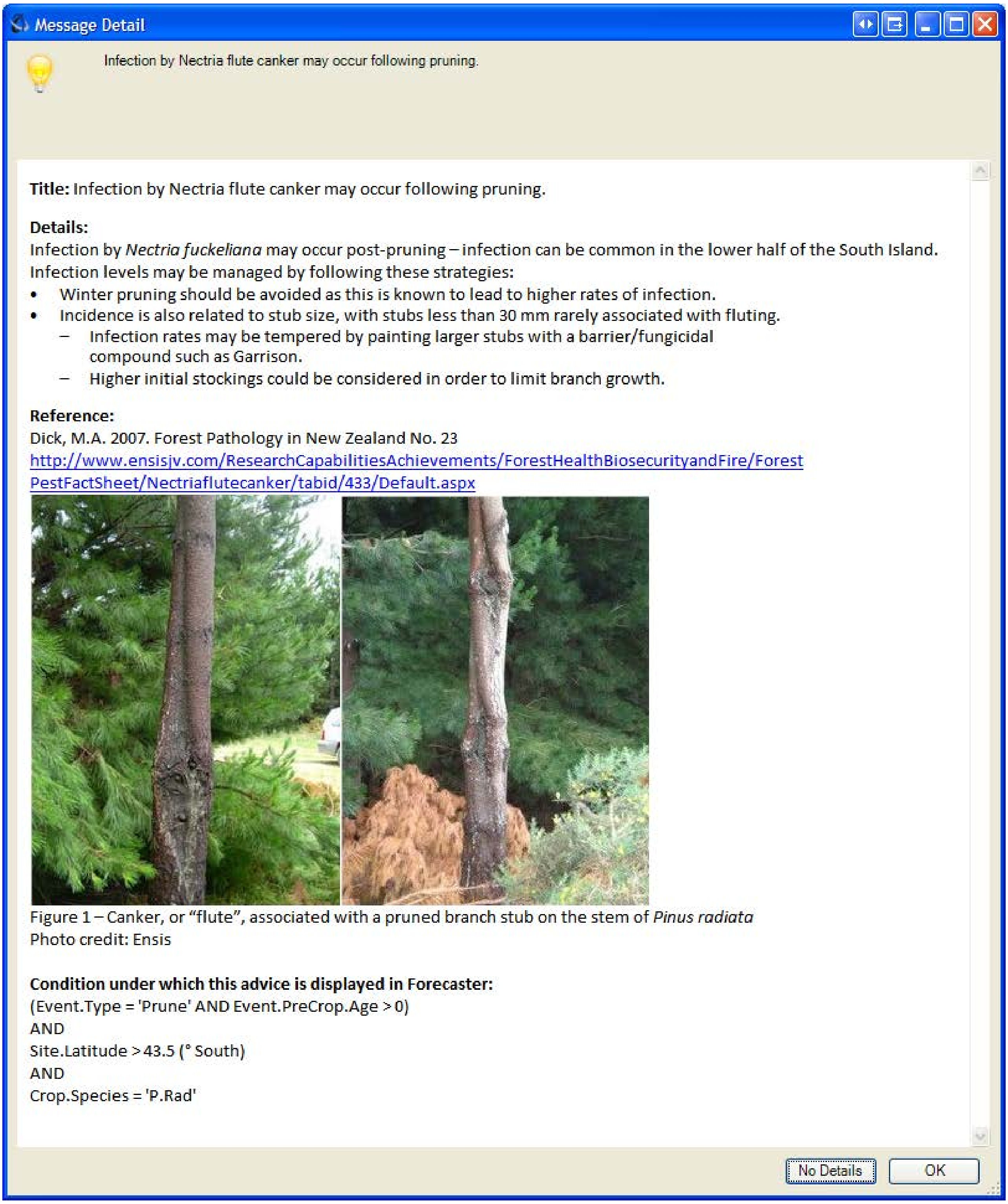
Two types of advice are supported:

- System advice – based on robust, published science. A library of system advice will be updated through future releases of Forecaster.
- User-defined advice – this is input by users into your own company database. It may include advice based on experience or knowledge within your company, or even business rules.

While a large volume of advice may be stored in the database, it will be presented to users only when relevant, i.e. when certain conditions of simulation meet pre-defined rules. For example, if pruning *P.radiata* in the lower South Island, a warning about risk of Nectria infection would be shown, identified with a light bulb icon within the Message Viewer:


ATLAS Messages - Forecaster 1.8.0.11
File
Options
Information
Advice
Warning
Error
Fatal
Include Subfolders
Suppress Duplicates
All Messages
Combination 1 - Crop: ; Site: Southla
Creating modelled stand
Command 1: Date = [Jan 2005]
Growing to condition
Event 1: Plant
Command 2: Date = [Jan 2010]
Growing to condition
Event 1: Measurement
Command 3: Crop.MeanTopHeig
Growing to condition
Event 1: Prune
Event 2: WasteThin
Command 4: Crop.MeanTopHeig
Growing to condition
Event 1: Prune
Event 2: WasteThin
Command 5: Crop.MeanTopHeig
Growing to condition
Event 1: Prune
Command 6: Crop.Age > 30
Growing to condition
Event 1: Stop
Message
Sep 2010 (Age 5.511) : Pruned 449.89 stems/ha. Mean lift DOS = 124.10.
Regression fit failed, trying an asymptotic fit.
Oct 2011 (Age 6.653) : Pruned 449.66 stems/ha. Mean lift DOS = 126.43.
Level of 26.693m is greater than tree height of 26.693m. Diameter is zero by definition.
Level of 15.5788300704081m is greater than tree height of 15.5788300704081m. Volume is equal to total tr...
Level of 15.2275835652994m is greater than tree height of 15.2275835652994m. Volume is equal to total tr...
Level of 14.7547174656965m is greater than tree height of 14.7547174656965m. Volume is equal to total tr...
Level of 13.7820352486719m is greater than tree height of 13.7820352486719m. Volume is equal to total tr...
Level of 12m is greater than tree height of 12m. Volume is equal to total tree volume by definition.
Level of 12.3457904837415m is greater than tree height of 12.3457904837415m. Volume is equal to total tr...
Jan 2010 (Age 5) : Pruned 450.00 stems/ha. Mean lift DOS = 112.39.
Infection by Nectria flute canker may occur following pruning.
Height value out of range: 9.800m is outside limits of 12 - 50m
Height value out of range: 9.797m is outside limits of 12 - 50m
Height value out of range: 9.455m is outside limits of 12 - 50m
Height value out of range: 9.424m is outside limits of 12 - 50m
Height value out of range: 8.645m is outside limits of 12 - 50m
Height value out of range: 7.775m is outside limits of 12 - 50m
Height value out of range: 51.024m is outside limits of 12 - 50m
Height value out of range: 11.839m is outside limits of 12 - 50m
34 messages showing

Double-clicking on the selected item, or clicking on the "..." button, will show further details of the practical advice:



Message Detail

Infection by Nectria flute canker may occur following pruning.

Title: Infection by Nectria flute canker may occur following pruning.

Details:
Infection by *Nectria fuckeliana* may occur post-pruning – infection can be common in the lower half of the South Island.
Infection levels may be managed by following these strategies:

- Winter pruning should be avoided as this is known to lead to higher rates of infection.
- Incidence is also related to stub size, with stubs less than 30 mm rarely associated with fluting.
  - Infection rates may be tempered by painting larger stubs with a barrier/fungicidal compound such as Garrison.
  - Higher initial stockings could be considered in order to limit branch growth.

Reference:
Dick, M.A. 2007. Forest Pathology in New Zealand No. 23
http://www.ensisjv.com/ResearchCapabilitiesAchievements/ForestHealthBiosecurityandFire/ForestPestFactSheet/Nectriaflutecanker/tabid/433/Default.aspx

Figure 1 – Canker, or "flute", associated with a pruned branch stub on the stem of *Pinus radiata*
Photo credit: Ensis

Condition under which this advice is displayed in Forecaster:
(Event.Type = 'Prune' AND Event.PreCrop.Age > 0)
AND
Site.Latitude > 43.5 (° South)
AND
Crop.Species = 'P.Rad'

No Details OK

Note that the information is merely presented for consideration of the risks, it doesn't actually stop a regime from being simulated.

Editing Practical Advice

Practical Advice entities are grouped in folders, and can be edited in a similar manner to other entities, i.e. they may be cut, copied and pasted to and from folders, and they can be renamed, deleted, created, updated and imported and exported via CSV files.

Initially, the master Practical Advice folder will contain a System folder and a User-defined folder. The System folder contains pre-defined Practical Advice entities. This folder and the entities within it are read-only, and cannot be changed. The User-Defined folder will initially be empty. It is recommended that new Practical Advice entities are created in this folder.

Each Practical Advice entity consists of the following:

Feature	Function
Name	A name identifying the entity (this must be unique within the containing group).
Title	A single line description of the Practical Advice. This description will appear in the Message Viewer at the completion of a simulation if the relevant conditions are met.
Condition	An expression which defines when the advice is displayed to the user. The advice will only be displayed in the Message Viewer if this condition has evaluated to true during the simulation.
Content	An optional HTML (or HTM) file containing the advice content, and possibly some associated image files.
Attachments	An optional list of files related to the Practical Advice.

Condition Tab

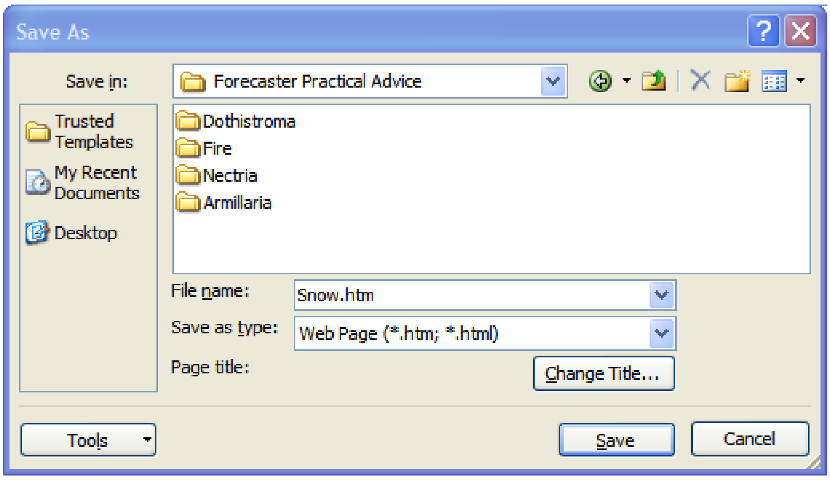
The Condition tab is used to enter an expression which is evaluated every month during a simulation. If the Condition evaluates to *True* at any time during the simulation, then that Practical Advice item will be displayed in the Message Viewer.

A simple language is used to define the Conditions. It allows the use of a number of "out of the box" Forecaster variables (for example SiteIndex, MeanTopHeight, PlantYear), as well as any user-defined variables (for example a Forest name loaded as a property against each site). This provides a great deal of flexibility in defining conditions.

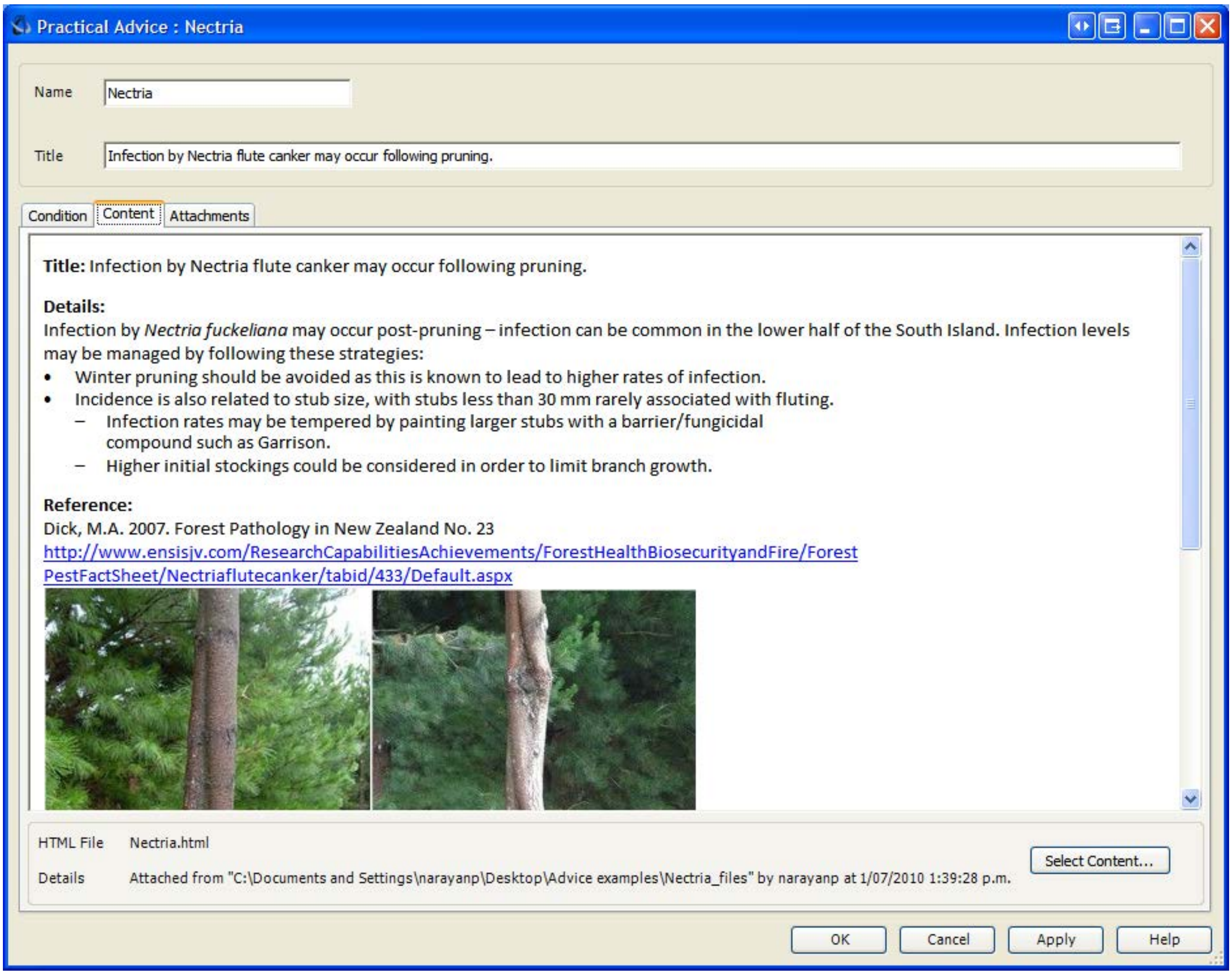
For more information on editing and evaluating conditions, see the Conditions section.

Content Tab

Further details pertaining to the practical advice can be included in rich format, for example diagrams, photos, charts, etc., as well as additional text. In order to attach rich-content advice, it must first be saved in HTML format, which is easily done for a Microsoft Word document via the **Save As** dialog:



The Content tab is used to embed an HTML (or HTM) file in a Practical Advice entity. As shown below, the top part of this form is a simple HTML viewer which shows the content of the HTML file currently linked to this Practical Advice record.



The HTML file can be embedded in the Practical Advice entity by dragging and dropping the file onto this tab, or by clicking the "Select Content..." button. If, together with the HTML file, there is a folder with the same name suffixed with "`_files`", then these files are assumed to be associated with the HTML file, and they are also copied into the Practical Advice entity. The "_files" folder usually contains any images associated with the HTML file. Microsoft Word will automatically create and populate a "_files" folder when a Word document is saved as an HTML file.

For detailed instructions on how to generate an HTML file using MS Word, please refer to the tutorial "Generating Practical Advice HTML files", available from the ATLAS Technology website.

Attachments Tab

The Attachments tab can be used to embed a copy of one or more files in a Practical Advice entity.

It is recommended that files used to create the HTML content are attached to the Practical Advice entity. By doing so, the content can be easily updated in future by saving the attached file, editing it, regenerating the HTML and then updating the content and re-attaching the file.

It is recommended that large files (i.e. greater than 10MB) are not attached.

The following table describes the functions of the fields and buttons in the Attachments tab:

Field/Button	Function
File Name	Lists file names currently attached to the Practical Advice entity.
Details	For each currently attached file, lists when the file was uploaded, from where, and by whom.
Add	Opens a dialog for you to select the file(s) you wish to attach. Files can also be attached by dragging and dropping the file(s) or folder(s) onto this tab.
Remove	Deletes the highlighted file(s) from the Practical Advice entity.
Save	Saves a copy of the highlighted file(s) to a nominated folder.

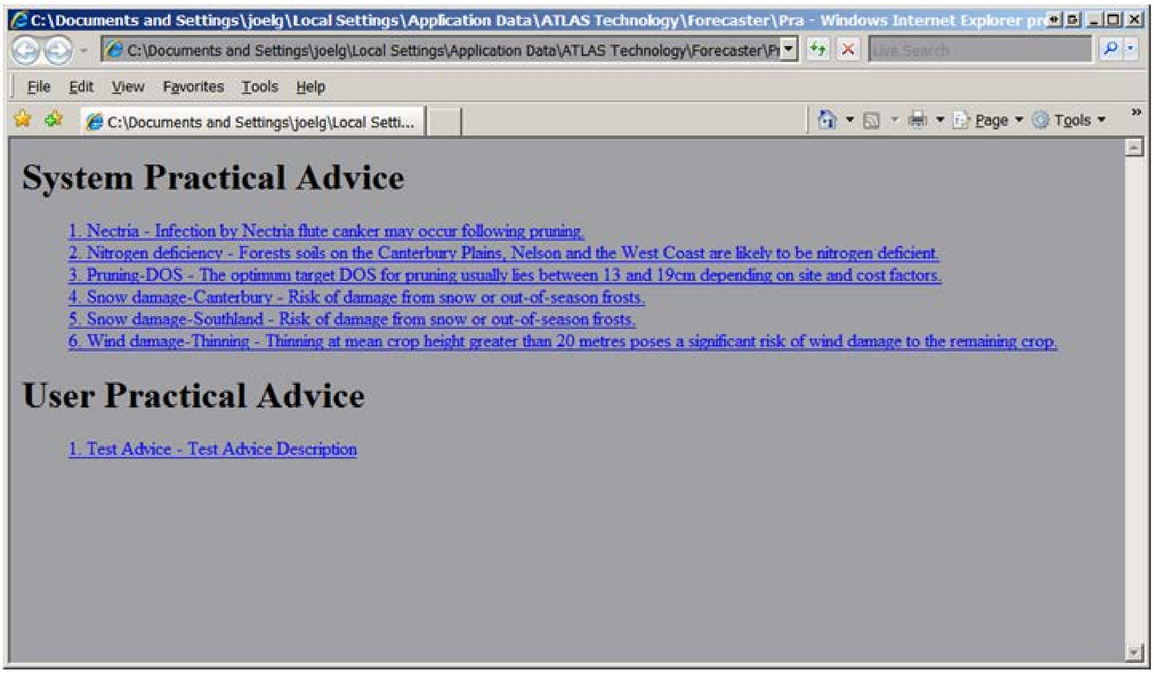
Potential Performance Issues

At the start of a simulation, all Practical Advice entities are loaded, then for every month in the simulation the condition of each Practical Advice entity is evaluated. If the condition for a Practical Advice entity evaluates to TRUE, then this Practical Advice will appear in the Message Viewer displayed at the end of the simulation. The loading of all Practical Advice entities and checking of the conditions will cause the simulation to consume more memory, and to run more slowly. Given this, it is recommended that most simulations be done with Practical Advice disabled. This may be done by de-selecting the main menu option **Tools | Show Practical Advice**, or de-selecting the main menu option **Tools | Show Messages**.

The order that variables are listed in the condition also impacts on processing performance. For more information see Short-Circuit Evaluation in the Evaluating Conditions section.

Browsing Practical Advice

The main menu option **Tools | Browse Practical Advice...** will export all Practical Advice entities, then create and display a contents page in a browser, with links to both System and User-defined Practical Advice content:



Conditions

Overview

A logical expression is an expression that can be evaluated to either *True* or *False*. It usually has the form:

variable comparison_operator value

but can also include arithmetic expressions. For example:

```
Site.Altitude < 300
Date = [ Sep 2010 ]
Crop.BasalArea < ( Event.PreCrop.BasalArea * 0.2 )
```

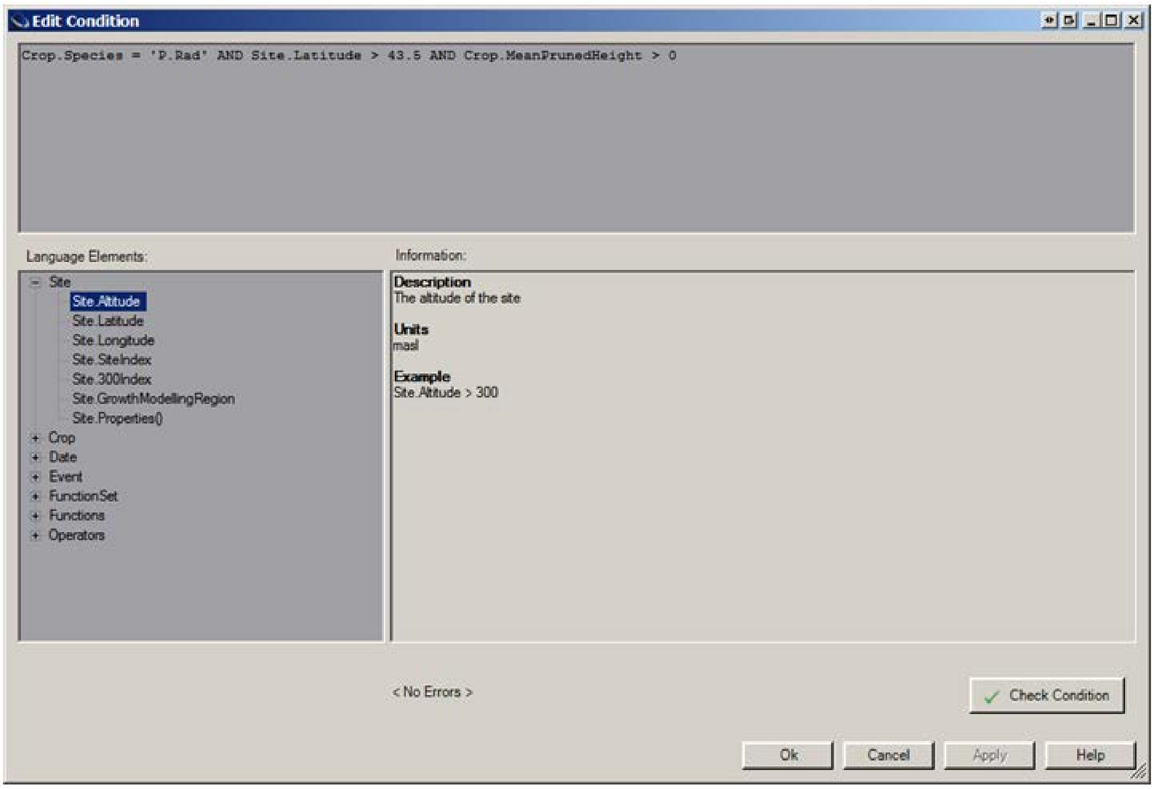
A Condition combines one or more logical expressions, using the logical operators AND, OR and parentheses "(" and ")", to produce a more complex expression which can itself be evaluated to either *True* or *False*. For example:

```
Crop.Age > 25 AND Site.GrowthModellingRegion = 'Southland'
Event.Type = 'WasteThin' AND Crop.BasalArea < 4.5
```

Note: The same syntax is used to define the Conditions used within Practical Advice entities as for those used in each Command within a Regime. This syntax is also used when specifying the timing of historic events in a Crop's history, however in those cases, only Date or Crop.Age variables can be used.

Editing Conditions

The Condition form appears when adding or editing conditions of user-defined Practical Advice.



The following table describes the functions of the fields and buttons in the Condition form:

Field/Button	Function
Top pane	This multi-line text box is used to enter or modify the expressions defining a Condition. Items can be typed into the box directly, or chosen from the Language Element list below. Note that variable names, function names and operators are not case-sensitive.
Language Elements	A list of valid variable names, function names and operators which may be used to define the expression. These include variables associated with user-defined entities: • Sites - e.g. altitude, site index; • Crops - e.g. species, stocking, mean top height; • Function Sets - e.g. growth model, taper table. Other available variables include those associated with: • Events which may occur throughout the simulation - e.g. event type, pre-event basal area; • Dates - e.g. year, month. In addition, the list also includes: • Expression operators - e.g. >, NOT, +, *; and • Functions - e.g. IF, IN, Log, Round. User-defined properties on either the site or the crop can also be used to define the expression - for example Site.Properties('WindRisk') could be used to create a practical advice record relating to a user-defined property named "WindRisk". This provides a great deal of flexibility in defining conditions. The elements are listed by category. Double clicking a language element will insert it into the text box above.
Information	A description of the selected language element, including units of measure where applicable.
Check Condition	Verifies that whether the Condition is valid. The results of the check are reported to the left of this button, and if the position of the error can be detected (i.e. the Line and Column are not set to -1) then double-clicking on the error will position the cursor in the text box at the start of the error.

Evaluating Conditions

Short-Circuit Evaluation

To minimize the slowdown caused by evaluating Conditions every month during a simulation, "short-circuit evaluation" is used. This means that the whole expression may not need to be evaluated, depending upon the results of initial expression. For example, in the following Condition:

```
Crop.Species = 'P.Rad' AND Site.Latitude > 43.5 AND Crop.MeanHeight > 0
```

if `Crop.Species` is not equal to `‘P.Rad’`, then the Condition will always be *False*, no matter what the results of the values of `Site.Latitude` and `Crop.MeanHeight` might be. Consequently, those final 2 expressions need not be evaluated (and, in fact, are not).

Given the above, it is recommended that variables which don't change through time (and therefore can be evaluated quickly) should be listed before any which do change through time.

Conditions Involving Equality

For variables used in a simple equality expressions (e.g. `Crop.BasalArea = 4.5`), if the variable is *increasing* with time, expression will evaluate to *True* for the first month in which the variable is *greater than* the target value, whereas if the variable is *decreasing* with time, the expression will evaluate to *True* for the first month in which the variable is *less than* the target value. For example, for the Condition `Crop.BasalArea = 4.5`, and where the basal area values are as follows:

Date	Basal Area
Dec 2020	3.80
Jan 2021	4.15
Feb 2021	4.39
Mar 2021	4.51
Apr 2021	4.64
May 2021	4.87

then the Condition will evaluate to *True* in March 2021, since this is the first month in which the value of Basal Area exceeds the target value of 4.5.

Care should be taken when comparing variables using the equality operator ("="), particularly when the variable being compared does not change during a simulation, and it includes a fractional part. For example, the following condition:

```
Site.SiteIndex = 25.0
```

will only evaluate to *True* if the site index is *exactly* 25.0, which is very unlikely to be the case if the value of Site Index is derived. Given this, it is recommended that the operators ">" or "<" operators are used in such cases.

System Settings

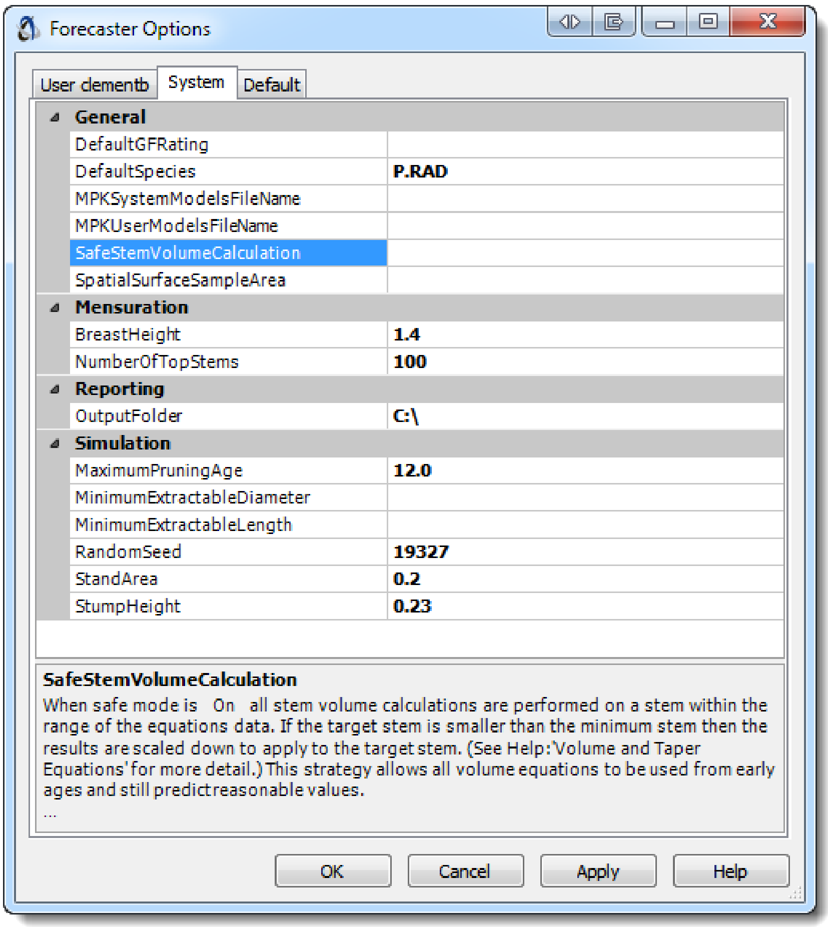
There are a series of settings that can be modified using the **Tools | Options** menu item. The settings are grouped according to the part of Forecaster they apply to - General, Mensuration etc.

Three levels of settings are used:

- Default - these settings cannot be changed, they are the "out-of-the-box" values that a new installation of Forecaster will use by default
- System - these can be used to over-ride the Default settings, for all users of a shared database
- User - these can be used to over-ride the System settings on a per-user basis.

For example, the default setting for the reporting output folder is `C:\` as this path is likely to be available on any installation. In a shared installation the system setting could be changed to a backed-up network location, but an individual user could over-ride this so that their reports are written to, for example, `D:\Forecaster Reports\`.

The form used for editing the settings includes a panel containing a description of the selected setting:



Importing and Exporting Data using CSV files

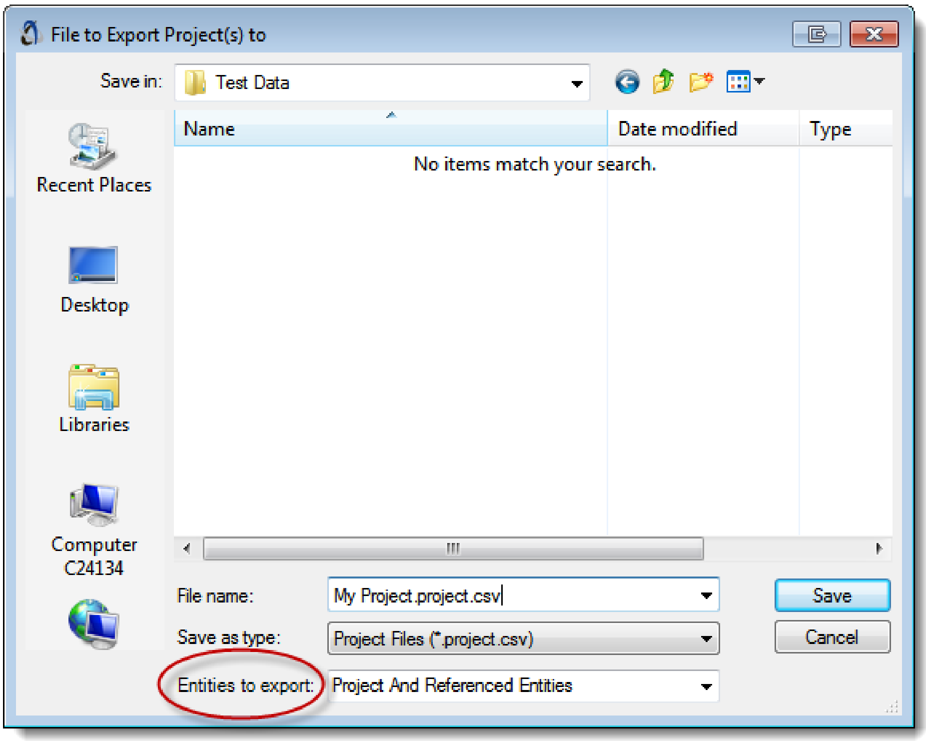
Forecaster entities can be exported to, and imported from comma-separated values (CSV) data files, either individually or as complete Projects. This allows:

- the transferring of data into and out of Microsoft Excel for alternate analysis
- a simple method of storing or archiving a dataset
- the transferring of data to/from another Forecaster database
- the sending of relevant data (usually an entire Project) to Scion Software Support as part of an error report, in order for the problem conditions to be more easily reproduced

Exporting Data

To Export one or more entities of the same type, select the entities to be exported, right-click inside the List View (upper right) Pane, and select **Export** form the context menu. A dialog box then prompts for the name of the file to be created, and the folder that it is to be written into.

When exporting a Project, it is possible (and very useful) to also export all of the entities that the Project references (uses). The Export dialog for Projects includes an extra dropdown: Entities to Export":



Selecting "Project and Referenced Entities" (the default behaviour) will generate CSV files for the Project and for each of the entities that it has been configured to use, whereas selecting "Project Only" will export only the Project itself.

The export process will create a file (or set of files) each of which has a file extension corresponding to its entity type. The naming convention is for the file extension to include the entity type, for example, exporting a Crop will produce a name of the form: `myCrop.crop.csv`.

Importing Data

Similarly, data can be imported from CSV files, either as separate entities or as an entire Project. To import data, select the type of entity to be imported in the Tree View (left) Pane, then right-click inside the List View Pane. From the Context menu select **Import**, and browse to the CSV file containing the data to be imported. Note that the file type in the Import dialog is automatically set to match the entity type.

When importing Projects, the Import dialog includes the option to import either the entire Project - including all of its component entities - or just the Project itself.

Note that the import process will overwrite any entities with the same names as those being imported.

Yield Generator Interface

The Yield Generator is a simplified interface to Forecaster, targeted at users whose primary interest is the production of yield tables. It is available to all members of the Radiata Theme of Future Forests Research (for information on how to gain access to this, please see the Contacts for Models section of this manual). There are two main parts to the application:

- Project definition - specifying the site, function set, and silvicultural regime with its crop.
- Yield results - the crop condition table and graph (time series), and the yield table resulting from running a simulation of the specified project entities.

This interface is built on the same underlying framework and engines as Forecaster to ensure consistency in the predictions, and to allow their use of regimes and other data sets. All information is saved to the Forecaster database and can be used as a starting point for more extensive analyses via the main Forecaster interface.

Yield Generator allows only a single combination of site, regime (incorporating the crop) and function set to be specified in one run. However, the regime may specify a range of clearfell ages, in order to produce a multi-row yield table.

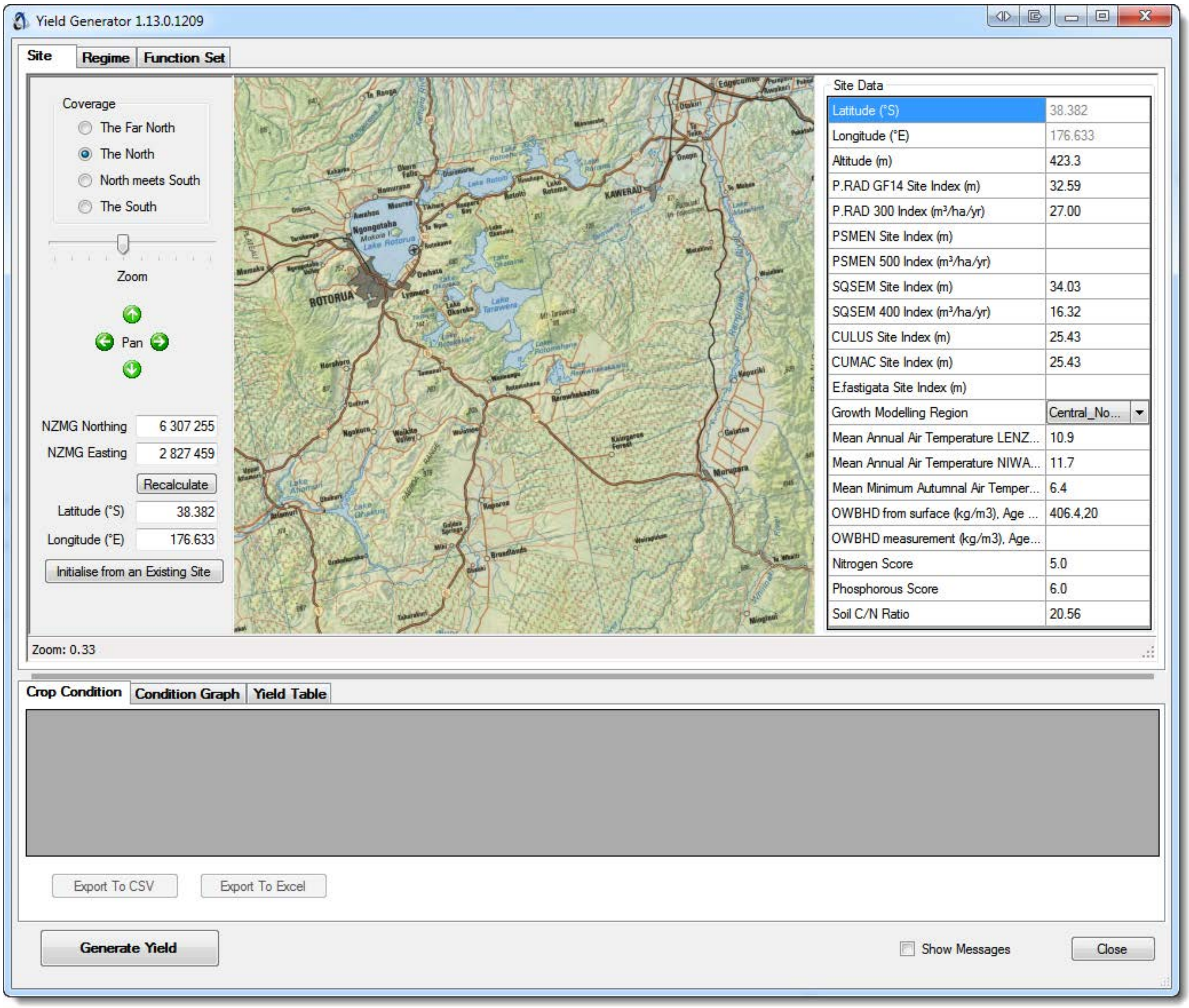
Cutting Strategies and Log Product Definitions

While some standard log product definitions and cutting strategies are available, it is not currently possible to edit these within the Yield Generator interface - they must be created or edited in the main Forecaster interface (see Log Product Definitions and Cutting Strategies for more information).

Yield Generator Interface

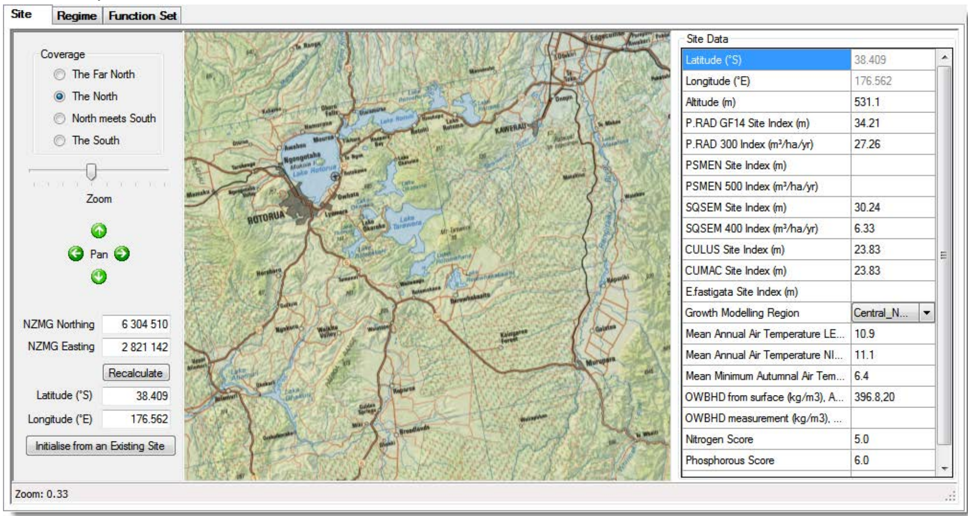
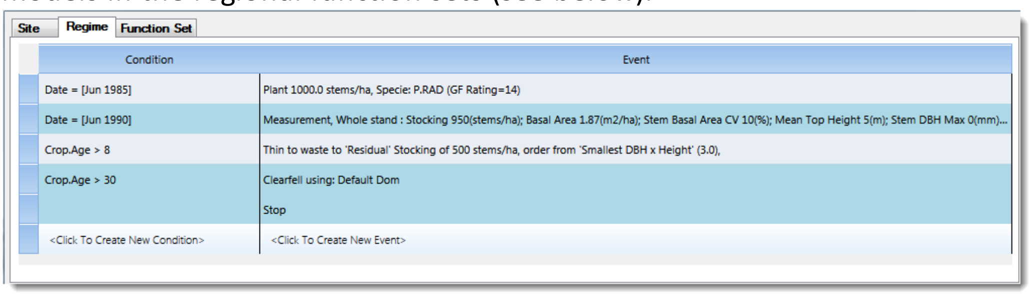
The Yield Generator interface has two main sections:

- an upper pane via which the user specifies the input data and conditions for a simulation, and
- a lower pane which displays the results of a successful simulation

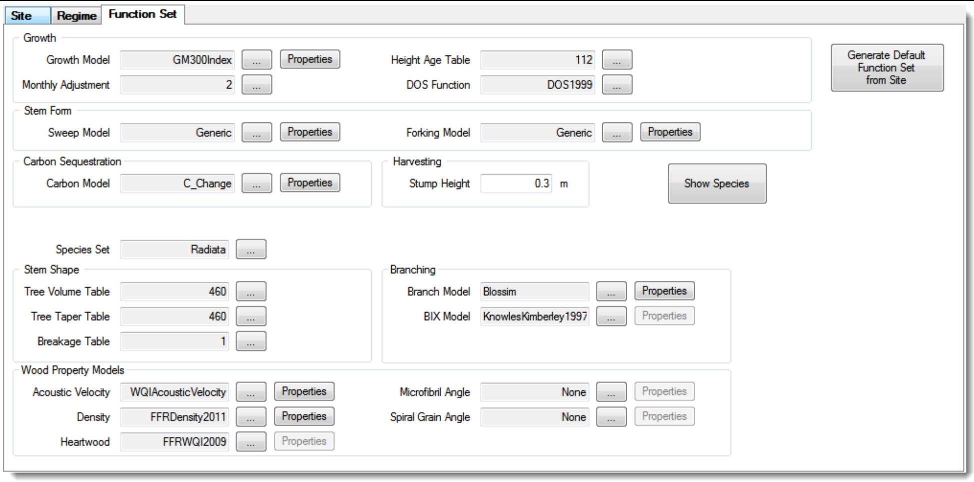

Yield Generator 1.13.0.1209
Site
Regime
Function Set
Coverage
The Far North
The North
North meets South
The South
Zoom
Pan
NZMG Northing 6 307 255
NZMG Easting 2 827 459
Recalculate
Latitude (°S) 38.382
Longitude (°E) 176.633
Initialise from an Existing Site
Zoom: 0.33
Site Data
Latitude (°S) 38.382
Longitude (°E) 176.633
Altitude (m) 423.3
P.RAD GF14 Site Index (m) 32.59
P.RAD 300 Index (m³/ha/yr) 27.00
PSMEN Site Index (m)
PSMEN 500 Index (m³/ha/yr)
SQSEM Site Index (m) 34.03
SQSEM 400 Index (m³/ha/yr) 16.32
CULUS Site Index (m) 25.43
CUMAC Site Index (m) 25.43
E.fastigata Site Index (m)
Growth Modelling Region Central_No...
Mean Annual Air Temperature LENZ... 10.9
Mean Annual Air Temperature NIWA... 11.7
Mean Minimum Autumnal Air Temper... 6.4
OWBHD from surface (kg/m3), Age ... 406.4,20
OWBHD measurement (kg/m3), Age...
Nitrogen Score 5.0
Phosphorous Score 6.0
Soil C/N Ratio 20.56
Crop Condition
Condition Graph
Yield Table
Export To CSV
Export To Excel
Generate Yield
Show Messages
Close

Field/function

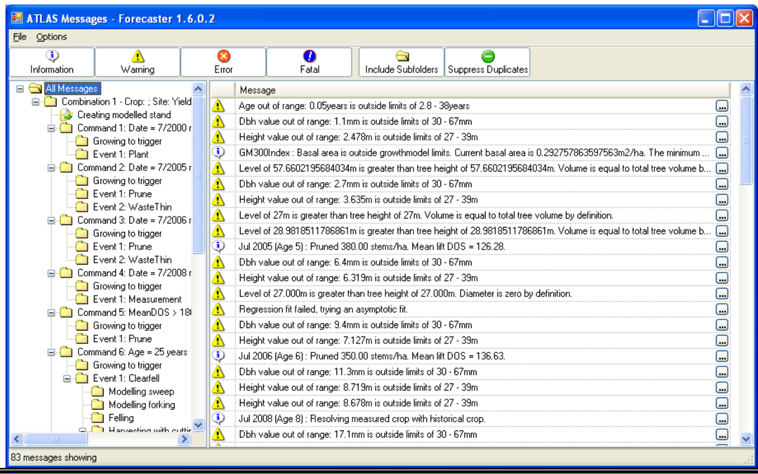
The following table describes the fields and buttons on the Yield Generator interface:

Field/Button	Function
Site tab	The site information is typically determined by selecting a location directly on the displayed map, zooming and panning as required (see Spatial Site Selection):  If a site still exists from a previous run of Yield Generator (see below) then it will be used as the initial location of this site. Further, any other site in the Forecaster database can be used to initialise the site's location by clicking the **Initialise from an Existing Site** button, and selecting a site from the displayed tree of sites.
Regime tab	The required silvicultural regime is entered into the Regime tab. This must include both a plant event and a measurement event at known dates. However "green-fields" scenarios may be modelled by deriving the measurement (see Generating a Starting Point Crop). Note that when adding a plant event, "GF Rating" is added as a property with a default value of GF14. To edit this, click the "Properties" button on the Plant Event form. A value for "GF Rating" is required by some of the models in the regional function sets (see below).  See Regimes for more detail on setting up regimes.
Function Set tab	A default function set can be generated for a given site and regime by clicking the **Generate Default Function Set from Site** button. This will create an appropriate function set, based on the selected location's region, and the species specified in the regime's Plant event (see Regional Function Sets).

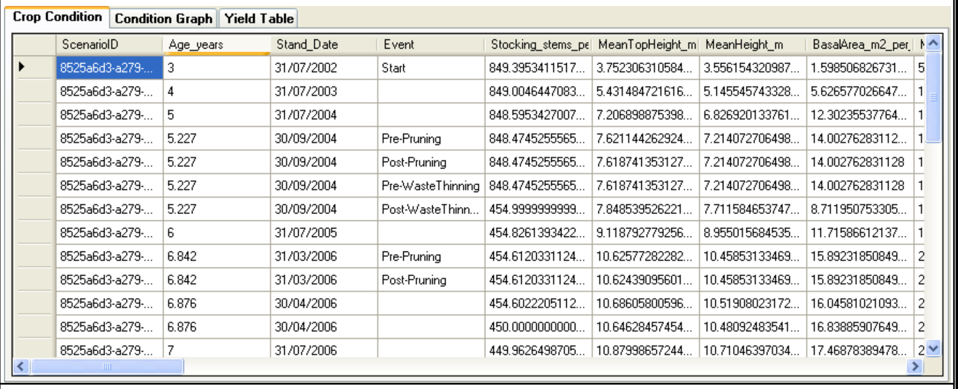
<table>
<tr><th>Field/Button</th><th>Function</th></tr>
<tr><td></td><td>



The defaults settings can be modified, if necessary, by selecting other models or functions, and adding or changing values on their properties (where applicable).</td></tr>
<tr><td>Generate Yield button</td><td>Once the site, regime and function set have been specified, clicking the Generate Yield button will run a full simulation, producing a yield table. The crop condition and yield table reports, and the crop condition graph will be displayed in the tabs in the lower pane.</td></tr>
<tr><td>Hide Messages check box</td><td>Ticking the box suppresses the display of the Message Viewer after the yield generation.



</td></tr>
</table>

<table>
<tr><th>Field/Button</th><th>Function</th></tr>
<tr><td>Crop Condition tab</td><td>This tab shows the table of Crop Condition data resulting from the simulation.

<table>
<tr><th></th><th>ScenarioID</th><th>Age_years</th><th>Stand_Date</th><th>Event</th><th>Stocking_stems_pe</th><th>MeanTopHeight_m</th><th>MeanHeight_m</th><th>BasalArea_m2_per_</th><th>N</th></tr>
<tr><td>▸</td><td>8525a6d3-a279-...</td><td>3</td><td>31/07/2002</td><td>Start</td><td>849.3953411517...</td><td>3.752306310584...</td><td>3.556154320987...</td><td>1.598506826731...</td><td>5</td></tr>
<tr><td></td><td>8525a6d3-a279-...</td><td>4</td><td>31/07/2003</td><td></td><td>849.0046447083...</td><td>5.431484721616...</td><td>5.145545743328...</td><td>5.626577026647...</td><td>1</td></tr>
<tr><td></td><td>8525a6d3-a279-...</td><td>5</td><td>31/07/2004</td><td></td><td>848.5953427007...</td><td>7.206898875398...</td><td>6.826920133761...</td><td>12.30235537764...</td><td>1</td></tr>
<tr><td></td><td>8525a6d3-a279-...</td><td>5.227</td><td>30/09/2004</td><td>Pre-Pruning</td><td>848.4745255565...</td><td>7.621144262924...</td><td>7.214072706498...</td><td>14.00276283112...</td><td>1</td></tr>
<tr><td></td><td>8525a6d3-a279-...</td><td>5.227</td><td>30/09/2004</td><td>Post-Pruning</td><td>848.4745255565...</td><td>7.618741353127...</td><td>7.214072706498...</td><td>14.002762831128</td><td>1</td></tr>
<tr><td></td><td>8525a6d3-a279-...</td><td>5.227</td><td>30/09/2004</td><td>Pre-WasteThinning</td><td>848.4745255565...</td><td>7.618741353127...</td><td>7.214072706498...</td><td>14.002762831128</td><td>1</td></tr>
<tr><td></td><td>8525a6d3-a279-...</td><td>5.227</td><td>30/09/2004</td><td>Post-WasteThinn...</td><td>454.9999999999...</td><td>7.848539526221...</td><td>7.711584653747...</td><td>8.711950753305...</td><td>1</td></tr>
<tr><td></td><td>8525a6d3-a279-...</td><td>6</td><td>31/07/2005</td><td></td><td>454.8261393422...</td><td>9.118792779256...</td><td>8.955015684535...</td><td>11.71586612137...</td><td>1</td></tr>
<tr><td></td><td>8525a6d3-a279-...</td><td>6.842</td><td>31/03/2006</td><td>Pre-Pruning</td><td>454.6120331124...</td><td>10.62577282282...</td><td>10.45853133469...</td><td>15.89231850849...</td><td>2</td></tr>
<tr><td></td><td>8525a6d3-a279-...</td><td>6.842</td><td>31/03/2006</td><td>Post-Pruning</td><td>454.6120331124...</td><td>10.62439095601...</td><td>10.45853133469...</td><td>15.89231850849...</td><td>2</td></tr>
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<tr><td></td><td>8525a6d3-a279-...</td><td>6.876</td><td>30/04/2006</td><td></td><td>450.0000000000...</td><td>10.64628457454...</td><td>10.48092483541...</td><td>16.83885907649...</td><td>2</td></tr>
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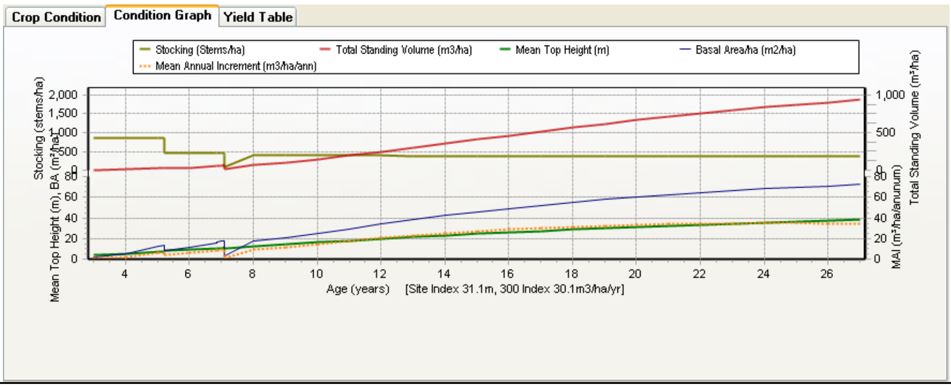
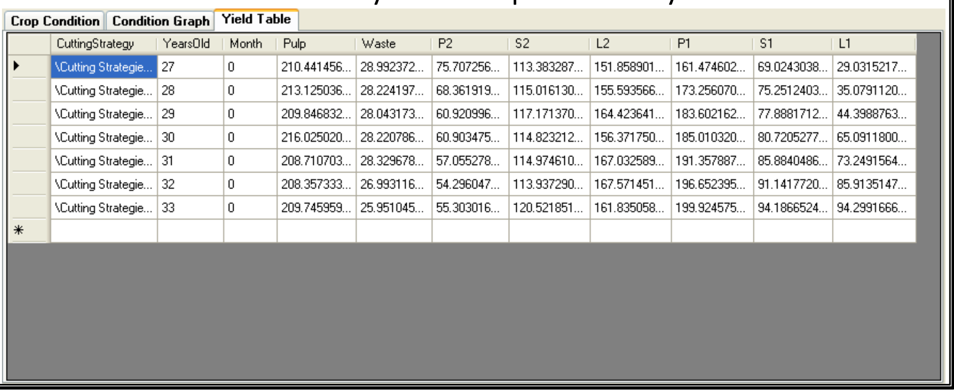
<tr><td>Condition Graph tab</td><td>This tab shows a graph of the crop condition data resulting from the simulation.


</td></tr>
<tr><td>Yield Table tab</td><td>This tab shows the table of yield data produced by the simulation.

<table>
<tr><th></th><th>CuttingStrategy</th><th>YearsOld</th><th>Month</th><th>Pulp</th><th>Waste</th><th>P2</th><th>S2</th><th>L2</th><th>P1</th><th>S1</th><th>L1</th></tr>
<tr><td>▸</td><td>\Cutting Strategie...</td><td>27</td><td>0</td><td>210.441456...</td><td>28.992372...</td><td>75.707256...</td><td>113.383287...</td><td>151.858901...</td><td>161.474602...</td><td>69.0243038...</td><td>29.0315217...</td></tr>
<tr><td></td><td>\Cutting Strategie...</td><td>28</td><td>0</td><td>213.125036...</td><td>28.224197...</td><td>68.361919...</td><td>115.016130...</td><td>155.593566...</td><td>173.256070...</td><td>75.2512403...</td><td>35.0791120...</td></tr>
<tr><td></td><td>\Cutting Strategie...</td><td>29</td><td>0</td><td>209.846832...</td><td>28.043173...</td><td>60.920996...</td><td>117.171370...</td><td>164.423641...</td><td>183.602162...</td><td>77.8881712...</td><td>44.3988763...</td></tr>
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<tr><td></td><td>\Cutting Strategie...</td><td>31</td><td>0</td><td>208.710703...</td><td>28.329678...</td><td>57.055278...</td><td>114.974610...</td><td>167.032589...</td><td>191.357887...</td><td>85.8840486...</td><td>73.2491564...</td></tr>
<tr><td></td><td>\Cutting Strategie...</td><td>32</td><td>0</td><td>208.357333...</td><td>26.993116...</td><td>54.296047...</td><td>113.937290...</td><td>167.571451...</td><td>196.652395...</td><td>91.1417720...</td><td>85.9135147...</td></tr>
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<tr><td>*</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
</td></tr>
</table>

Saving Simulation Data

Once a combination has been successfully simulated, the site, regime, function set and project are saved to the Forecaster database, from where they may be accessed via the main Forecaster interface for editing, copying etc. Each entity is saved into a base folder called `_YieldGenerator`, within which a subfolder will be created for each user. For example, the site created in the Yield Generator will be saved in Forecaster in the `\Sites\_YieldGenerator\(`*`username`*`)\` folder, and with the name `YieldGenerator`. Any such site, regime or function set entities are used to initialise Yield Generator when it is next run.

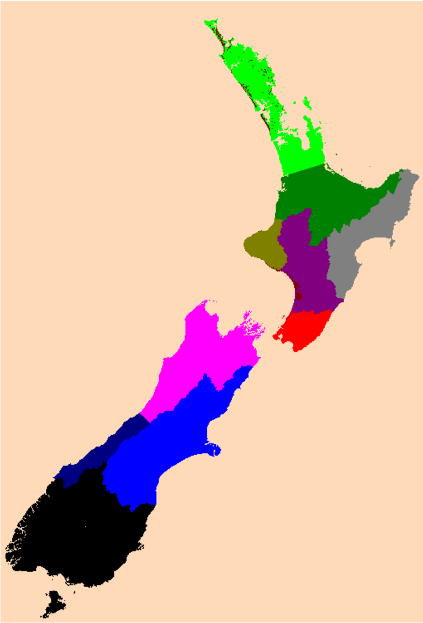
Note that when the Yield Generator is next run, the existing “YieldGenerator” entities within each of the project, site, regime, etc. folders (for that user) will be over-written. Any of these entities may be copied to any other locations within Forecaster's folder hierarchy, so that if further analysis is required, the relevant entities should at least be renamed, or (preferably) copied to another location in the folder hierarchy.

Regional Function Sets

The location of a stand has a strong influence on its growth rate as well as on the form of the stems and the quality of the wood it can produce. By grouping a set of modelling functions that are applicable to a specific region, more accurate predictions of growth, yield and quality can be made.
Growth and yield models are usually developed for particular regions or sites. The following regions are commonly identified in New Zealand:

- Auckland Clays
- North Island Sands
- Central North Island
- East coast of the North Island (Hawke's Bay)
- Nelson
- Westland
- Canterbury
- Southland/Otago

In Forecaster, region is determined via location (easting and northing) from the following surface:



Note that while most boundaries coincide with broad geo-physical divisions or political administrations, the North Island coastal sands are a non-contiguous collection of areas derived from soil type.

Default Function Sets for Radiata Pine

Regional function sets for radiata pine have been compiled for the listed regions as well as for the southern North Island (Wellington, Wanganui, Taranaki). Region-specific instances of the following functions are nominated in the Function Sets:

- Monthly growth adjustment (end-monthly adjustments to age which allow for seasonal growth)
- Breakage table (amount and severity of stem breakage on felling)

Some functions/models can be applied across regions as they are independent of location, or they respond to location-specific variables such as altitude or rainfall. These functions include:

- Stand height/age function - 112
- DOS function - *DOS1999*
- Sweep model - *Generic*
- Forking model - *Generic*
- Tree volume and taper function – 460 All NZ 3-point
- Wood Density model – *FFRDensity*
- Wood stiffness model – *WQIAcousticVelocity*
- Heartwood model – *FFRWQI2009*
- Branch Index (BIX) - *KnowlesKimberley1997*

Some hybrid functions include both regional effects as well as location-specific variables. Regional effects are specified for the following models (via model properties):

- 300 Index growth model - Regional drift parameter
- BLOSSIM branch model - Regional setting

Those functions which respond to location-specific variables can obtain values from a series of geo-surfaces (rainfall, altitude, growth indices, etc) that are incorporated in the modelling system. These regional function sets can be used as a starting point for creating a more localized set if there are particular local conditions that can be modelled more precisely using different functions.

Default Function Sets for Other Species

Function sets are also available for *E.fastigata, C.macrocarpa, C.lusitanica*, Redwoods, and Douglas-fir. Because the models for these species are not yet as mature as those for radiata pine, they are mostly national function sets (although a Douglas-fir regional function set is available for the Nelson region).

Command Line Interface

Forecaster can be run in command line mode - FCMD (Forecaster CoMmanD).
In this case, entities are defined in csv files (see CSV section) and Forecaster is run from a command line prompt.

Entering the command `FCMD` with no arguments will display a description of the available options, for example:

```
Forecaster command line FCMD V1.7.1.2
Copyright (c) 2008 New Zealand Forest Research Institute. All rights reserved.

Usage :
=======
FCMD /CropsFile=csv-file          | /CropsGroup=group
     /SitesFile=csv-file          | /SitesGroup=group
     /RegimesFile=csv-file        | /RegimesGroup=group
     /FunctionSetsFile=csv-file   | /FunctionSetsGroup=group
     /ReportOptionsFile=csv-file  | /ReportOptionsGroup=group
     /MessageFile=message-file
     /OptionsFile=options-file
     /ProjectsFile=csv-file
     /ImportOnly=true

         OR

FCMD /ProjectName=project-name
     /MessageFile=message-file
     /OptionsFile=options-file
     /ImportOnly=true

where :
  csv-file is the name of a CSV file containing entities to be imported
  group is the name of a group containing existing entities
  message-file is the name of the file in which messages are to be written
  options-file is the name of the file containing system options
  project-name is the full name to an existing project within Forecaster.
  and: /ImportOnly=true will mean that a simulation is not performed

Examples :
==========
1. The following command line simulates an existing project within Forecaster

   FCMD "/Project=\Projects\My Project"

2. The following command line imports entities from each of the files specified
   into a folder called "Temp" immediately below each master group, creates a
   project containing all combinations of the imported entities, analyses the
   project writing any messages to the specifed message file and then deletes
   contents of the "Temp" folders prior to exiting.

   FCMD "/CropsFile=C:\Crop Data\Forest 342 crops.csv"
        "/SitesFile=C:\Site Data\Hawkes Bay.csv"
```

```
        "/RegimesFile=C:\Regime Data\Three Prune, Two Thin.csv"
        "/FunctionSetsFile=C:\FunctionSet Data\Hawkes Bay Functions.csv"
        "/ReportOptionsFile=C:\ReportOptions Data\Standard Reports.csv"
        /MessageFile=C:\ForecasterMessages.msg
```

3. The following command line creates a project in "\Projects\Temp" containing all combinations of the entities in the specified groups, analyses the project writing any messages to the specifed message file and then deletes the contents of the "Temp" folders prior to exiting.

```
   FCMD "/CropsGroup=Forest 342 crops"
        "/SitesGroup=Hawkes Bay"
        "/RegimesGroup=Three Prune, Two Thin"
        "/FunctionSetsGroup=Hawkes Bay Functions"
        "/ReportOptionsGroup=Standard Reports"
        /MessageFile=C:\ForecasterMessages.msg
```

Notes :
=======

1. The "Temp" folders are created if they do not exist.
2. The contents of the "Temp" folders are deleted prior to any entities being imported and after the simulation has completed.
3. If arguments contain spaces then they must surrounded by double quotes.

Software Overview and Installation

Overview

Forecaster is a framework which supports different growth and yield models plus other mensurational functions which are used in concert to simulate the effects of genetics, site and management on the growth of a stand as well as the timing, volume and properties of its log product yields.

Forecaster is a multi-user system for use in enterprises where it is essential to share common definitions of entities like log product (grade) definitions, regimes, etc. This provides consistency and promotes a common understanding between parts of a forestry business, which can tend to become silos of information when under pressure to perform. Users must concur on naming conventions and areas of responsibility for the benefits of a shared system to be realised.

As a single-user system, Forecaster can be installed on one PC with no difference in the functionality or interface.

Forecaster will function correctly only if installed on an adequate system. See Installing/ Uninstalling Forecaster for a list of minimum requirements.

System Components

The system has two main interfaces: a Graphical User Interface based on Windows and Forms, and a command-line interface for processing batches of stands.
Both of these interfaces use the Forecaster simulation engine to process the input information in order to produce estimates of stand condition and log yield.

Underlying the interfaces and the engine is a data access layer which interfaces to the SQL Server database. This database holds current versions of entities such as crops, regimes, log grade definitions etc.

The system is built on the Microsoft .NET framework, and so requires .NET runtime to be installed.

Interfaces to Forecaster

There are two options for running Forecaster:

1. **Graphical User Interface**

Within the Forecaster GUI, users can:

- Define entities (crops, regimes,...) interactively by filling in the on-screen forms;
- Define a Project as a combination of entities, and more than one instance of each entity so that multiple scenarios are generated;
- Control the scenarios to be analysed via the Scenario list;

- Analyse multiple scenarios in a single simulation run.

2. **Command Line Interface**

Alternatively, Forecaster can be run in command line mode. In this case, entities are defined via CSV files, and Forecaster is run from the command line prompt `FCMD`(Forecaster CoMmanD).

In this section

This section contains the following topics:

Topics
Install/Uninstall Forecaster
Contacts

Installing/Uninstalling Forecaster

Minimum System Requirements

See the ATLAS Technology website: http://www.atlastech.co.nz/products/forecaster/system-requirements-for-running-ffr-forecaster

Installing Forecaster

See the document "Getting Started.doc" (available from Forecaster Support page of the ATLAS Technology website) for instructions on installing the software, acquiring a licence, and creating an initial database.

Uninstalling Forecaster

1. Open the **Control Panel** from the **Settings** menu on the Windows **Start** menu
2. Double-click the **Add or Remove Programs** icon
3. Select **Forecaster**, and click the **Remove** button to uninstall

Contacts

Contacting Scion Software Support

Support email: software.support@scionresearch.com

Phone: +64 7 343 5584

Facsimile: +64 7 343 5679

Web: www.scionresearch.com

Physical Address: 49 Sala Street,
Rotorua 3010,
New Zealand

Postal address: Private Bag 3020,
Rotorua 3046,
New Zealand

Phones and email are monitored during standard NZ business hours

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