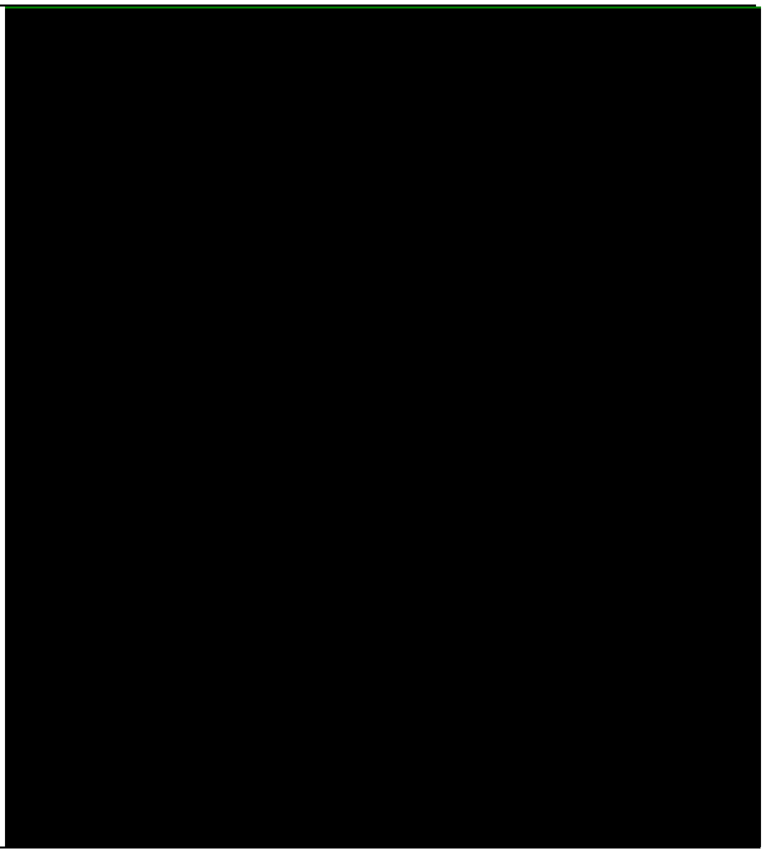

Strategic Yield Scheduler

Southern Region

A project undertaken as part of the NSW Comprehensive Regional Assessments

February 2001

[redacted]

STRATEGIC YIELD SCHEDULER

SOUTHERN REGION

STATE FORESTS OF NSW

A project undertaken for
the Joint Commonwealth NSW Regional Forest Agreement Steering Committee
as part of the
NSW Comprehensive Regional Assessments
project number NA54/FRA

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The project has been overseen and the methodology has been developed through the FRAMES Technical Committee which includes representatives from the New South Wales and Commonwealth Governments and stakeholder groups.

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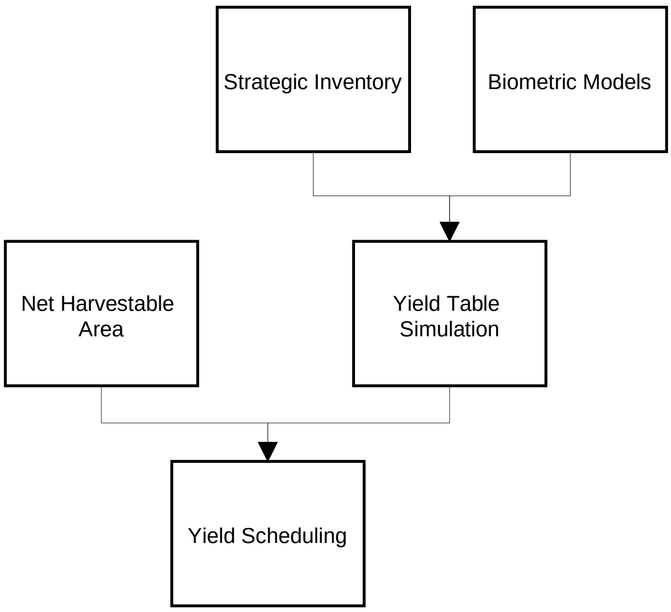
CONTENTS

PROJECT SUMMARY

This report describes a project undertaken as part of the comprehensive regional assessments of forests in New South Wales. The comprehensive regional assessments (CRAs) provide the scientific basis on which the State and Commonwealth Governments will sign regional forest agreements (RFAs) for major forest areas of New South Wales. These agreements will determine the future of these forests, providing a balance between conservation and ecologically sustainable use of forest resources.

This project is one of five modules of the Forest Resource and Management Evaluation System (FRAMES), which was the tool used in CRA/RFA negotiations to calculate sustainable wood flows over time.

FIGURE 1-1: FRAMES MODULES AND RELATIONSHIPS



Project objectives

1. To provide a tool to select from among a range of yields by management strategy (from the FRAMES Yield Simulator) the set of yields that produce sustainable wood flow volumes by quality class, size and species group for a range of management options and a varying resource base. These yields are responsive to the set of environmental protocols applying to the management strategies chosen.

2. To track over time forest values such as proportion by growth stage, to enable assessment of the long term implications of particular silvicultural practices.
3. To develop an effective system that is easy to use, interactive and sufficiently responsive for RFA negotiations.

Methods

A yield scheduling framework was developed to integrate the net harvestable area and predicted yields under alternative management strategies to determine future wood supply forecasts. The framework was built around the linear programming forest yield scheduling model *Spectrum*.

Development of the framework involved 5 broad stages:

1. *Spectrum* model set up and design
2. Development of area and yield input databases
3. Model template construction. This included definition of objectives, management actions and constraints; importing databases, and custom report development.
4. Model testing and validation
5. Development of model input and output linkages and reports. This included the definition, design, formatting, construction of electronic linkages (data flows) between:
    - C-PLAN, ESFM tools, GIS spatial analysis units and net area inputs;
    - Net area and yield simulator models and FRAMES and various outputs;
    - FRAMES and FRAMES reports; and
    - FRAMES and the economic and social model data.

Key results and products

Development of a semi-automated and integrated yield scheduling framework and modelling approach centred on *Spectrum*, which enables the rapid and repeated determination of sustainable wood flows and wood supply capacity under a range of silvicultural options and for varying resource bases.

1. INTRODUCTION

The development of a Regional Forest Agreement for the Southern NSW Comprehensive Regional Assessment (CRA) regions was dependent on understanding the currently available wood resources in the regions forests, and the expected yields which can be sustained over time under a proposed conservation reserve design.

The Forest Resource and Management System (FRAMES) Technical Committee was established to develop the methodology for determining the available wood resource and future yields, and to oversee progress on the work. The objectives of the FRAMES Technical Committee objectives were to:

- determine ecologically sustainable wood flows and expected sawlog sizes and qualities for a range of management options and a varying resources base for use in the RFA integration;
- provide reliable ecologically sustainable yield figures as a basis for an RFA between the Commonwealth and NSW;
- provide a basis for ongoing ecologically sustainable management of wood flows by State Forests of NSW;
- provide information on resource characteristics for use in long term planning by wood-based industries in NSW; and
- provide information on and validation of the modelled effects of environmental and silvicultural options for use in developing proposals for ecologically sustainable forest management.

The FRAMES objectives were achieved through 4 primary projects:

- Forest inventory – which provides an assessment of the current resource and data for yield simulation;
- Net harvest area determination – provides an estimate of the productive land area available for harvest;
- Growth and yield simulation – predicts yields of logs under alternative management strategies; and
- Yield scheduling – the final step in FRAMES which integrates the net harvestable area and predicted yields under alternative management strategies, to predict future wood supply.

The FRAMES Technical Committee recommended the use of a yield scheduling model for determining the long term wood supply from State Forests of NSW' native forests in the

Southern CRA regions. The yield scheduling model *Spectrum* was used to determine the sustainable wood flows and wood supply capacity under a range of silvicultural options and for varying resource bases.

The primary focus was to evaluate the impacts of multiple conservation reserve designs on sustainable wood supplies and to converge on management options which maximised both conservation targets and wood supply. The wood supply forecasts provided were direct inputs into the socio-economic evaluation models.

This report provides an overview of the yield scheduling approach used for the Southern Region Comprehensive Regional Assessment.

2. BACKGROUND

Strategic yield scheduling determines the long term wood supply and/or cashflow capable of being produced from a forest resource under a wide range of management constraints, and is a mechanism for identifying a long term forest management strategy which achieves a desirable wood supply and/or cashflow profile over time. Other non-timber management objectives can also be modelled.

Yield scheduling is normally done using computer based models. This is due to the computational complexity involved in defining the forest characteristics, range of silvicultural options, forest management constraints, the linkages and dependencies between these, together with evaluating and determining the optimal long term forest management strategy.

The objectives of yield scheduling may involve determining one or more of the following:

- calculating long tern sustainability under any given management strategy;
- calculating the capacity for even flow of non declining yield;
- a strategy which maximise the wood volume (one or more log product volumes) or Net Present Value for a defined period;
- maximum potential wood supply capacity and characteristics independent of wood supply requirements;
- capacity to supply at a level necessary to develop or supply existing and proposed market opportunities;
- whether wood supply requirements can be met;
- to smooth or regulate the wood supply level and composition at threshold levels to supply markets;
- the most cost-effective way to meet wood supply targets given a range of management constraints and options;
- to measure the sensitivity of changing constraints on the woodflow or cashflow profile; and
- to measure the impact of changing wood supply requirements on the forest management strategy.

During the yield scheduling process, the forest resource is often modelled in multiple phases, initially to determine the wood supply capacity, and then progressively implementing new constraints or modifying constraints, until a satisfactory wood supply target / profile or cashflow is achieved.

A management strategy determined through yield scheduling typically includes the identification of appropriate silvicultural options for forest areas and the allocation of forest areas to a harvesting sequence in a manner which best meets the management objectives. Such a management strategy might also involve a replanting and/or afforestation schedule in plantations and even-aged natural forests, though typically not for uneven-aged natural forests.

The strategic yield scheduler models the management of a forest resource over a long term (multiple rotations and cutting cycles). Strategic level scheduling models for a term sufficient to cover multiple rotations or cutting cycles of the forest resource. This might be done to either determine that current wood supply targets can be satisfied, or to demonstrate that harvesting is sustainable, or to determine the impacts of low or high levels of cutting in the short to medium term. Very broad and large forest units and high levels of forest constraints are used in strategic modelling as opposed to short to medium term harvest planning where small area units and micro-level constraints are used.

Management constraints in strategic level modelling may impose restrictions on the:

- level and timing of volume harvested;
- log product volume and composition;
- minimum / maximum cashflow levels (revenue and/or expenditure);
- geographical limits, magnitude and spatial distribution the area harvested;
- species or forest type harvested;
- re/afforestation quantities and compositions;
- permissible silvicultural options;
- length rotation or cutting cycle; and
- non-forest constraints.

The wood volume constraints are typically specified with the requirement to either be above a minimum level and not to exceed a maximum level for a defined period(s), to be tightly regulated (smoothed) as non-declining or long term sustainable.

Harvest scheduling computer models are based on mathematical programming techniques due to the computational complexity and size of the modelling problem. Two common techniques used are simulation and optimisation.

The simulation approach involves representing the forest resource (characteristics, linkages and dependencies) and then modelling the consequences (wood supply level and characteristic, cashflow profile) of a user defined management strategy. Finding an acceptable management strategy involves significant trial and error through repetitive cycles of simulation.

Simulation has certain advantages over conventional optimisation techniques. The outcomes are more easily understood as the relationships, options and constraints implemented are determined by the modeller; multiple objectives can be monitored; the area units do not need to be highly aggregated, allowing the modelling to be more operationally focussed and spatially presented; soft constraints (permissible modification of management constraints to represent trade-offs e.g. deviation from budget or production targets, timing of pre-harvest roading construction) can be modelled with hard constraints (non-modifiable restrictions e.g. permissible silvicultural options, minimum or maximum harvest level); simulation enables the modeller to derive multiple suitable solutions, and to explore practical management options around optimal solutions to derive an appropriate management rather than a purely mathematical optimal solution.

Optimisation involves defining the resource, management constraints and the objective. An optimisation based yield scheduler selects the mix of forest management strategies (harvesting timing and intensity, silvicultural alternatives, replant / afforestation levels, timing and characteristics) from among the range of options that best achieves (optimises) the desired objective within the specified constraints. Through various mathematical programming techniques such as linear programming, a strategy can be found which provides an optimal solution i.e. a management strategy which best meets the objective and satisfies the management constraints. This approach enables far more complex interactions, constraints and objectives to be modelled and within a very short turn-around time.

Alternative more sophisticated mathematical programming approaches have been and are being developed. However, for the majority of problems, which exclude detailed spatial interactions and constraints, and are at a strategic rather than operational level of planning, the linear programming approach provides an effective, comparatively inexpensive and easily understood approach.

The scheduling model *Spectrum* used for this process is a linear programming model developed by the USDA Forest Service. This product is designed for strategic level modelling which is compatible with the CRA objectives, can be used to solve different scenarios, and find solutions rapidly (say, 30-60 minutes) - the time frame demanded of the process in the RFA negotiations.

3. *SPECTRUM* MODEL

Spectrum is an linear programming (LP) based forest planning model used to optimise land allocation and activity and output scheduling for a forest over a specified planning horizon. It includes a data entry system, model manager, matrix generator and report software. A commercial LP package is used to solve the LP matrix generated by *Spectrum*. The matrix generator reads and interprets model data and creates rows and columns for the LP software to solve. The report utilities interprets the LP solution and produces a series of reports and data base files (USDA Forest Service, 1997).

Spectrum features include:

- multiple mathematical programming options to model/simulate management scenarios across landscapes. Capabilities include linear, goal and mixed integer formulations;
- objective functions including MAX/MIN, MIN/MAX, and goal programming, and flexible functions for addressing biodiversity issues;
- ability for linear approximation of non-linear relationships (mixed integer formulation);
- temporal resolution for addressing sustainability issues;
- generalised constraint specification;
- vegetation mortality and decision tree modelling; and
- a generalised graphical user interface, relational database entry system, matrix generator and report writer.

Some of the features of *Spectrum* which made it suitable for long term yield scheduling of the SFNSW forest estate include:

- easy to use, interactive and sufficiently responsive for RFA negotiations;

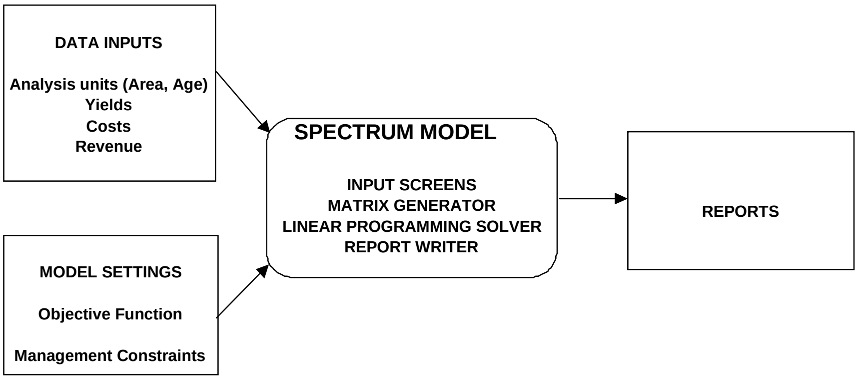
- capacity to model uneven aged native forest as well as even aged plantation resource;

- ability to determine long term wood supply options from a varying forest resource under a range of silvicultural treatment options and management constraints; and

- low cost. The *Spectrum* model is freely available from the USDA Forest Service (world wide web or direct). The user only needs to purchase a commercial optimisation software package (C-WHIZ was used) required for solving the linear programming matrix generated within *Spectrum*.

Conceptually the yield scheduling process using the *Spectrum* model comprises the components outlined in Figure 3-1. Area and yield data inputs (and financial data if desirable) are imported into the *Spectrum* model via the graphical user interface (GUI). The objective function and constraints are manually selected and defined also through the GUI. Spectrum creates a matrix containing the yield data by analysis unit (area units), objective function to be optimised and any associated constraints. The *Spectrum* LP matrix is then processed with a commercial linear programming solution package (C-WHIZ). If a feasible solution can be found, the LP package will process the modelled problem until it is solved i.e. identifies the optimal solution which best meets the objective function and satisfies all of the specified constraints. The *Spectrum* report writer transforms the LP solver output into either user customised or standard reports.

FIGURE 3-1: SCHEMATIC DIAGRAM OF *SPECTRUM* MODEL COMPONENTS AND LINKAGES



4. OVERVIEW OF MODELLING APPROACH AND METHODOLOGY

The application of *Spectrum* in FRAMES in the RFA negotiation involved the development of a range of data bases, data transformation and summary reporting scripts, and the formulation of a model template which characterised the forest resource and management practices in NSW. The relationship between the various components of the yield scheduling framework and the process are illustrated in Figure 4-1. This process was semi-automated to enable repeated analyses.

The development of the yield scheduling framework involved five broad stages, details of which are discussed in the following sections of this report.

1. Model set up and design

- Set up hardware and software platform
- Identify model formulation
- Identify data input file requirements and structures
- Design area and yield database

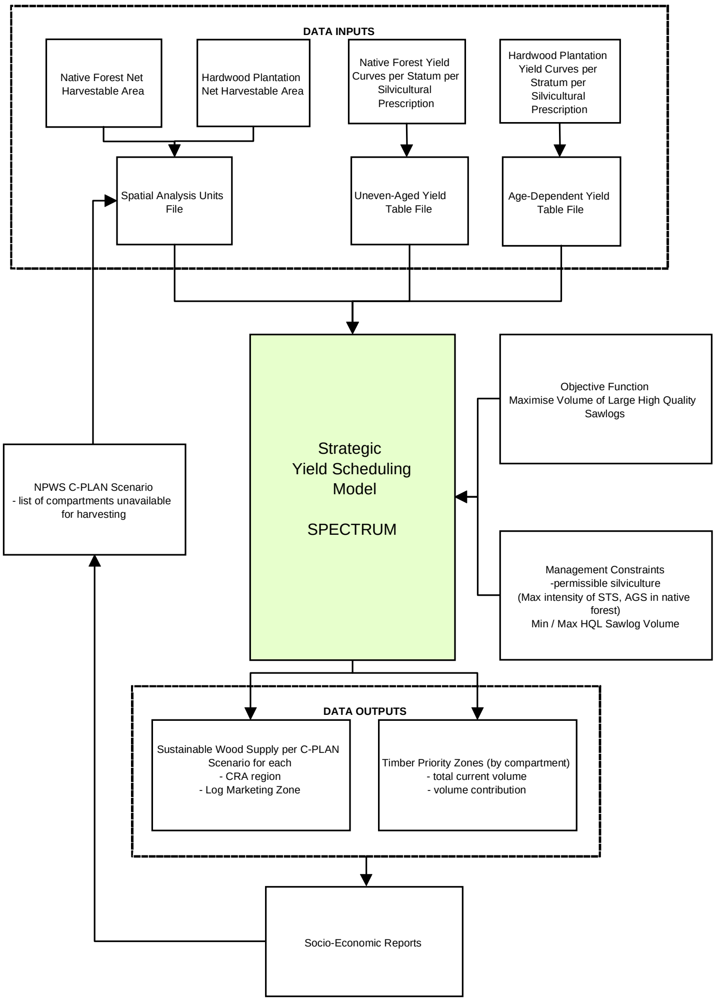
2. Development of input databases

- Define land attributes & groups
- Build net harvest area analysis units
- Build yield tables

3. Model construction

- Import of yield tables and net harvestable area data
- Construction of database
- Definition of management actions (activities, outputs, conditions)
- Definition of goals and objective function
- Formulation of matrix
- Solving LP problem
- Development of custom reports

FIGURE 4-1: *SPECTRUM* MODEL FRAMEWORK



4. Model testing and validation

Repeated model runs, changing input variables to test validity of results and sensitivity.

5. Model input and output linkages and reports

Definition, design, formatting, construction of electronic linkages (data flows) between:

- C-PLAN, ESFM tools, GIS spatial analysis units and net area inputs;
- Net area and yield simulator models and FRAMES and various outputs;
- FRAMES and FRAMES reports; and
- FRAMES and the economic and social model data.

5. MODEL INPUT FILE REQUIREMENTS AND STRUCTURE

Two main data inputs are required for the yield scheduler:

- *Area Statements* – the net harvestable area of the forest management units supplied by the ESFM Project 4 and the FRAMES Yield Simulator net harvestable area modifier sub-project; and

- *Yield Tables* – expected harvest volumes for each stratum supplied by the FRAMES native forest yield simulator project (m^3/ha by 4 products by period for alternative silvicultural options) and from the hardwood plantations growth and yield simulation project (m^3/ha by 4 products by age for existing and subsequent rotations).

The area and yield tables are prepared external to *Spectrum* and are imported as comma delimited files. The following sections outline the structure of the data required, and the methodology used to derive and automate the preparation of these data.

5.1 FORMULATION OF LAND ATTRIBUTES AND AREA STATEMENTS (ANALYSIS UNITS)

5.1.1 Structure of area file

In *Spectrum* the forest land base (area) is defined in terms of analysis units. “Layers” and their attributes define analysis units. The land base was classified by up to 6 layer variables (location, site capability, forest type, silviculture & management intent) and each variable has up to 125 unique values (“attributes”). Each analysis unit has a unique ID number and unique combination of attributes.

The layers used to describe the native forest estate (no plantations are represented in database) were:

- Timber catchment and timber price zone;
- Timber supply zone;
- Strategic forest inventory stratum;
- Forest type (moist or dry native forest) (these were defined but not used); and
- Disturbance intensity – maximum permissible harvesting intensity (South Coast only), or a unique code identifying the mix of silvicultural systems (Tumut only).

The analysis unit file structure is illustrated in Table 5a. The file used in *Spectrum* is a comma delimited (csv) file.

TABLE 5.A: ANALYSIS UNIT INPUT FILE STRUCTURE

Analysis Unit Unique ID Number	Blank Column	Timber Catchment / Timber Price Zone (Layer 1)	Timber Supply Zone (Layer 2)	Uneven aged native forest strata number (Layer 3)	Forest type (Layer 4)	Intensity (Layer 5)	Unused (Layer 6)	Blank Column	Area (ha)
9		1_1	604	16	Moist	heavy			4.27
10		1_1	604	18	Moist	heavy			0.29
11		1_1	604	19	Moist	heavy			1.83
12		1_3	4202	2	Moist	heavy			37.26
13		1_3	4202	3	Moist	heavy			52.55
14		1_3	4202	4	Moist	heavy			700.41
15		1_3	4202	5	Moist	heavy			774.13

5.1.2 Net Harvest Area Generation

The *Spectrum* area data file was created using the NHAQUERY software which extracts the area data from a Spatial Analysis Units (SAU) database (Geographical Information System data files with details on the attributes and area of each planning unit). The SAU comprises details representing the location and area of State forest land holdings available and accessible for timber production operations and those areas protected through conservation protocols (either defined as forests zones that are entirely excluded from timber production practices, or emphasis zones where restricted practices may be applied). The Net Harvest Area is that component of the land base that is outside the defined timber exclusion areas (refer State Forests of NSW February 2001 and Section 6.11.1 of this report for further details).

NHAQUERY determines the net harvest area by deducting the following factors from the total area:

1. C-PLAN Reserve design – planning units nominated for inclusion in a formal or informal reserve.

3. User specified exclusions:

- agreed management protocols such as the EPA licence conditions and NPWS general protocols;
- NPWS species specific management protocols
- terrain factors (e.g. steep slopes);
- accessibility factors (road access);
- leasehold conditions (timber availability encumbered by lease conditions);
- State Forests forest management priorities (visual quality retention, reserves);
- harvesting operation factors (e.g. proximity to buffer zones, rocky or bouldery conditions, traffic impediments);
- economic factors; and
- timber merchantability factors.

4. User specified net area modifiers.

The net harvest area modifiers comprised:

- a reduction factor to account for the probability that part of the available harvestable area will not be harvested due to unmapped and unmappable factors additional to the general ESFM protocols.

- estimates of Candidate old-growth exclusion zones not included in the SAU database (South Coast only).

The attributes excluded from the harvestable area and which defined the Southern Region NHA are outlined in Table 5b.

TABLE 5.B: STATE FOREST AREA EXCLUSION OPTIONS

Attribute Description	Attribute Code	Southern Region CRA sub-region	
		Sth Coast	Tumut
EPA filter strips on mapped drainage lines	EPAFILTER1	Y	Y
NPWS filter strips on mapped drainage lines	NPWSFILTER	Y	Y
EPA inherent hazard class 4 for < 50% canopy removal	IHAZ4LT50	Y	n/a
EPA inherent hazard class 4 for >= 50% canopy removal	IHAZ4GT50	n/a	Y
Softwood plantation (FMZ 6)	SWD_PL	Y	Y
Hardwood plantation (FMZ 5)	HWD_PL	Y	Y
Forest Management Zone 1 - Special protection	FMZ1	Y	Y
Forest Management Zone 2 - Special management	FMZ2	Y	Y
Forest Management Zone 3 - Special prescription. Areas of crown land leases (3F) unavailable for harvesting.	FMZ3UNAV	Y	Y
Forest Management Zone 7 - Non forest use	FMZ7	Y	Y
Physically and economically inaccessible	PEI	n/a	Y
CRAFTI rainforest *- including buffers around warm temperate forest*	CRFT_RF	Y	Y
CRAFTI heath	CRFT_HEATH	Y	Y
CRAFTI wetlands	CRFT_WET	Y	Y
CRAFTI rocky outcrops	CRFT_ROCK	Y	Y
CRAFTI rare and non-commercial forest types	CRFT_RNC	Y	n/a
Unmerchantable forest types	UNMERCH	Y	Y
Forest roads	ROADS	Y	Y
Corroboree Frog Habitat	FROG	n/a	Y
Provisionally identified wilderness areas	PIDWILD	Y	Y
Identified and declared wilderness areas	IDWILD	Y	Y
Old Growth Forest Ecosystem 7 – *Southern Coastal Hinterland Shrub / Tussock Grass Dry Forest – E. sieberi*	OG_7	Y	n/a
Old Growth Forest Ecosystem 9 – *Coastal Lowlands Cycad / Shrub Dry Forest – Corymbia maculata*	OG_9	Y	n/a
Old Growth Forest Ecosystem 10 – *Southern Coastal Lowlands Shrub / Grass Dry Forest – E. globoidea / E. longiflora*	OG_10	Y	n/a
Old Growth Forest Ecosystem 21 – *Northern Coastal Hinterland Moist Shrub Forest – C . maculata / E. pilularis*	OG_21	Y	n/a
Old Growth Forest Ecosystem 48 – *Coastal Lowlands Riparian Herb / Grass Forest – various Eucalypts*	OG_48	Y	n/a
Old Growth Forest Ecosystem 61 – *Southern Escarpment Edge moist Shrub Forest – E. fraxinoides*	OG_61	Y	n/a
Old Growth Forest Ecosystem 115 – *South East Tablelands Dry Shrub / Tussock Grass Forest – E. rossii / E. mannifera / Pultenaea procumbens / Chionochloa pallida*	OG_115	Y	n/a

Note: Old Growth Forest Ecosystems areas defined are only those areas ≥ 10 hectares. All Candidate Old Growth areas are included as a net harvest area modifier (GIS raster based area determination) due to complexity in representing the fragmented nature of the old growth ecosystems.
"Y" denotes that yes this is an exclusion option and "n/a" denotes that exclusion option is not applicable.

5.1.3 Land attributes

Timber Catchment

Timber Catchments are areas of State forest from which industries source their timber supplies (broad wood supply zones) and reflect a combination of factors:

- broad forest management and administrative boundaries;
- large areas which supply industry under existing contracts;
- areas of distinct timber species groups (coastal, tableland);
- large contiguous areas worked by specific industries;
- distinct geographical areas - physical or economic catchment areas in which the wood flows are similar due to geographical factors and inter-catchment wood movement is not practical or economically viable, and /or reflect economic haulage distances to specific ports and/or industrial facilities.

South Coast CRA sub-region:
There are three Timber Catchments in the South Coast CRA sub region – one each in the coastal and tablelands zones of the South Coast and nominally one for the Moss Vale area (all of the Moss Vale forests had exclusions of at least one type).

Tumut CRA sub-region:
There are two Timber Catchments in the Tumut sub region; one for the forests in the Tumut area, on the west of the Great Divide, and one for Ingebirah State forest, on the east. The topography of the subdivision creates practical and economic barriers to east - west movement of the timber and, as a consequence, separate industries have developed around these two resources. The commitments to industry follow this natural division, with the wood from the Tumut area allocated to mills in and around the towns of Tumut and , and the wood from Ingebirah State forest allocated to a mill on the South Coast, as part of the Eden RFA.

The TCs are amalgamations of timber price zones and timber supply priority zones.

TABLE 5.C: TIMBER CATCHMENTS

CRA sub-region	Catchment Name	*SPECTRUM* No.
South Coast	Coastal	1
	Tablelands	2
	Moss Vale	N/A
Tumut	Tumut	4
	Ingebirah	5

Timber Price Zone

Timber Price Zones are geographically contiguous areas with similar log royalty structures based on timber species groups, harvesting terrain and haulage distance to markets.

This variable can be used for economic based modelling, and for linking to specific silvicultural systems. It was not used in modelling constraints for restricting or identifying preferred silvicultural options. The Timber Catchment and Timber Supply Zones (see below) were adequate for these constraints.

TABLE 5.D: TIMBER PRICE ZONES

CRA sub-region	Timber Price Zone	Management Area (No._Location)	*SPECTRUM* No.
South Coast	Moss Vale	35	1_1
	Badja	4	2_2
	Narooma - Coastal	42_C	1_3
	Narooma - Foothills	42_F	1_4
	Nowra	44	1_5
	Queanbeyan	46	2_6
	Batemans Bay- Foothills	6_F	1_7, 2_7
	Batemans Bay - Inland Coastal	6_IC	1_8
	Batemans Bay - Outer Coastal	6_OC	1_9
Tumut	Bago SF No. 560 & Maragle SF No. 556	1	4_1
	Buccleuch SF Nos 967, 592 & 593 and Bungongo SF No 582.	2	4_2
	Ingebirah SF	1	5_1

Timber Supply Zone

Timber Supply Zones are small groups of compartments within a Timber Catchment that have similar timber resource characteristics and silvicultural requirements. These are logical self-contained timber management units in terms of infrastructure and geographical boundaries. In evaluating wood supply options the Timber Supply Zones provide a good geographical basis for reporting the options' source of wood.

South Coast CRA sub-region:
There are 46 Timber Supply Zones in the South Coast CRA sub-region, 32 of which are in the Coastal TC and 14 in the Tablelands Timber Catchment.

The Timber Supply Zones are labelled by Management Area and a sequential number code. For example, the first nine Timber Supply Zones in Narooma Management Area (No. 42) are coded 4201 to 4209.

Tumut CRA sub-region:
There is only one Timber Supply Zones in the Ingebirah Timber Catchment. In the Tumut Timber Catchment, there are 31 Timber Supply Zones ranked in order of priority for timber production purposes (1 = most important, 31 = least important). The ranking enables comparison of the relative value, to industry, of logical manageable units of forest. Highest priority was assigned to groups of compartments with the highest proportion of Alpine Ash forest-type; the highest volume of currently merchantable high quality large sawlogs; the best access and the easiest terrain. Conversely, lowest priority was assigned to groups of compartments with the highest proportion of non-merchantable forest-types; the lowest volume of currently merchantable high quality large sawlogs; the worst access and the steepest terrain. Weighting was given, in descending order of importance, to species, current volume, access and terrain.

TABLE 5.E: CRA REGION TIMBER SUPPLY ZONES

CRA sub-region	Timber Catchment	No. of Timber Supply Zones
South Coast	1 (Coastal)	32
	2 (Tablelands)	14
Tumut	4 (Tumut)	31
	5 (Ingebirah)	1

Strategic Forest Inventory Strata

The stratification of the commercial Southern Region native forest resource contained 25 strata, 20 in the South Coast CRA sub-region and 5 in the Tumut CRA sub-region. These inventory strata are combinations of Forest Floristics (expressed as Yield Association Groups) and Forest Structure Class (Tables 5d to 5h). Non-commercial forest areas were not represented in the *Spectrum* area databases as they were excluded from the net harvestable area.

South Coast:

TABLE 5.F: SOUTH COAST CRA SUB-REGION NATIVE FOREST STRATA

Yield Association Group	Forest Structure Class			
	Late Mature	Mixed Age Mature	Mixed Age Young	Regrowth Dominant
Brown Barrel / Messmate	1	6	12	18
Blackbutt / Sydney Blue Gum		2	8	14
Spotted Gum		3	9	15
Silvertop Ash		4	10	16
Stringybark / Coast Grey Box / Forest Red Gum / Woollybutt		5	11	17
Gum		7	13	19
Apples / Peppermint / Scribbly Gum				20

Tumut:
The strata were selected on a combination of species dominance (Alpine Ash), and stand condition. Stand condition reflects the history and intensity of disturbance and forest management intervention, particularly past harvesting and silvicultural treatment and fire. The Alpine Ash forests of Bago and Maragle have significant differences in past history and age classes to warrant a separate stratum for each. For simplicity the lesser area of Alpine Ash type within Buccleuch area, which also has a lengthy history of disturbance, is included in the Mixed Aged Young Hardwood Stratum. The Mixed Age Mature Hardwood Stratum is generally devoid of Alpine Ash and is situated in the Buccleuch/Bungongo area i.e. outside the Bago/Maragle geographic area.

TABLE 5.G: TUMUT CRA SUB-REGION NATIVE FOREST STRATA

Yield Association	Forest Structure Class				
	Mixed Age Young (Bago)	Mixed Age Mature (Maragle)	Mixed Age Mature (Bago / Maragle)	Mixed Age Young (Tumut)	Mixed Age Mature (Tumut)
Alpine Ash	21	22			
Bago / Maragle Hardwoods			23		
Buccleuch Alpine Ash / High Quality & Low Quality Non-Ash Hardwoods				24	25

A single unique yield table was created for Strata 30, Ingebirah State Forest in SE NSW.

TABLE 5.H: SOUTH COAST FOREST YIELD ASSOCIATIONS

Yield Association Group	Yield Association No.
Brown Barrel/Messmate	9
Gum	10
Blackbutt/Sydney Blue Gum	1,2
Spotted Gum	3
Silvertop Ash	4
Stringybark/Coast Grey Box/Forest Red Gum/Woollybutt	5,6
Apples/Peppermint/Scribbly Gum	7,11

TABLE 5.I: SOUTHERN CRA REGION YIELD ASSOCIATIONS

Yield Association No.	Description	RN17 Forest Types
1	Blackbutt	36,37,39,41,42
2	Sydney Blue Gum	46,49,50
3	Spotted Gum	70,73,74,75,76
4	Silvertop Ash	112,113,114,162
5	Stringybark	68,84,115,116,121,123,126,128,130,132,133,169
6	Coast Grey Box/Forest Red Gum/Woollybutt	63,65,85,86,88
7	Apples	105,106,129
8	Alpine Ash	
9	Brown Barrel/Messmate	150,151,152,154,155,156
10	Gum	157,158,159,160,165,166,141
11	Peppermint/Scribbly Gum	109,110,111,117,118,119,120,124,125,131,40
12	Western Box	
13	Snow Gum	
14	Rainforest	
15	Cypress Pine	
16	Non Eucalypt Forest	
17	Non Forest	

The yield associations used are amalgams of RN 17 forest types or their equivalent CRAFTI codes.

TABLE 5.J: FOREST STRUCTURE CLASSES

Stratum	Yield Association	CRAFTI structure codes
1	9	SA??2/3/4; TA???
2	1, 2	SA???; SC???; TA???; TB??4
3	3	SC1M3/4; SC1P?; SCNN3/4; TA???; TB??4
4	4	SA??2/3/4; SB???; SC1J?; SC1M?; SCNN1/2/3; TB??4
5	5, 6	SA1M3/4; SA1P3/4; SANN3/4; SB1M4; SB1P2/3/4; SBNN4; TB??1/2/3
6	9	SB1J4; SB1M3/4; SB1P3/4; SBNN3/4; SC1M3/4; SC1P3/4; TB???; TC??4
7	10	SA??4; SC1J3/4; SC1M2/3/4; SC1M2/3/4; SCNN2/3/4; TA???; TC???
8	1, 2	SB???; TB?N1/2/3; TC???
9	3	SA1?2/3/4; SB1J3/4; SB1M?; SB1P?; SBNN?; SC1J2/3/4; TB??1/2/3; TC??3/4
10	4	SC1P?; SCNN4; TA???; TB??1/2; TC???
11	5, 6	SAIJ2/3/4; SA1M2; SA1P2; SANN2; SB1J2/3/4; SB1M2/3; SBNN2/3; SC???; TA???; TB??4; TC???
12	9	SB1J1/2/3; SB1M1/2; SB1P1/2; SBNN2; SC1J?; SC1M1/2; SC1P1/2; SCNN?; TC??1/2/3
13	10	SA??2/3; SB???; SC1J1/2; SC1M1; SC1P1; SCNN1; TB???
14	1, 2	D????; F????; G????
15	3	D????; E????; F????; G????; SB1J1/2; SC1M1/2; TC??1/2
16	4	D????; E????; F????; G????
17	5, 6	D????; E????; F????; G????
19	9	D????; E????; F????; G????
19	10	D????; E????; F????; G????
20	7, 11	All, **except** SA1J1; SA1M1; SA1P1; SB1J4; SB1M1

? = wildcard – all eligible codes in the code sequence are valid

Yield association/structure code matrix for South Coast. The forest structure classes were derived from the Southern CRA Region CRAFTI data.

CRAFTI Structure Codes

- Growth Stage

  Regrowth %
  t <10% RCC
  s 10-30%
  e >30%
  Senescing %
  C <10% RCC
  B 10-30%
  A >30%

- Site Height (SF only)

  0 <20m
  1 20m +

- Growth Stage where on SF & Site Ht. > 20m

  Regrowth %
  d 30-50% RCC
  f 50-70%
  g >70%

- Regrowth size class on SF & Site Ht. > 20m

  J <30cm dbhob
  P 30-50cm
  M even mix

- Understorey

  g grassy
  s dry shrub/heath
  m moist shrubby
  R rock
  y mid stratum
  L lantana

- Relative Stand Density

  1 <25%
  2 26-50%
  3 51-75%
  4 >75%

- Disturbance indicators 1: must apply to >50% of polygon

  n No evidence of disturbance
  x Recent logging
  c Older logging
  g Canopy Gaps
  z Clustering of different crown sizes &/or tree heights
  s Dead standing trees >5 per ha
  L Lantana
  w Other weeds
  a Native pioneers e.g. wattle
  p evidence of intensive grazing
  d Crown damage (severe fire, dieback)

- Disturbance indicators 2: indicate point sources (<2ha) only

  b Bare soil (erosion, landslips, mining)
  o Evidence of past clearing, rural residential subdivision
  J Tracks or other visible disturbance. Include transmission lines and roads that split the polygon into portions of less than 30% of polygon area

Native Forest Types

The area database was structured with broad forest type definitions (moist and dry forest) to enable forest type based constraints to be applied during the wood supply modelling. This option was not used.

Disturbance Intensity

The Disturbance Intensity field defines the maximum intensity of disturbance (expressed in silviculture) possible for an area of uneven-aged native forest. This was expressed differently for the South Coast and the Tumut CRA sub-regions.

South Coast Subregion:

The Australian Group Selection (AGS) and Single Tree Selection (STS) silviculture systems were modelled at 3 different harvesting intensity levels (light, moderate, heavy), and separate yield curves were generated for these (refer Section 5.2.1). The STS harvesting intensity refers to the proportion of the standing crop basal area removed on any average hectare. The AGS intensity collectively refers to the size of created gaps, return time of next logging operation, proportion of a given area gapped in a single operation and the proportion of the net harvestable area which is retained and not subject to harvesting. The lower intensity silviculture has a lower impact on the overstorey canopy and creates less disturbance to the site.

In the area database, every analysis unit (unique unit of land) had the disturbance intensity class set at the maximum class (heavy), therefore light, moderate or heavy intensity operations could be applied to that analysis unit. The permissible intensity (less than or equal to the maximum defined intensity) was set by using *SPECTRUM's* management action definitions and schedules (Section 6.5).

The *Intensity Classes* used include:

light	=	light intensity management
medium	=	moderate intensity management
heavy	=	heavy intensity management

Tumut Subregion:

The wood supply forecasts for the Tumut subdivision of the Southern CRA were based on single weighted average yield tables developed for multiple silvicultural regimes across identified strata. Each yield table was assigned a unique code so the correct yield tables could be themed to the appropriate strata. The disturbance code was redefined as the code identifying the unique mixtures of Australian Group Selection (AGS) and Single Tree Selection (STS) with different intensities of harvesting within each primary silvicultural system.

The options include:

mix 1	=	mixed AGS / STS silviculture for strata 21
mix 2	=	mixed AGS / STS silviculture for strata 22
mix 3	=	mixed AGS / STS silviculture for strata 23
mix 4	=	mixed AGS / STS silviculture for strata 24
mix 5	=	mixed AGS / STS silviculture for strata 25

The 5 mixed silviculture classes for the Tumut CRA sub-region strata are based on 77.5% STS moderate intensity, 4.5% AGS Moderate intensity and 18% AGS light intensity silviculture. The AGS and STS silvicultural specifications for the various strata are not identical. Refer Section Appendix 1.3.

5.2 YIELD TABLES

The expected per hectare yields of log products arising from native forests managed under a range of silvicultural scenarios were represented as yield table files. The native forest yields were characterised using uneven-aged yield tables in *Spectrum*. Uneven-aged yield tables contain expected yields that are a function of time (period) with a separate yield for each period in the model planning horizon. Refer to Tables in Appendix 1.6

Since FRAMES is a strategic tool and the inventory was conducted at the strata level, the yield tables reflect strata level yield predictions. Assignment of yields to compartments was inappropriate and would have implied a level of accuracy that cannot be justified.

5.2.1 Native Forest Yields

Regulation of the flow of wood fibre from an extensive native forest resource which is heterogeneous (in structure, species composition, extent, productivity and the management history) requires a wide range of cutting cycle lengths, intensities of harvest, and the need to stagger commencing implementation of a regulated cut in different portions of the resource. Consequently, for the Southern Region CRA regions multiple yield tables were provided for each strata to ensure *Spectrum* had the flexibility to apply the appropriate blend of silvicultural options to achieve the wood supply targets and under the constraints imposed.

Yield tables which contain the predicted volume of log product (m^3/ha by four products) harvested by five year period were generated for each of the native forest strata.

South Coast CRA sub-region:
For the South Coast 42 yield tables per strata were generated, each representing the yield streams expected if managed under different silvicultural regimes, different intensities of management and to reflect different transition periods (delays) before a regulated harvest cycle is applied.

The options included combinations of:

- 2 silvicultural options (STS & AGS);
- 3 intensity levels for silviculture (light, moderate, heavy); and
- 7 delay periods (five year delays before first harvest can commence in area).

Tumut CRA sub-region:
For the Tumut subregion 42 yield tables per strata were generated, each representing the yield streams expected if managed under different silvicultural regimes, different intensities of management and to reflect different transition periods (delays) before a regulated harvest cycle is applied. The options included combinations of:

- 2 silvicultural options (STS & AGS);
- 3 intensity levels for silviculture (light, moderate, heavy); and
- 7 delay periods (5 year delays before first harvest can commence in area).

However, the Tumut yield tables were combined into 30 weighted average tables to enable pre-determined blends of preferred silviculture to be assigned to specific strata.

- 5 strata specific silvicultural options (STS & AGS; light, moderate, heavy harvesting intensity) labelled Mix1 to Mix 5; and
- 7 delay periods.

Yield Table Structure

For the South Coast CRA sub-region, each yield table type constructed reflects the yield stream profile from the stratum when managed under a single silvicultural regime / intensity for the whole planning horizon. In the case of the Tumut CRA sub-region each yield table type constructed represents the weighted average yield stream profile based on a predetermined blend of silvicultural options, for the stratum over the whole planning horizon.

The *Spectrum* model problem was created as a Model I formulation (refer Section 6.2) meaning that each analysis unit (the smallest subset of a strata) is assigned a single yield table in the first period of the modelling planning horizon which is retained throughout the complete planning horizon. There is no scope for allocating another uneven-aged yield table to the analysis unit midstream in the planning horizon.

The native forest yields were modelled as uneven-aged *Spectrum* yield tables which contain volume coefficients (m^3/ha of each log product) for each time period that volume is removed, and a stream of volume coefficients for the entire planning horizon to track the standing inventory volume before each harvest removal. The generation of the native forest yield tables was automated using the FRAMES yield simulator (refer Appendix 1.4) coupled with the use of a PERL script to transform and format the simulator output data into the appropriate *Spectrum* CSV import file format (refer Section 6.11.2).

The yield table data developed and imported into *Spectrum* is structured as 2 files (refer Appendix 1.6) which comprise:

(a) File 1 - yield table definition:
- stratum and silvicultural option;
- yield table type (uneven aged);
- management action attributes;
- period of first yield; and
- unique stratum age class ID which links with file 2.

(b) File 2 - Merchantable yields for each stratum age class, by:
- harvest yield or inventory standing volume prior to harvest;
- log product (HQL, HQS,LQ, Pulp); and
- period.

Native Forest Strategic vs Operational Level Yields

The native forest yield tables are strategic level yield tables which exhibit two distinct differences from operational level (compartment / management unit) yields:

(a) the yield tables reflect the stratum average yield stream. The strategic level stratum yield tables represent the average flows on a regional basis if each constituent management area is stringently managed according to the silvicultural prescription. At an operational level, the volume harvested and timing of the harvest is a function of management history, productivity, species composition and forest structure of a forest block; and the need for each unit of forest to be harvested as part of a larger harvest block to produce wood on an economic basis. The harvest timing imposed on individual units of forest may be optimal because of the over-riding economic objectives and practical harvesting considerations.

(b) A given management unit will yield larger periodic volumes rather than a steady stream of small volumes each period as implied by the strategic level yield table.

5.2.2 Yield Table Log Products

The native forest and hardwood plantation yield tables comprise volumes of 4 generic log grades (refer Tables 5k to 5m and Appendix 1.5):

TABLE 5.K: LOG PRODUCT SPECIFICATIONS FOR SOUTH COAST CRA SUB-REGION

Product	Acceptable qualities	Value	Minimum SED	Maximum SED	Maximum LED	Minimum length	Maximum length	Acceptable species
Large high quality1	AE	52.00	380	1000	2999	3.6	15.4	ASB,BAN,BBG,BBT,BSB,CBX,FAS,FRG,GBX,GIB,GPM,GYG,IBK,MAG,MDG,MKG,MMT,NPM,RBW,RIB,RMY,RPM,RSB,SBG,SHG,SPG,SPM,STA,TRP,WBT,WHA,WSB,YER,YSB
Large high quality2	AE	52.00	375	1000	2999	5.0	15.4	(as above)
Large high quality3	AE	52.00	365	1000	2999	7.0	15.4	(as above)
Large high quality4	AE	52.00	355	1000	2999	9.0	15.4	(as above)
Large high quality5	AE	52.00	345	1000	2999	11.0	15.4	(as above)
Small high quality	AE	25.00	250	380	500	3.6	15.4	ASB,BAN,BBG,BBT,BSB,CBX,FAS,FRG,GBX,GIB,GPM,GYG,IBK,MAG,MDG,MKG,MMT,NPM,OCE,RBW,RIB,RMY,RPM,RSB,SBG,SHG,SPG,SPM,STA,TRP,WBT,WHA,WSB,YER,YSB
Low quality	BAE	12.00	300	1000	2999	2.4	15.4	ABX,ASB,BAN,BBG,BBT,BPM,BSB,CBX,FAS,FRG,GBX,GIB,GPM,GYG,IBK,MAG,MDG,MKG,MMT,MTG,NPM,OCE,PPM,RAP,RBW,RIB,RMY,RPM,RSB,SAP,SBG,SHG,SPG,SPM,STA,TBX,TRP,WBT,WHA,WSB,YER,YSB
Pulp	PBAE	7.50	100	1000	2999	3.0	15.4	ABX,ASB,BBG,BBT,BPM,BSA,BSB,CBX,FAS,GPM,MAG,MDG,MKG,MMG,MMT,MTG,NPM,PPM,RPM,RSB,SHG,SNG,SPG,SPM,STA,WHA,WSB,YER,YSB

TABLE 5.L: LOG PRODUCT SPECIFICATIONS FOR TUMUT CRA SUB-REGION

Product	Acceptable qualities	Value	Minimum SED	Maximum SED	Maximum LED	Minimum length	Maximum length	Acceptable species
Large high quality1	AE	52.00	380	1000	2999	3.6	15.4	ALA,BPM,EUR,FAS,MAG,MMT,MTG,NPM
Large high quality2	AE	52.00	375	1000	2999	5.0	15.4	(as above)
Large high quality3	AE	52.00	365	1000	2999	7.0	15.4	(as above)
Large high quality4	AE	52.00	355	1000	2999	9.0	15.4	(as above)
Large high quality5	AE	52.00	345	1000	2999	11.0	15.4	(as above)
Small high quality	AE	25.00	250	380	500	3.6	15.4	(as above)
Low quality	BAE	12.00	250	700	2999	3.6	15.4	(as above)
Pulp	PBAE	7.50	100	700	2999	3.6	15.4	ALA,BPM,EUR,FAS,MAG,MMT,MTG,NPM,RSB,SBK,SNG

Values for all products: Stump height = 0 (stump height is measured explicitly and categorised as waste); round-off length = 0.2m; cost of saw cut = $0.50

TABLE 5.M: DESCRIPTION OF QUALITY CODES

MARVL Inventory Quality Codes	Product	General Log Grades
A	High quality product	quota sawlogs, small graded sawlogs, sleeper logs, veneer logs, larger poles, piles and girders
E	Elite quality product	Existing or potential veneer, piles, poles, or girders (subset of A quality Code)
B	Low quality product	salvage sawlogs, non-compulsory logs, small sawlogs
P	Pulp	pulp
W	Waste	stump, long butts, dockings

6. MODEL SET-UP, DESIGN AND CONSTRUCTION

6.1 HARDWARE AND SOFTWARE PLATFORM

The *Spectrum* model and associated LP optimisation package C-WHIZ were set up on IBM compatible personal computers in Windows NT and Windows 95 operating environments. The version of *Spectrum* does NOT run under Windows; it is executed directly from DOS.

The *Spectrum* yield scheduling model is available free from the USDA Forest Service on the worldwide web. The model files are contained in several self extracting ZIP files. The minimum hardware specifications for running *Spectrum* on a microcomputer are:

- an IBM compatible 80386 or better machine;
- an Intel math coprocessor;
- a minimum of 8 megabytes (MB) of random access memory (RAM) 16 MB is recommended; and
- a hard disk with at least 200 MB free space.

C-WHIZ a commercial LP software package used to solve *Spectrum* generated matrices can be used on personal computers and selected UNIX workstations. The PC version of C-WHIZ requires an i386 or better CPU with at least 2mb RAM, a math coprocessor, and DOS 3.1 or later.

6.2 MODEL FORMULATION

Spectrum can be structured as a Model 1 or Model 2 formulation which is effectively the mechanism by which the management options (and therefore yield tables) are assigned to the unit areas during the determination of a modelling solution.

In a Model 1 formulation each forest age class or forest strata forms a management unit whose integrity is retained throughout the planning horizon. Each analysis unit hectare is assigned to one of many possible predetermined management schedules for the complete planning horizon.

In a Model 2 formulation each age class (or strata) containing hectares in the first period form a management unit until these hectares are harvested. All hectares that are harvested and regenerated in each period form a new age class (or strata) and management unit until they are harvested again. Over the planning horizon a stand can be assigned one of many different management sequences.

For the CRA strategic yield scheduling a Model 1 formulation was used. This decision was made because of the characteristics of the uneven aged native forest management and the way the native forest yield tables were developed.

The Yield Simulator was designed to generate a yield table for a stratum over the whole planning horizon according to a particular silvicultural option. For each strata, a yield table was provided for each of a range of silvicultural options (AGS/STS, Light/Medium/Heavy intensity, different delay periods). Changes in silvicultural management for a given hectare of land during the planning horizon were not modelled as the aim was to model the yields under consistent silvicultural regimes.

The *Spectrum* Model 1 formulation assigns one of the yield table options to a strata analysis unit in the first period of the modelling planning horizon. The yields in all future periods arise from the same yield table assigned in period 1.

Under a Model 1 formulation a partially complete range of management options are provided for each management unit. This can result in sub-optimal solutions being derived. A Model 2 formulation has the advantage in that the management options assigned to an area can be changed over time. For example, the intensity and timing of harvesting events could be modified between cutting cycles.

As the CRA modelling is a strategic level modelling, whereupon the strata data were collected at a broad level, and resources did not permit high resolution detailed data to be collected and analysed, the model 1 option was adopted. This selected formulation determined the way in which the yield scheduling model templates were constructed.

6.3 CONSTRUCTION OF MODEL TEMPLATE

A separate *Spectrum* model template was prepared for each of the South Coast and Tumut CRA sub-regions.

The construction of a complete model template ready to undertake yield scheduling involved multiple stages:

1. Define attributes and variables

- Create Timber Catchments and Timber Price Zone attributes;
- Create Timber Supply Zones attributes;
- Create silvicultural practice attributes;
- Add silvicultural practice land groups;
- Create disturbance intensity attributes; and
- Add disturbance intensity groups.

2. Define management action attributes

- Define planning horizon and modelling period length;
- Create management action activity (native forest harvesting) and output variables (timber products);
- Define management action attributes (management emphases and intensities) and groups. The emphasis describes the general management goal, and the intensity describes the varying levels of management used to achieve the goal.;
- Define forest treatments (Treatment Types e.g. clearcutting, selection cutting, and thinning); and

- Define yield composites (groupings of activities and outputs, and relationships).

3. Import data files

- Import area (analysis unit) data file; and
- Import yield tables.

4. Create Attribute and Variable Groups

- Create Timber Catchment & Timber Price Zone groups;
- Create Timber Supply Zones groups; and
- Create native forest Strata groups.

Create Management Themes

- Create management action definition. These include a name, management emphasis, management intensity, and a list of activities, outputs, and conditions. Land Themes (groups of analysis units by attributes) to which the management action may be applied were specified; and
- Create management action schedules for each management action.

5. Develop customised solution report specifications.

6. Set up default objective function.

7. Define wood supply general and harvest policy constraints.

Once a model was constructed for a CRA sub-region it was used as a template for the subsequent model runs. As the negotiations largely centred around variations in the conservation reserve design and the impact of area changes on yields, a given model template was repeatedly used and the area file was simply modified and imported to override the previous area data file. The yield tables were periodically reconstructed to reflect expected yields from plots within a newly defined population as forest was placed in reserves. The remaining plots in the net harvestable area were used in the re-simulation of yield table, which then formed the basis of another template.

6.4 IMPORT OF YIELD TABLES AND NET HARVESTABLE AREA DATA

The yield tables and net harvestable area data files created in preceding modules of FRAMES were structured as comma delimited files (csv) so they could be imported into *Spectrum* in preference to being manually entered through the graphical user interface. The analysis unit and yield data are imported through the *Spectrum* Partial Model Imports GUI. The yield data are imported as two files (refer Appendix 1.6) and the area data is imported as a single data file.

The net harvest area comma delimited file creation was semi-automated with the *NHAQUERY_SR.EXE* model, and the PERL script *NativeYield_STHCRA.pl* was used to transform the native forest yield tables into csv file format for importation into *Spectrum*. The semi-automation was arranged so that (a) variants of the area and yield data could be repeatedly and promptly processed during the negotiation process, and (b) to eliminate data transcription and formatting errors which could arise from manual data file creation or manual data entry through the GUI.

NHAQUERY_SR.EXE was used to create the analysis unit file of the native hardwood forest net harvestable areas from the spatial analysis files, C-PLAN and user defined exclusions (refer Section 6.11.1). *NativeYield_STHCRA.pl* was used to read in native hardwood forest yield tables generated from the Native Forest Yield Simulator and to reformat these as CSV files for import into *Spectrum*.

6.5 DEFINITION OF MANAGEMENT ACTIONS (ACTIVITIES, OUTPUTS, CONDITIONS)

Management actions (harvesting system options) were defined so that the *Spectrum* model relates relevant data (analysis unit and yield data options) to constrain the appropriate or preferred management options which apply to specific analysis units (strata). Details on the management actions follow.

6.5.1 Planning horizon

A planning horizon of 200 years was used for the *Spectrum* modelling. The CRA negotiation yield scheduling focused on exploring the wood supply levels for a term of 20 years under various formal reserve design, but the modelling process was conducted beyond the 20 year period to ascertain the long term sustainable yield.

The 200 year planning horizon was used because native eucalypt forest growth rate is low and it was important to model the impacts of the harvesting strategy and silvicultural options on the long term sustainable yield. A planning horizon of 200 years was selected to cover a full rotation of the slow growing native forest strata to reflect the impact of forest structural change on wood supply.

The specifications in *Spectrum* were:

Begin Year	=	1999
Periods for planning horizon	=	40
Each period	=	5 years

6.5.2 Activities and Outputs

A forest management plan consists of a set of management actions applied to specific land units. Management actions include activities and outputs. Management activities (native forest harvesting) and outputs (timber products) were defined in *Spectrum*.

Activities included in the CRA model only included:

ue_harvest	=	harvest uneven aged native forest (m^3)

The activity were qualified with settings:

- acre - sets the spatial units for activity or output coefficients. If the units are "per acre", then a coefficient is the same for each acre on each analysis unit. In contrast, if the units are "per area" then the coefficient applies to the entire analysis unit regardless of size.

- period - attributes measured on a periodic basis already have the number of years/period taken into account. In contrast the coefficient of an attribute measured on a yearly basis is multiplied by the number of years in each period to obtain the periodic total.

Outputs are the results of activities. Outputs included in the CRA model were:

HQ_L_Sawlog	=	high quality (large) sawlogs (m^3)
HQ_S_Sawlog	=	high quality (small) sawlogs (m^3)

LQ_Sawlog = low quality sawlogs (m^3)
Pulp = pulp logs (m^3)
Wood (group) = multi-product of wood volume. Total volume (m^3) of wood from all product types (HQL+HQS+LQ+PULP).
netarea_ue = net area of uneven aged native forest harvested (ha)

These activities were qualified with acre and period settings defined as above.

6.5.3 Treatment types

Treatment types were used to define the yield information within a given yield table.

In the uneven-aged native forests (uneven-aged yields) the following treatments were defined:
Sel-F = selection harvest, first entry
Sel-L = selection harvest, later entries
INV = selection harvest, inventory

The uneven age forest yield tables show the yield flow for the whole planning horizon. The Sel-F treatment indicates the first period yield and the Sel-L treatment shows the yields expected for each subsequent period. The INV shows the standing yields. This is used for assessing residual stands or the stand condition over time.

6.5.4 Yield Composites

Management actions included the activity native forest harvesting which produces multiple outputs (timber products). The activities, outputs and relationships were grouped together in a yield composite that is associated with a management action. Yield composites eliminate the need to repetitively list all the activities and outputs involved in each management action.

The uneven-aged harvesting yield composite “ue_c”, is linked to the independent variable *wood. The yield composite dependencies are defined in Table 6a.

TABLE 6.A: YIELD COMPOSITE UE_C

Dependent	Units	Independent	Type	Form	Treatment	Factor
ue_harvest	Amount	Wood	Time	Simple	-	1.000
Netarea_ue	acres treated	Wood	Time	Simple	-	1.000
Total_Wood	Amount	Wood	Time	Simple	-	1.000

ue_harvest = uneven-aged harvesting (m^3) (activity)
netarea_ue = net area that receives uneven-aged treatment (ha) (output)
Total_Wood = total amount of wood from all product types (m^3) (output)
*wood = multiproduct of wood volume HQ_L_sawlog + HQ_S_sawlog + LQ_sawlog + Pulp (m^3) (output)
Amount = state the dependent variable is related to the amount of the independent variable
Acres Treated = the dependent variable is related to the acres associated with the independent variable
Time = time dependent relationship. The dependent activity or output occurs at the same time as the independent activity or output occurs
Simple = functional form which relates the dependent variable to the independent with only one factor that does not vary over time, age, qualifier or land attribute.
Factor = dependent variable multiplicative factor

6.5.5 Management Action Attributes

Management action attributes consist of *Management Emphases* and *Management Intensities*. Management emphasis describes the general management goal, while management intensity describes various levels of management available to achieve the goal. The land units to which management action attributes can be applied are specified in the management action definitions discussed below.

The Emphasis classes used are the classes of silviculture modelled, which include:
gtimb = group selection timber
stimb = single timber selection
sgtim = stimb and gtimb group
mtimb = mixed AGS / STS silviculture

AGS and STS silviculture options were provided for all of the uneven aged native forests, predetermined mix of AGS / STS options were also provided for strata in the Tumut CRA sub-region. The individual silvicultural regime options were not used for the Tumut CRA sub-region. These were restricted in the analysis unit database by specifying permissible disturbance type.

The *Intensity Classes* used include:
light = light intensity management
medium = moderate intensity management
heavy = heavy intensity management
mix 1 = mixed AGS / STS silviculture for strata 21
mix 2 = mixed AGS / STS silviculture for strata 22
mix 3 = mixed AGS / STS silviculture for strata 23
mix 4 = mixed AGS / STS silviculture for strata 24
mix 5 = mixed AGS / STS silviculture for strata 25

The five mixed silviculture classes for the Tumut CRA sub-region strata are based on 77.5% STS moderate intensity, 4.5% AGS Moderate intensity and 18% AGS Light intensity silviculture. The AGS and STS silvicultural specifications for the various strata are outlined in Appendix 1.2 and 1.3.

6.5.6 Management Action Definition

Management action definitions comprise two parts:

Options

The management actions comprise the silvicultural regime options which will be used to achieve the modelling objectives. Each silvicultural regime is defined in terms of the management emphasis, management intensity, schedule type, and yield composite associated with the management action.

The management emphasis and management intensity defines "what" the action is trying to accomplish and "why" the action was developed. The schedule type defines "how" and "when" the action will be implemented, and the yield composite contains the set of activities, outputs, and conditions that occur as a result of the action being implemented.

The management action options defined in the CRA model are outlined in Table 6B.

TABLE 6.B: MANAGEMENT ACTION DEFINITIONS

Management Action	Management Emphasis	Management Intensity	Yield Composite	Schedule Type
Australian Group Selection Heavy	gtimb	heavy	ue_c	uneven_aged
Australian Group Selection Medium	gtimb	medium	ue_c	uneven_aged
Australian Group Selection Light	gtimb	light	ue_c	uneven_aged
Single Tree Selection Heavy	stimb	heavy	ue_c	uneven_aged
Single Tree Selection Medium	stimb	medium	ue_c	uneven_aged
Single Tree Selection Light	stimb	light	ue_c	uneven_aged
Mixed Silviculture Option 1	mtimb	Mix1	ue_c	uneven_aged
Mixed Silviculture Option 2	mtimb	Mix2	ue_c	uneven_aged
Mixed Silviculture Option 3	mtimb	Mix3	ue_c	uneven_aged
Mixed Silviculture Option 4	mtimb	Mix4	ue_c	uneven_aged
Mixed Silviculture Option 5	mtimb	Mix5	ue_c	uneven_aged

Where:
gtimb = group selection silviculture
stimb = single tree selection silviculture
ptimb = plantation silviculture
mtimb = mixed AGS / STS silviculture

Themeing

Themeing involves defining the analysis units (land unit) to which a management action may be applied, or conversely, this process defines which management actions can or cannot be allocated to given areas of land. Themeing enables the model user to restrict the application and range of suitable and preferred management options.

Where multiple management options exist for an analysis unit, LP Solver in the *Spectrum* model may allocate more than one regime spatially i.e subdivide the area analysis unit up into as many units as necessary, and allocate unique management actions to each of the subdivisions. The way in which *Spectrum* allocates management actions temporally varies depends on the model formulation. *Spectrum* only selects one action for a given unit of land when a Model I formulation is used (i.e the management action and therefore yield profile applies for the planning horizon), but under a Model 2 formulation *Spectrum* may allocate multiple management action options temporally.

For the Southern CRA, management actions were themed to specific groups of land units to reflect valid and preferred silvicultural options. The approach used for the South Coast CRA sub-region was based on identifying preferred silviculture regime options for strata with specific floristic and structural characteristics. Certain silvicultural options were not permitted. For the Tumut CRA sub-region, forest strata were each linked to a single weighted average yield tables based on the current blend of preferred silvicultural practices.

South Coast CRA sub-region:

The preferred silviculture for South Coast sub-region varies according to site productivity, forest type and forest structure.

In general Single Tree Selection (STS) is the preferred silviculture. However, in some strata and in some Timber Supply Zones, Group Selection (GS) or a combination of GS and STS is the preferred silviculture. Local knowledge of the forest types and geographical areas has been used to nominate preferred silviculture to broad groups and to identify which Timber Supply Zones are appropriate for the preferred silviculture.

Three broad groupings of strata were designated:

- A Regrowth Group comprising Strata 14, 15, 16, 17, 18 and 19
- A "Reset" Group comprising Strata 1, 2, 3, 6, 8 and 9.
- An Other Group comprising Strata 4, 5, 7, 10, 11, 12, 13 and 20

A "Reset" is the commencement of a stands' rotation. The formation of gaps or discrete patches (of varying sizes) of complete tree over a landscape is referred to as Group Selection.

The Regrowth Group

The strata in the Regrowth group within Timber Supply Zones 602, 605, 613, 621, 4206, 4405 and 4407 are considered to be characterised by a relatively uniform structure and to have a size class distribution suited to commercial thinning and ultimately a reset harvesting, exclusively by GS.

In Timber Supply Zones 403, 601, 612, 614, 4207, 4402, 4404, 4602, 4604 and 4606, the strata in the regrowth group are more variable in their structure and size class. These strata will be managed on a site specific basis by either GS or STS, as appropriate.

In all other Timber Supply Zone, the strata in the regrowth group will be managed by STS.

The Reset Group

The strata designated in the "Reset" group include those mature and mixed age yield associations of high productivity, which in localities identified by Timber Supply Zone 403, 613, 614, 621, 4203, 4602, 4604, 4606 generally contain tall moist forest. These forests are often characterised by trees with large crowns and have dense moist understoreys and moist groundcover. Successful regeneration and growth of these forests following harvesting requires large gaps provided by GS. This is particularly important in the moist Spotted Gum forest, which does not have the lignotuber pool that provides a large proportion of the regeneration on the more typical, drier Spotted Gum sites.

In all other Timber Supply Zone, the strata in the reset group will be managed by STS.

Other Strata

The strata in the Other group will be managed by STS.
Table 6c summarises the preferred silviculture by Strata and Timber Supply Zone.

TABLE 6.C: GEOGRAPHICAL EXTENT OF SILVICULTURE WITHIN SOUTH COAST CRA SUB-REGION

Timber Supply Zone	Silvicultural System						*SPECTRUM* TSZ Theme Code
	Single Tree Selection			Group Selection			
	Regrowth	Reset	Other	Regrowth	Reset	Other	
601	Y	Y	Y	Y	n/a	n/a	ALL_RG
612	Y	Y	Y	Y	n/a	n/a	
4207	Y	Y	Y	Y	n/a	n/a	
4402	Y	Y	Y	Y	n/a	n/a	
4404	Y	Y	Y	Y	n/a	n/a	
35	Y	Y	Y	n/a	n/a	n/a	ALLNIL
401	Y	Y	Y	n/a	n/a	n/a	
404	Y	Y	Y	n/a	n/a	n/a	
603	Y	Y	Y	n/a	n/a	n/a	
604	Y	Y	Y	n/a	n/a	n/a	
607	Y	Y	Y	n/a	n/a	n/a	
608	Y	Y	Y	n/a	n/a	n/a	
609	Y	Y	Y	n/a	n/a	n/a	
616	Y	Y	Y	n/a	n/a	n/a	
617	Y	Y	Y	n/a	n/a	n/a	
619	Y	Y	Y	n/a	n/a	n/a	
620	Y	Y	Y	n/a	n/a	n/a	
622	Y	Y	Y	n/a	n/a	n/a	
4201	Y	Y	Y	n/a	n/a	n/a	
4202	Y	Y	Y	n/a	n/a	n/a	
4204	Y	Y	Y	n/a	n/a	n/a	
4205	Y	Y	Y	n/a	n/a	n/a	
4208	Y	Y	Y	n/a	n/a	n/a	
4209	Y	Y	Y	n/a	n/a	n/a	
4401	Y	Y	Y	n/a	n/a	n/a	
4403	Y	Y	Y	n/a	n/a	n/a	
4406	Y	Y	Y	n/a	n/a	n/a	
4603	Y	Y	Y	n/a	n/a	n/a	
4605	Y	Y	Y	n/a	n/a	n/a	
4607	Y	Y	Y	n/a	n/a	n/a	
4608	Y	Y	Y	n/a	n/a	n/a	
403	Y	n/a	Y	Y	Y	n/a	RG_ALL
614	Y	n/a	Y	Y	Y	n/a	
4602	Y	n/a	Y	Y	Y	n/a	
4604	Y	n/a	Y	Y	Y	n/a	
4606	Y	n/a	Y	Y	Y	n/a	
4203	Y	n/a	Y	n/a	Y	n/a	RG_RS
602	n/a	Y	Y	Y	n/a	n/a	RS_RG
605	n/a	Y	Y	Y	n/a	n/a	
4206	n/a	Y	Y	Y	n/a	n/a	
4405	n/a	Y	Y	Y	n/a	n/a	
4407	n/a	Y	Y	Y	n/a	n/a	
613	n/a	n/a	Y	Y	Y	n/a	NILALL
621	n/a	n/a	Y	Y	Y	n/a	

Note: Y = yes silvicultural option is applicable in Timber Supply Zone. n/a = indicates that the silvicultural option is not applicable. The *SPECTRUM* Timber Supply Zone theme codes are explained in section below.

Examples of these rules are:

- Timber Supply Zone 35 will have STS everywhere, always (i.e. no exceptions)
- Timber Supply Zone 602 regrowth can only have GS.
- Timber Supply Zone 613 will have STS, except for its regrowth which can only have GS, and its reset stands which can only have GS
- Timber Supply Zone 403 will have STS, except for its regrowth which can have either STS or GS (assume the scheduler will pick the most productive), and its reset stands which can have only GS
- Timber Supply Zone 4203 will have STS, except for its reset stands which can have only GS.

The management actions were themed to analysis units via land attributes (Table 6D). The management actions are linked to land units using land attribute **groups** reflecting the Geographical Extent of Silviculture options. Both Timber Supply Zone and strata groups were used to simplify the expression of themes.

TABLE 6.D: MANAGEMENT ACTION DEFINITION LAND THEMES

Management Action	Analysis Unit	TC_TPZ	TSZ	Strata	Prac	Distub
Group Selection Heavy	All	All	All_RG	Regrow	All	Heavy
	All	All	NILALL	RegRes	All	Heavy
	All	All	RG_ALL	RegRes	All	Heavy
	All	All	RG_RS	Reset	All	Heavy
	All	All	RS_RG	Regrow	All	Heavy
Group Selection Medium	All	All	All_RG	Regrow	All	gp_mh
	All	All	NILALL	RegRes	All	gp_mh
	All	All	RG_ALL	RegRes	All	gp_mh
	All	All	RG_RS	Reset	All	gp_mh
	All	All	RS_RG	Regrow	All	gp_mh
Group Selection Light	All	All	All_RG	Regrow	All	gp_lmh
	All	All	NILALL	RegRes	All	gp_lmh
	All	All	RG_ALL	RegRes	All	gp_lmh
	All	All	RG_RS	Reset	All	gp_lmh
	All	All	RS_RG	Regrow	All	gp_lmh
Single Tree Selection Heavy	All	All	ALLNIL	All	All	Heavy
	All	All	All_RG	All	All	Heavy
	All	All	RG_ALL	EXRES	All	Heavy
	All	All	RG_RS	EXRES	All	Heavy
	All	All	RS_RG	EXREG	All	Heavy
	All	All	NILALL	EXRSRG	All	Heavy
Single Tree Selection Medium	All	All	ALLNIL	All	All	gp_mh
	All	All	All_RG	All	All	gp_mh
	All	All	RG_ALL	EXRES	All	gp_mh
	All	All	RG_RS	EXRES	All	gp_mh
	All	All	RS_RG	EXREG	All	gp_mh
	All	All	NILALL	EXRSRG	All	gp_mh
Single Tree Selection Light	All	All	ALLNIL	All	All	gp_lmh
	All	All	All_RG	All	All	gp_lmh
	All	All	RG_ALL	EXRES	All	gp_lmh
	All	All	RG_RS	EXRES	All	gp_lmh
	All	All	RS_RG	EXREG	All	gp_lmh
	All	All	NILALL	EXRSRG	All	gp_lmh

Where:

TC_TPZ	=	Timber Catchment and Timber Price Zone.
TSZ	=	Timber Supply Zone. (Groups are defined below)
Strata	=	Strategic inventory strata. (Groups are defined below).
Prac	=	Silvicultural practice.
Distub	=	Disturbance intensity
heavy	=	The management action can only be used on sites where heavy intensity silviculture is permitted
gp_mh	=	The management action can only be used on sites where medium and heavy intensity silviculture are permitted
gp_lmh	=	The management action can be used on all sites in which light, medium, and heavy intensity silviculture is permissible.
All	=	Signifies all options are applicable.

Timber Supply Zone groups:
Code order: STS_GS

TSZ group options for STS and GS

ALL	=	Silviculture is applicable to both Regrowth and Reset stands
NIL	=	Silviculture is not applicable to either Regrowth or Reset stands
RG	=	Silviculture is applicable to Regrowth stands only
RS	=	Silviculture is applicable to Reset stands only

Group combinations included:

ALLNIL	=	Regrowth & Reset STS, no GS silviculture
ALL_RG	=	Regrowth & Reset STS, Regrowth GS silviculture only
NILALL	=	No STS silviculture, Regrowth & Reset GS
RG_ALL	=	Regrowth STS silviculture only, Regrowth & Reset GS
RG_RS	=	Regrowth STS & Reset GS silviculture only
RS_RG	=	Reset STS & Regrowth GS silviculture only

For example:

ALLNIL	=	STS is applicable to both regrowth and reset stands, GS is not applicable to regrowth or reset stands.
RS_RG	=	STS is applicable to reset stands NOT regrowth, GS is not applicable to regrowth NOT reset stands.

Strata groups:

EXREG	=	All strata except regrowth (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 20)
EXRES	=	All strata except reset (4, 5, 7, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20
EXRSRG	=	All strata NOT regrowth or reset (4, 5, 7, 10, 11, 12, 13, 20)
RegRes	=	Regrowth and reset strata (1, 2, 3, 6, 8, 9, 14, 15, 16, 17, 18, 19)
Regrow	=	Regrowth strata (14, 15, 16, 17, 18, 19)
Reset	=	Reset strata (1, 2, 3, 6, 8, 9)

(EX* = codes to enable themeing of STS silviculture. STS applies to all strata EXCEPT those specified)

Tumut CRA Sub-region:

Composite yield tables based on multiple silvicultural regimes across a strata were used in the Tumut CRA sub-region. Each single yield table is a weighted average yield table, each reflecting the different silvicultural systems and silvicultural intensities which are used in combination across a given strata. The 5 mixed yield table classes for the Tumut CRA sub-region strata are based on 77.5% STS moderate intensity, 4.5% AGS Moderate intensity and 18% AGS Light intensity silviculture. The AGS and STS silvicultural specifications for the various strata are not identical. Refer Appendix 1.3.

The purpose of using single composite yield tables reflecting current practice, in preference to a separate yield table for each silvicultural option, was to constrain the blend of silvicultural options which will be applied within broad CRA inventory strata. It is not possible to regulate this in *SPECTRUM*, rather it is only possible to specify the range of silvicultural options which apply to a given geographical area or strata. *SPECTRUM* selects the blend of silviculture which best achieves the wood supply objective function and satisfies the constraints. It is not practical to spatially define these areas therefore weighted average yield tables were developed to reflect the average level of each harvesting system within a given strata.

The forest structure varies continually across the landscape, such that an area scheduled for harvesting may require GS and STS of different intensities, and thinning operations, over different parts of the same harvesting area. The strategic forest inventory conducted was a comparatively low intensity for such an extensive and heterogeneous native forest resource, resulting in broad strata encompassing a wide range of structure classes, forests with different market demands / options for products and operational issues. Consequently no single yield table should be applied across the whole strata. These factors lead to the adoption of this approach.

The yield tables (silviculture) applicable to a strata were constrained to reflect the average realistic blend of silviculture which occurs in practice. An “unregulated” approach (providing multiple silvicultural options for a strata in *SPECTRUM*) could lead to unsuitable blends of silviculture being applied (i.e. does not reflect preferred or appropriate management practices).

Regulating the allocation of yield tables was achieved through the management actions land themes (mixed silv options) and management action schedule in conjunction with use of the land attribute disturbance intensity label “mix#” in the analysis unit database. The opportunity to model the full range of silvicultural regimes (AGS and STS options) in an unconstrained model was also provided, but not used.

TABLE 6.E: MANAGEMENT ACTION DEFINITION LAND THEMES

Management Action	Analysis Unit	TC_TPZ	TSZ	Strata	Prac	Distub
Group Selection Heavy	All	All	All	Riv	All	Heavy
Group Selection Medium	All	All	All	Riv	All	gp_mh
Group Selection Light	All	All	All	Riv	All	gp_lmh
Single Tree Selection Heavy	All	All	All	All	All	Heavy
Single Tree Selection Medium	All	All	All	Riv	All	gp_mh
Single Tree Selection Light	All	All	All	Riv	All	gp_lmh
Mixed Silv Option 1	All	All	All	21	All	mix1
Mixed Silv Option 2	All	All	All	22	All	mix2
Mixed Silv Option 3	All	All	All	23	All	mix3
Mixed Silv Option 4	All	All	All	24	All	mix4
Mixed Silv Option 5	All	All	All	25	All	mix5

Where:

TC_TPZ= Timber Catchment and Timber Price Zone
TSZ = Timber Supply Zone. (Groups are defined below)
Strata = Strategic inventory strata. (Groups are defined below)
Prac = Silvicultural practice
Distub = Disturbance intensity
heavy = the management action can only be used on sites where heavy intensity silviculture is permitted
gp_mh = the management action can only be used on sites where medium and heavy intensity silviculture are permitted
gp_lmh = the management action can be used on all sites in which light, medium, and heavy intensity silviculture is permissible
mix1 = the management action can only be applied where there is mixed AGS / STS silviculture for strata 21
mix2 = the management action can only be applied where there is mixed AGS / STS silviculture for strata 22
mix3 = the management action can only be applied where there is mixed AGS / STS silviculture for strata 23
mix4 = the management action can only be applied where there is mixed AGS / STS silviculture for strata 24
mix5 = the management action can only be applied where there is mixed AGS / STS silviculture for strata 25
All = signifies all options are applicable

Strata group "Riv" (Riverina) includes all Tumut strata 21 – 25, and excludes strata 30 (Ingebyrah State Forest) in SE NSW.

6.5.7 Management Action Schedules

Each management action has a schedule and schedule timing options. Schedule timing options are the time periods in which a management action may take place. The LP solver selects the timing option that best satisfies the objective function and constraint set associated with the model. Each management action was themed to one or more analysis units (strata).

Schedule

All of the analysis units associated with an uneven-aged forest management action have Uneven-Aged schedules. The schedule reflects the themeing – permissible and desirable options by land unit.

TABLE 6.F: MANAGEMENT ACTION SCHEDULE LAND THEMES – SOUTH COAST CRA SUB_REGION UNEVEN AGE NATIVE FOREST

Management Action	Analysis Unit	TC_TPZ	TSZ	Strata	Prac	Distub	Emphasis	Intensity
Group Selection Heavy	All	All	All_RG	Regrow	All	Heavy	gtimb	heavy
	All	All	NILALL	RegRes	All	Heavy	gtimb	heavy
	All	All	RG_ALL	RegRes	All	Heavy	gtimb	heavy
	All	All	RG_RS	Reset	All	Heavy	gtimb	heavy
	All	All	RS_RG	Regrow	All	Heavy	gtimb	heavy
Group Selection Medium	All	All	All_RG	Regrow	All	gp_mh	gtimb	medium
	All	All	NILALL	RegRes	All	gp_mh	gtimb	medium
	All	All	RG_ALL	RegRes	All	gp_mh	gtimb	medium
	All	All	RG_RS	Reset	All	gp_mh	gtimb	medium
	All	All	RS_RG	Regrow	All	gp_mh	gtimb	medium
Group Selection Light	All	All	All_RG	Regrow	All	gp_lmh	gtimb	light
	All	All	NILALL	RegRes	All	gp_lmh	gtimb	light
	All	All	RG_ALL	RegRes	All	gp_lmh	gtimb	light
	All	All	RG_RS	Reset	All	gp_lmh	gtimb	light
	All	All	RS_RG	Regrow	All	gp_lmh	gtimb	light
Single Tree Selection Heavy	All	All	ALLNIL	All	All	Heavy	stimb	heavy
	All	All	All_RG	All	All	Heavy	stimb	heavy
	All	All	RG_ALL	EXRES	All	Heavy	stimb	heavy
	All	All	RG_RS	EXRES	All	Heavy	stimb	heavy
	All	All	RS_RG	EXREG	All	Heavy	stimb	heavy
	All	All	NILALL	EXRSRG	All	Heavy	stimb	heavy
Single Tree Selection Medium	All	All	ALLNIL	All	All	gp_mh	stimb	medium
	All	All	All_RG	All	All	gp_mh	stimb	medium
	All	All	RG_ALL	EXRES	All	gp_mh	stimb	medium
	All	All	RG_RS	EXRES	All	gp_mh	stimb	medium
	All	All	RS_RG	EXREG	All	gp_mh	stimb	medium
	All	All	NILALL	EXRSRG	All	gp_mh	stimb	medium
Single Tree Selection Light	All	All	ALLNIL	All	All	gp_lmh	stimb	light
	All	All	All_RG	All	All	gp_lmh	stimb	light
	All	All	RG_ALL	EXRES	All	gp_lmh	stimb	light
	All	All	RG_RS	EXRES	All	gp_lmh	stimb	light
	All	All	RS_RG	EXREG	All	gp_lmh	stimb	light
	All	All	NILALL	EXRSRG	All	gp_lmh	stimb	light

TABLE 6.G: MANAGEMENT ACTION SCHEDULE LAND THEMES – TUMUT CRA SUB_REGION UNEVEN AGE NATIVE FOREST

Management Action	Analysis Unit	TC_TPZ	TSZ	Strata	Prac	Distub	Emphasis	Intensity
Group Selection Heavy	All	All	All	Riv	All	Heavy	gtimb	heavy
Group Selection Medium	All	All	All	Riv	All	gp_mh	gtimb	medium
Group Selection Light	All	All	All	Riv	All	gp_lmh	gtimb	light
Single Tree Selection Heavy	All	All	All	Riv	All	Heavy	stimb	heavy
Single Tree Selection Heavy	All	All	All	30	All	Heavy	stimb	heavy
Single Tree Selection Medium	All	All	All	Riv	All	gp_mh	stimb	medium
Single Tree Selection Light	All	All	All	Riv	All	gp_lmh	stimb	light
Mixed Silv Option 1	All	All	All	21	All	mix1	mtimb	Mix1
Mixed Silv Option 2	All	All	All	22	All	mix2	mtimb	Mix2
Mixed Silv Option 3	All	All	All	23	All	mix3	mtimb	Mix3
Mixed Silv Option 4	All	All	All	24	All	mix4	mtimb	Mix4
Mixed Silv Option 5	All	All	All	25	All	mix5	mtimb	Mix5

Schedule timing

TABLE 6.H: UNEVEN-AGED FOREST SCHEDULE

Management Action	Periods to begin removal sequence
Australian Group Selection Heavy	1 – 7
Australian Group Selection Medium	1 – 7
Australian Group Selection Light	1 – 7
Single Tree Selection Heavy	1 – 7
Single Tree Selection Medium	1 – 7
Single Tree Selection Light	1 – 7
Mixed Silvicultural Option 1	1 – 7
Mixed Silvicultural Option 2	1 – 7
Mixed Silvicultural Option 3	1 – 7
Mixed Silvicultural Option 4	1 – 7
Mixed Silvicultural Option 5	1 – 7

The “begin removal sequence” time periods specified correspond to the range of yield table delay options (period 1 corresponds to no period delay, period 2 corresponds to one period delay etc). The “begin-removal” dates are specified in the yield table data file.

6.6 DEFINITION OF GOALS AND OBJECTIVE FUNCTION

The wood supply modelling was aimed at evaluating the impacts of proposed new conservation reserve designs on wood supply, and ascertaining a management strategy which would best achieve meeting State Forests' current commitments of native forest products to industry in the Southern CRA regions, while achieving long term sustainability.

The objective function specified in *Spectrum* was to maximise the volume of large high quality sawlog (≥40cm cdub) volumes within the defined constraints. The large High Quality Log volume alone was used as the product to maximise in *Spectrum* because it was identified as the limiting factor. Other forest products are either by-products of quota quality harvesting and/or have typically been considerably less than maximum volumes capable of being produced.

Though in the Tumut CRA sub-region it was necessary to also monitor whether the volume of high quality small logs produced from Ash strata was sufficient to meet industry demands, as the Ash resource capacity relative to the demand is limited.

TABLE 6.I: SUMMARY OF WOOD SUPPLY COMMITMENTS IN SOUTHERN CRA REGION (M^3/YEAR)

Timber Catchment	Management Area	Term & Wood Supply Agreements		Short Term Agreements		
		High Quality Large	High Quality Small	High Quality Large	High Quality Small	Low Quality
South Coast Coastal	Batemans Bay	12,265		3,855	7,710	8,150
	Narooma	13,860		4,322	3,660	7,450
	Nowra	750		225	550	650
	Coastal Total	**26,875**		**8,402**	**11,920**	**16,250**
South Coast Tablelands	Badja	1,615		485	25	2,500
	Queanbeyan	3,385		1,015	125	9,250
	All East MA's				50	1,000
	Tablelands Total	**5,000**		**1,500**	**200**	**12,750**
	South Coast Total	**31,875**		**9,902**	**12,120**	**29,000**
Southern Highlands	Bago / Maragle - Ash	17,932	1,585	3,910	453	4,500
(Tumut)	Bago / Maragle - Hardwood			2,000	1,000	1,000
	Buccleuch - Ash			1,500		
	Buccleuch - Hardwood	13,500	1,500			
	Southern Highlands Total	**31,432**	**3,085**	**7,410**	**1,453**	**5,500**
Ingebirah *		1,000				
	Tumut Total	**32,432**	**3,085**	**7,410**	**1,453**	**5,500**
	Southern CRA Region Total	**64,307**	**3,085**	**17,312**	**13,573**	**34,500**

* Resource committed to Eden Management Area (20,000 total HQL volume)

6.7 CONSTRAINTS

The constraints on harvesting of Southern Region forest resources on State forest included:

(a) Restrictions on area available for harvesting due to:
- EPA licence conditions;
- NPWS conservation protocols;
- protected forest types - rainforest and rare forest types; and
- exclusions identified by SFNSW in Forest Management Zoning such as non-commercial forest, physically and economically inaccessible areas

(b) Permissible silvicultural options due to EPA / NPWS protocols:
- Australian Group Selection silviculture restrictions on gap size and return time; and
- Single Tree Selection silviculture restrictions on maximum proportion of basal area removal.

(c) Forest management requirements:
- meet current contractual wood supply levels for term of contracts and aim to extend these to at least 20 years;
- minimise log cartage between wood supply catchments when meeting supply; commitments to industry as these would not occur in practice due to prohibitive transportation costs;
- achieve appropriate species mix of required product;
- achieve a future sustainable supply of high quality sawlogs;
- achieve and maintain a suitable native forest composition, structure and distribution to achieve a sustainable wood supply. Where possible enhance over time through improved silviculture and regulating harvesting; and
- implementing silvicultural prescriptions in native forest – minimum harvesting triggers for economic volume and composition of log products, achieving adequate site disturbance and canopy removal for regeneration, retaining adequate regeneration and habitat trees.

The constraints were modelled using two mechanisms. The constraints on the area available for harvesting and the restrictions on silvicultural prescriptions were largely accounted for in the preparation of data imported into *SPECTRUM*. While constraints on the wood supply and the permissible silvicultural options were addressed in the yield scheduling process.

6.7.1 Constraints external to model

The constraints accounted for in the preparation of data imported into model included the derivation of the net harvestable area and the yield tables. As the harvest area constraints (exclusion areas) were subject to variation, the database was structured to permit recalculation of the area data files imported (State Forests of NSW, February 2001). Similarly the yield constraints (silvicultural prescriptions and log specifications) were subject to variation. The yield simulator model was designed to permit recalculation of yield tables resulting from different silvicultural conditions and log specifications.

Net Harvestable Area

The Net Harvestable Area of native forest used in the *Spectrum* model was calculated using NHAQUERY (refer Section 6.11.1). This NHA model enables the area datafiles for *Spectrum* to be recalculated after identifying different area exclusion factors, conservation (C-PLAN)

reserve designs and threatened flora and fauna species strike rates. Strike rates for the South coast CRA sub-region were 6.2% and the Tumut CRA sub-region were 4.0%
During the "options development phase" of the CRA negotiations, the FRAMES net harvest area was recalculated to determine the impact of:

(a) C-Plan scenario conservation reserve exclusions. These are compartments unavailable for harvesting.

(b) modifying proposed Candidate old growth and Identified wilderness area definitions and extent.

Yield Table

The native forest strata yields per net harvestable hectare were simulated for the range of silvicultural systems and prescriptions, log specifications and management options (delay periods before commencing cutting cycle). Restrictions on silvicultural regimes were accounted for in the design of the yield tables.

It should be noted that these yields per hectare are average strata yields per hectare. For a given stratum the yield arising from individual plots are summed and then divided by the total number of plots in the stratum. As the maturity of plots within a stratum varies, the number of plots contributing to yield (i.e. those harvested) varies each year. So the stratum average yield per hectare does not resemble the yield from a specific hectare within the stratum, rather the average yield expected from a conceptual stratum hectare. When the yield is multiplied by the stratum area, the correct total yield is calculated.

The silvicultural systems only included STS and GS. Clear cutting was not permitted.

The constraints on silvicultural prescriptions included:

- maximum basal area removal in STS (40% basal area in heavy intensity operation);
- maximum gap size in GS (The maximum modelled was 100 m gap for heavy operation, but in the more accepted medium intensity operation – the maximum permissible gap was 70m;
- minimum return time between harvesting operations in GS working circle (10 years in initial silvicultural strategy);
- minimum log length 3.6m for HQL logs; and
- habitat retention (minimum no. trees required were monitored. No explicit mechanism was modelled).

6.7.2 Modelling constraints

The *Spectrum* model template built for modelling the future management of the Southern Region NSW forests was structured to enable a range of management constraints to be represented.

The constraint options available included:

General wood supply constraints

General constraints were set up to enable the representation of minimum or maximum target volumes of high quality log (wood supply term agreements or maximum achievable volume, which ever was the lesser).

To apply a general constraint, constraint variables were defined. The constraint variables identify which product (e.g. large high quality logs) and the areas from which the product can be sourced (e.g. whole region, catchment, strata etc).
The analysis units were structured with attributes which enable the constraints to be applied to multiple themes or geographical areas. The classes include:

- Timber Supply Catchment (aggregates of timber supply zones);
- Timber Price Zones
- Timber Supply Zone;
- strata or groups of strata;
- forest type / "silvicultural practice" (moist, dry forest types); and
- disturbance intensity – maximum harvesting intensity permissible in a given area.

The range of **outputs** and **activities** (log product volumes, areas harvested, forest type volumes) available for defining a constraint variable were:

Outputs:
- large HQ sawlog volume (HQ_L_sawlog);
- small HQ sawlog volume (HQ_S_sawlog);
- low value sawlog volume (LQ_sawlog);
- pulp volume (PULP); and
- net area of uneven-aged forest harvested (netarea_ue).

Activities:
- plantation harvest volume (pl_harvest); and
- uneven-aged forest harvest (ue_harvest).

For each General Constraint applied to a variable, the details specified are:
- period(s) applicable;
- operator (minimum, maximum or exact value); and
- quantity of product defined for 5 year period (volume of HQL).

Constraints can be applied to areas ranging from individual analysis units to the whole resource. Different approaches were used for the South Coast and Tumut CRA sub-regions.

South Coast CRA sub-region:

There are distinct differences in the species composition between the coastal and tablelands catchments so production within each needs to be regulated to supply industry with the appropriate species mix of required product. Similarly production levels from wood supply catchments need to be regulated to avoid significant fluctuations over time. When wood supply modelling was undertaken and the unconstrained model runs evaluated, it was established that the level of variation in production from each catchment and the composition were acceptable, so it was only necessary to monitor, and not constrain, these.

Constraining the level of harvest / wood production in timber catchments within specific bounds is necessary to ensure changes in harvesting at an operational level are realistic, and constraints on the sources are necessary to ensure production for nearby industry is maintained within economical transport distances. Without constraints on the source of wood, the LP model driven by the objective function to maximise the overall wood supply, may select options with substantially erratic changes in the source of wood over time. The spatial and temporal volatility may necessitate inter-wood supply catchment log cartage to meet supply commitments to industry. This is unfavourable in practice due to prohibitive transportation costs. In the Southern region the Timber Catchment 1 and Timber Catchment 2 wood flows were seen as manageable (based on local knowledge and outcomes of preliminary modelling) and no adjustment to account for any transportation constraints was applied.

No explicit constraints were applied to model the market requirements in the South Coast sub-region. The whole of the resource was modelled collectively, with wood supply constraints applying equally across the resource

In modelling scenarios developed for the South Coast, production was constrained to a minimum of 42,000 m^3 /year HQL for the 200 year planning horizon, which is the current level of industry consumption.

The constraint variables defined for the South Coast were:

TABLE 6.J: SOUTH COAST WOOD SUPPLY CONSTRAINT SETTINGS

Variable	Period	Operator	Volume (m3/period)
All	1-40	≥	210,000

Where:
All = volume of large high quality sawlogs that can be sourced from all areas
TC_*n* = volume of large high quality sawlogs that can be sourced from Timber catchment *n*

Tumut CRA sub-region:

The Tumut CRA sub-region forest strata were modelled with a range of wood supply constraints to achieve an even sustained level of wood production, and to model specific aspects of resource forest management which account for differences in species composition, forest structure and logging history:

- production was modelled for non-Ash hardwoods and Ash separately as they supply distinctly different industries and it was necessary to obtain an even level of production for each species class.
- the level of Ash and Hardwood production were each constrained to maximise the minimum level of sustained production over the 200 year planning horizon. It was not necessary to enter an upper limit constraint over the planning horizon to mitigate against “spikes” in production. It was not possible to achieve a non-declining or smoothed wood supply profile for the Tumut sub-region.
- Maragle State Forest Ash Strata 22 (Mash) and Buccleuch State Forest Mixed Age Young Strata 24 (Buy) are immature regrowth strata so harvesting was restricted in the first 10 years. The management plans advocate that harvesting not commence until 2010 in these strata.
- the Ingebyrah State Forest resource was managed as a completely separate source of fibre as it is geographically distant, and the wood supply is committed to the South East CRA region (Eden) industry.

Constraint variables defined for the volume of large high quality sawlogs:

TABLE 6.K: TUMUT WOOD SUPPLY CONSTRAINT SETTINGS

Variable	Period	Operator	Volume (m3/period)
Ash	1 – 40	≥	76,000
Hwd	1 – 40	≥	116,000
BuY	1-2	=	0
MAsh	1-2	=	0

Where:

All	=	all areas (Strata 21, 22, 23, 24, 25, 30)
Ash	=	Ash strata (21, 22)
Bash	=	Bago Ash strata (21)
BMHw	=	Bago / Maragle Hardwoods (Strata 23)
BuO	=	Buccleuch Mixed Age Mature (Strata 25)
BuY	=	Buccleuch Mixed Age Young (Strata 24)
Hwd	=	Non-Ash Strata (23, 24, 25)
Inge	=	Ingebyrah (Strata 30)
Mash	=	Maragle Ash (Strata 22)

Harvest Policy Wood Supply Constraints

The harvest policy constraints enable the magnitude and rate of wood supply to be regulated. These constraints are used in conjunction with the minimum, maximum, equality levels of production defined in the general constraints. The harvest policy constraints are applied to the HQL log product from the whole resource. However, they can be applied to other defined outputs (one or more log products and defined forest areas).

Options include:

- non-declining yield. The constraint is used to ensure wood production does not diminish but continues to be maintained or increase over time. The minimum and maximum increase in the wood supply is specified for a defined period(s) so that the rate of increase can be regulated;
- sequential yield. The constraint is used to smooth the yield flow. The maximum decrease and maximum increase are specified for a defined period(s) to regulate the maximum level of change in harvest levels between periods. A zero decrease and increase will create an even wood flow which is equivalent to emulating a sustainable yield; and
- absolute yield. The constraint is used to limit the total wood supply to within defined bounds. The minimum and maximum levels of change in harvested volume are specified for defined period(s).

South Coast CRA sub-region:

Wood supply smoothing constraints were applied to the South Coast resource to regulate the level of change in production. Initially for periods 1- 4, the maximum smoothed sustained production was required, involving a sequential constraint of 0.0%. Then in periods 5 – 40 the yield was smoothed to a maximum of 5%. The smoothing constraint was required to mitigate against peaks and troughs in future production. The 5% level is arbitrary, as higher or lower levels of smoothing were possible, but the wood supply profile were either “volatile” or too constrained. A tighter upper smoothing constraint was not implemented as the future resource volume growth was increasing due to improvements in forest silviculture and long term sustainable yield, and a tighter lower level was not imposed because the production was still volatile. To permit reasonable future increases in yield from forest improvements some flexibility in the smoothing constraint was required. The 5% level was used consistently in repeated model runs to enable comparability of the impact of conservation reserve designs on wood production levels.

Tumut CRA sub-region:

Meaningful smoothing constraints could not be applied in the Tumut sub-region computer runs due to the rigid level of volatility in production, which is attributable to the low number of strata and associated yield tables.

Native forest silvicultural prescription restrictions

Multiple silvicultural constraints were applied in *Spectrum*:

- preferred silviculture systems were restricted to specific forest types in South Coast sub-region forest types
- the blend of silvicultural systems and intensity of operations in the Tumut sub-region were restricted

To identify which silvicultural options could be applied (were permissible) to different areas of native forest (land themes), three components of *SPECTRUM* were used collectively - the analysis unit, management action definitions and management action schedules. The land themes (analysis units grouped by specific combinations of attributes) to which the management action can be applied were defined for each management action (e.g. STS heavy intensity).

South Coast CRA sub-region:

The land themes were used for constraining silviculture in the South Coast CRA sub-region included:

- native forest Timber Supply Zone groups; and
- native forest Strata groups

Tumut CRA sub-region:

To restrict the silvicultural system and intensity of silviculture in the Tumut CRA sub-region, several stages were involved:

- yield tables were built based on multiple silvicultural systems and intensities (weighted average yield were derived for the pre-defined blend required);
- the disturbance intensity in the analysis unit file, management action definitions, and management action schedules were defined using unique variables to reflect the preferred silviculture blend; and
- the strata to which a specific mixed yield table could be applied were linked to specific strata land units in the management action definition and schedule land themes.

The latter two constraints achieve the same desired effect, but having both provided the flexibility to model or report on each variable independently.

Details on the silvicultural themeing and rationale are outlined in section 6.5.6 above, and details of the silviculture are outlined in Appendices 1.2 and 1.3.

6.8 FORMULATION OF LP MATRIX AND OBTAINING PROBLEM SOLUTION

The linear programming (LP) matrix generation and problem solving are automated stages of the *Spectrum* modelling. Once a model has been constructed, the *Spectrum* model is run to generate an LP matrix and is solved with the optimisation package C-WHIZ.

The matrix default report MAT.FIL is automatically generated and contains a summary of the model data; list of all activities and outputs that occur on each analysis unit for each management action and schedule; and a list of all the model data errors encountered during matrix generation which require correction before solving the matrix. The majority of the data format and data relationship errors were corrected in the initial templates formulated. The matrix generation time varied with the size of the model and the speed of the computer used. Once an LP matrix was generated without errors, it was solved using the solution software LP package C-WHIZ. Each time an LP matrix is solved the LP report (LP.FIL) and LP solution files (LP.SOL) are created. The LP report contains model summary statistics, timing information on problem input and solution phases, matrix reduction information, abbreviated iteration log and complete solution results. The LP solution files contains the optimal objective function value and information associated with each row and column in the solution. The file is written in the standard LP mathematical programming solution format.

When the LP solver is executed it will converge on an optimal solution and reports either (a) a feasible solution - the most favourable option which maximises / minimises the objective function subject to the constraints imposed, or (b) an infeasible solution where two or more constraints cannot be simultaneously satisfied.

Where an infeasible solution occurred the constraints were relaxed or modified (e.g. minimum HQL volume, % change in volume between periods). While the reasons for the infeasible solutions can be derived from the LP report, experience gained from repeated analyses plus the quick processing time of *Spectrum* runs, enabled yield scheduling staff to quickly identify constraint levels which would provide feasible solutions through a trial and error approach.

Feasible solutions were evaluated and improved where possible by imposing tighter or additional constraints and modifying the objective function until the best feasible solution that could be arrived at. The process of deriving an acceptable LP problem solution for a given conservation reserve design was typically multi-staged (refer Section 7.3). This involved optimising a component of the resource (subsection of strata) and/or planning horizon (wood agreement term or proposed guaranteed wood supply period) according to one objective function and constraints. Then, either the outcomes from this were translated into constraints so the sustainable yield for the remaining strata and / or planning could be ascertained; or additional constraints were simply imposed.

6.9 DEVELOPMENT OF CUSTOM SOLUTION REPORTS

Once the LP matrix has been solved and a feasible solution obtained, solution reports can be generated. Reports include the following types, the information in which can be summarised by analysis unit and forest wide:

- all activities and outputs;
- customised activity and outputs;
- complete financial summary;
- all treatment types;
- customised treatment types;
- all inventory, harvest, and growth;
- customised inventory, harvest, and growth;
- customised acres by age class;
- database reports;
- goal objective report; and
- allocation summary.

Spectrum generates reports in two formats:

- report format - a DOS file for printing (RPT.FIL); and
- export format - a comma delimited file for export to spreadsheets, ArcView, or other programs (COMADEL.TXT).

Spectrum run solution reports were required during model runs to evaluate solutions and to present summaries of the wood supply forecasts. Customised solution reports were constructed in *Spectrum* to provide output details of the wood supply forecasts. Perl script (REWRITE_SR.pl) was written to translate the export report COMADEL.TXT into a format able to be used in other applications). Microsoft Excel programs (SUMMARY_SC.XLS and SUMMARY_TT.XLS) were developed to create summary tables and histograms of the South Coast and Tumut CRA Sub-region resource respectively.

The customised solution report was structured to provide details for each analysis unit and the whole forest resource on the wood volume and area of uneven-aged native forest harvested by log product (large and small high quality log, low quality log, pulp) and 5 year time interval over the 200 year planning horizon (refer Table 6I). The forest level summary information provides the volume and area data by prescribed silvicultural system and disturbance intensity. The full range of reporting category specified in the custom report are listed in Appendix 2.

TABLE 6.L: EXCERPT OF ANALYSIS UNIT DETAILS IN RPT.FIL REPORT

```
ANALYSIS UNIT:   2           30.    ACRES

    MANAGEMENT ACTION:   Single tree sel medium                              30.         ACRES
           1_1    604    4      Moist  heavy    .    stimb  Medium
           Yield Composite(s):   ue_c
         PROPORTION          OUTPUT NAME
              1.000    (!!      )!!      *!!      +!!

           Column Name:          1u2#'! 3
           Existing Schedule:    ENTRY:   3   HARV:  45
           Regen Schedule:       ENTRY:   0   HARV:   1
           Beginning Age:         1
     - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

A10.2  MULTI-PERIOD OPTIONAL REPORT FOR ANALYSIS UNIT         u2#   u2#
       ACTIVITIES, OUTPUTS AND THEIR FINANCIAL EFFECTS

ACTIVITY/OUTPUT          UNITS
COD  AU /  TC_TPZ TSZ    STRATA PRAC   DISTUB Layer6 Emphas Intens
    ZONE

    TREATMENT TYPE     - QUALIFIER --  - QUALIFIER --
                       SY   MIN   MAX  SY   MIN   MAX
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                                                                          PERIOD
                                                          1       2       3       4       5
                                                          6       7       8       9      10
                                                         11      12      13      14      15
                                                         16      17      18      19      20
                                                         21      22      23      24      25
                                                         26      27      28      29      30
                                                         31      32      33      34      35
                                                         36      37      38      39      40

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
    HQ_L_sawlog             cum
HSM           .      .      .      .      .      .    stimb  Medium

                                   OUTPUT/PERIOD                         348       7       8
( 6-10)                                                  88      31      31       8      38
(11-15)                                                  38      20      38      65      41
(16-20)                                                  88      77      17      53      72
(21-25)                                                  50      65      45      66      51
(26-30)                                                  65      33      55      64      50
(31-35)                                                  53      55      75      82      43
(36-40)                                                  69      66      69      35      26
    HQ_S_sawlog             cum
SSM           .      .      .      .      .      .    stimb  Medium

                                   OUTPUT/PERIOD                          51               3
( 6-10)                                                  17      11      17       5       7
(11-15)                                                  15       3      15      38      20
(16-20)                                                  33      53       8      21      20
(21-25)                                                  23      25      26      15      28
(26-30)                                                  19      16      29      33      20
(31-35)                                                  16      26      24      20      17
(36-40)                                                  28      15      27      15       9
    LQ_sawlog               cum
LSM           .      .      .      .      .      .    stimb  Medium

                                   OUTPUT/PERIOD                         593       9      35
( 6-10)                                                 291      32     104      37      55
(11-15)                                                  60      22      50      69      26
(16-20)                                                  49      77      22      36      38
(21-25)                                                  38      52      41      42      26
(26-30)                                                  47      23      38      47      32
(31-35)                                                  30      54      43      46      32
(36-40)                                                  46      33      42      24      16
    Pulp                    cum
```

```
PSM           .      .      .      .      .      .    stimb  Medium

                                   OUTPUT/PERIOD                    445       6      41
( 6-10)                                               206      63   100      44     100
(11-15)                                                99      42    78     125      72
(16-20)                                               139     182    43      97     113
(21-25)                                                92     124   118     116      95
(26-30)                                               129      76    94     126      89
(31-35)                                               105     102   131     153      63
(36-40)                                                91      92   101      76      43
    netarea_ue              hectares
ASM           .      .      .      .      .      .    stimb  Medium

                                   OUTPUT/PERIOD                     60      60      60
( 6-10)                                                60      60    60      60      60
(11-15)                                                60      60    60      60      60
(16-20)                                                60      60    60      60      60
(21-25)                                                60      60    60      60      60
(26-30)                                                60      60    60      60      60
(31-35)                                                60      60    60      60      60
(36-40)                                                60      60    60      60      60
    HQ_L_sawlog             cum
FWL           .      .      .      .      .      .      .      .

                                   OUTPUT/PERIOD                    348       7       8
( 6-10)                                                88      31    31       8      38
(11-15)                                                38      20    38      65      41
(16-20)                                                88      77    17      53      72
(21-25)                                                50      65    45      66      51
(26-30)                                                65      33    55      64      50
(31-35)                                                53      55    75      82      43
(36-40)                                                69      66    69      35      26
    HQ_S_sawlog             cum
FWS           .      .      .      .      .      .      .      .

                                   OUTPUT/PERIOD                     51               3
( 6-10)                                                17      11    17       5       7
(11-15)                                                15       3    15      38      20
(16-20)                                                33      53     8      21      20
(21-25)                                                23      25    26      15      28
(26-30)                                                19      16    29      33      20
(31-35)                                                16      26    24      20      17
(36-40)                                                28      15    27      15       9
***********************************************************
```

6.10 MODEL TESTING AND VALIDATION

The model templates created for the South Coast and Tumut sub-regions were subjected to acceptance testing and validation.

1. Verification of model template:

- all analysis unit and yield data was imported and interpreted correctly by Spectrum;
- all land attributes were valid and the correct groups created;
- planning horizon and period length was valid;
- all management action activities & output variables and attributes & groups were present and valid;
- all management action definitions and schedules were complete and valid;
- the custom report specifications generated correct report format and content; and
- full suite of objective functions and constraints were correctly set up and functional.

2. Testing of *Spectrum* model:

- the Spectrum model would work under Windows 95 and Windows NT operating system; and
- the C-WHIZ LP solver settings were made and functioned correctly.

3. Reasonability testing of *Spectrum* model:

- high level wholesale checks of model runs were made to verify that the magnitudes of harvest (volume and area) were realistic and the database was being correctly interpreted.
- the model templates were run repeatedly changing input variables to test validity of results and sensitivity. Checks included evaluating whether the magnitude and trends of solutions were logical and realistic; and
- repeated runs included different net harvestable area, permissible management action definitions & schedules, and different harvest level constraints.

4. Distribution quality control procedure:

The model templates were set-up and cut onto on compact disks so these models could be readily installed on computers of all stakeholders in the CRA negotiations. Necessary installation instructions were prepared to ensure all computer settings and the file directory structures were correctly established.

6.11 MODEL INPUT AND OUTPUT LINKAGES AND REPORTS

The strategic yield scheduling framework developed for using *Spectrum* comprises a set of routines which provide the following functions and outputs:

- semi-automated construction and formatting of net harvest area yield table input files for *Spectrum*;
- an interface with C-PLAN to make updated analyses in response to nominated CAR reserve scenarios;
- automated analysis of varying ESFM protocols on net harvest area;
- summary report of net harvest area and area exclusions;
- summary report of the forecasted long term wood supply by management area, log product, species and silvicultural strategies;
- output file (GIS link) which serves as input to spatial display of harvesting patterns over time; and
- data in formats appropriate for the economic and social models.

The purposes of the routines are:

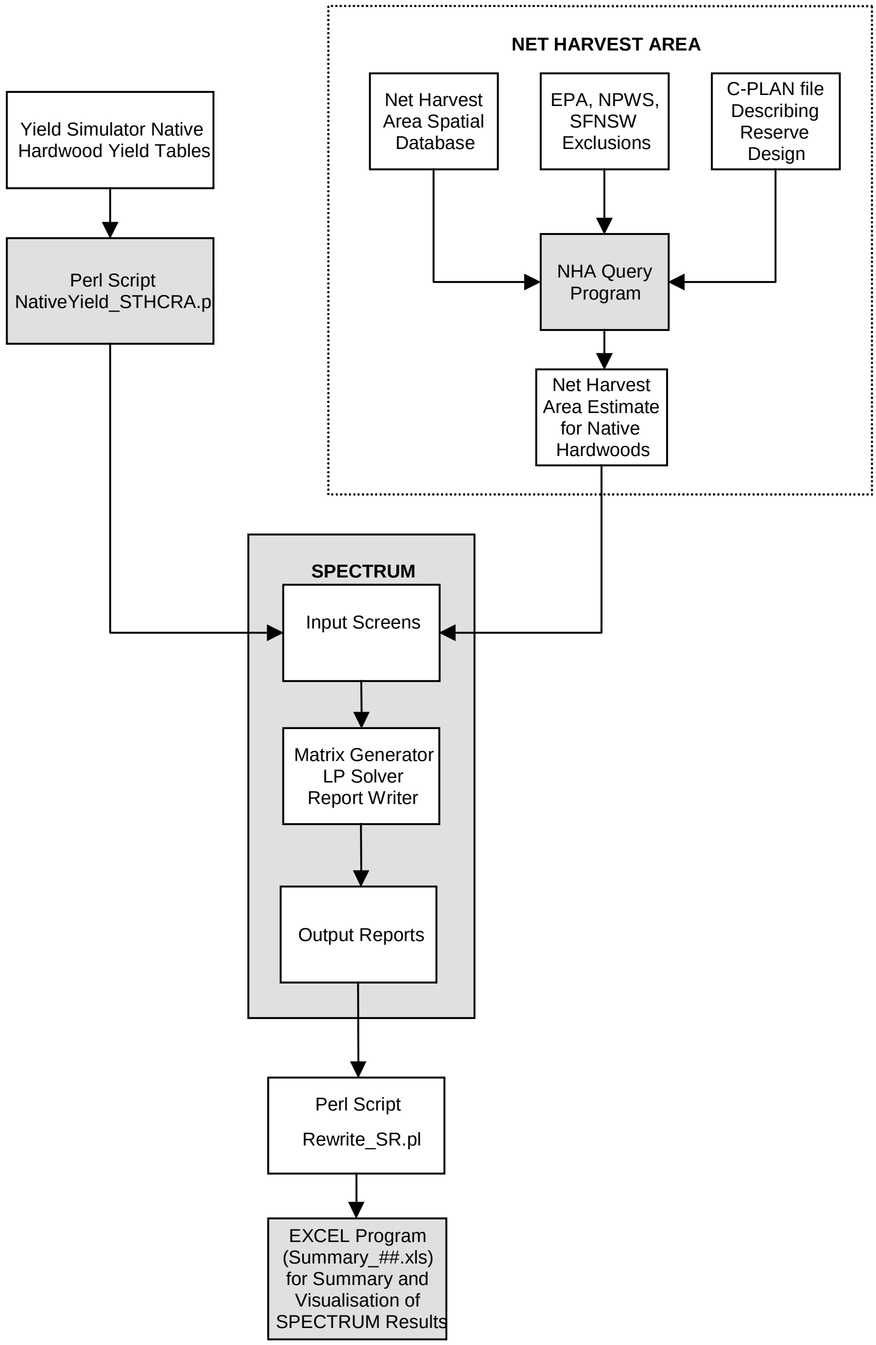
- to provide electronic linkages / interfaces between the various input data sources (GIS analysis units, C-PLAN, yield table files), *Spectrum* and the various required outputs. This process enables the prompt and repeated construction of files in a consistent format, eliminates transcription and formatting errors, and data compatibility issues;
- to transform input and output files into more useful customised summary reports for reporting the status of scenarios and to facilitate evaluation of inputs and results; and
- to provide supplementary files for linkages with other applications (GIS) and models.

The models and routines developed include:

NHAQUERY_SR.exe	=	net harvest area determination
Native yield.pl	=	transforms native forest yield simulator output files into *Spectrum* yield table input files
Rewrite.pl	=	transforms *Spectrum* output file into Summary.xls input file rewrite.csv
Summary_##.xls	=	summarises of wood supply results report (## = version: SC for South Coast and TT for Tumut)
Species.pl	=	calculates future volume of species by timber catchment
Species.xls	=	summarises of wood supply by species projection

A range of scripts were written in PERL language (file *.pl) to assist in converting and formatting data into appropriate input and output files for *Spectrum* and summary Excel spreadsheet models.

FIGURE 6-1: SCHEMATIC DIAGRAM OF YIELD SCHEDULING MODELLING FRAMEWORK



6.11.1 NHAQUERY Model

The NHAQUERY_SR model determines the net harvest area by deducting the following factors from the total forest area.

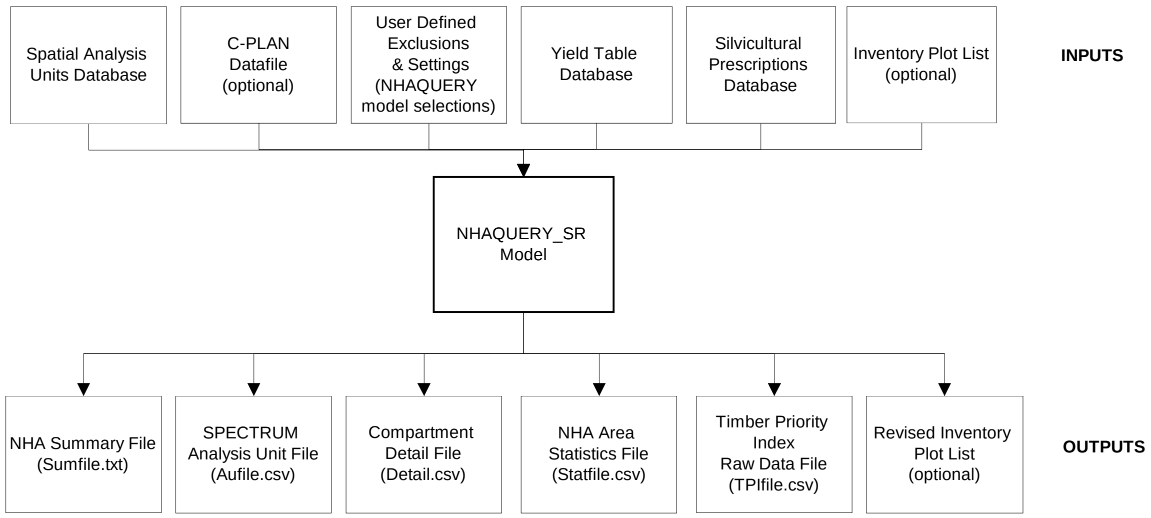
(a) C-PLAN proposed conservation reserve design file – planning units nominated for inclusion in a formal or informal reserve;

(b) user defined exclusions such as agreed EPA licence conditions and NPWS management protocols, SFNSW exclusions (adverse terrain and accessibility factors, leasehold conditions, State Forests management priorities, physical operability factors and economically inaccessible area, unmerchantable areas); and

(c) net area planned vs actual harvest modifier which accounts for the probability of non-harvest and old growth net harvestable area (NHA) modifier.

The NHAQUERY model extracts the reserve design, exclusions, and modifiers from the Spatial Analysis Units (SAU) database which has details on the attributes and area of each planning unit in the total forest area. The NHA is that component of the forested land base that is outside the defined timber exclusion areas.

FIGURE 6-2: DIAGRAMMATIC REPRESENTATION OF NHAQUERY FUNCTIONALITY



Note: User defined exclusions and settings include EPA licence conditions, NPWS protocols, SFNSW ESFM exclusions, NHA planned vs actual harvest area modifier, old growth NHA modifier and threatened flora and fauna species strike rates.

The C-PLAN file contains a description of the proposed conservation reserve design.

NHAQUERY_SR was designed to be repeatedly and quickly run to generate the net harvest area analysis unit file from the spatial analysis unit database by specifying the C-PLAN file, NHA modifiers, exclusions and threatened species strike rates.
The NHA query program (NHAQUERY.exe) is activated by an EXCEL program (NHAQUERY_SR.XLS) where the user specifies the following model settings:

- CRA region modelling zone
- Directory and filenames of input files:
  - Spatial analysis unit (SAU) database
  - NHAQUERY executable
  - C-PLAN reserve design file
  - Yield table database
  - Silvicultural prescriptions database
  - Initial inventory plot list (optional)
- Directory and filenames of output reports:
  - *SPECTRUM* Analysis Unit Input File
  - NHA summary report
  - NHA statistics details file
  - Timber priority index file
  - Compartment details file
  - Revised inventory plot list (optional)
- Native forest harvestable area exclusions
- NHA modifier
- Planning units (SFNSW or RACD)
- Threatened fauna and flora species strike rate

Examples of NHAQUERY outputs

TABLE 6.M: SUMFILE.TXT - NET HARVEST AREA SUMMARY FILE

Version 2.0l - November 17, 1999
0.0620 Strike rate
Using planning units from region: racdpluid
Planning unit identifier: racdpluid
Containing yield file version: d:\FRAMES\NHA_SC\INPUTS\YLDS.CSV
43,440 records read from yield file d:\FRAMES\NHA_SC\INPUTS\YLDS.CSV
Analysis units output to: d:\FRAMES\NHA_SC\REPORTS\AUFILE.CSV
Timber Priority Index output to: d:\FRAMES\NHA_SC\REPORTS\TPIFILE.CSV
Silviculture specification from: d:\FRAMES\NHA_SC\INPUTS\SILV.CSV
26 records read from TPI silv file d:\FRAMES\NHA_SC\INPUTS\SILV.CSV
Compartment detail output to: d:\FRAMES\NHA_SC\REPORTS\DETAIL.CSV
Summary text output to: d:\FRAMES\NHA_SC\REPORTS\SUMFILE.TXT
Summary CSV output to: d:\FRAMES\NHA_SC\REPORTS\STATFILE.CSV
Coverage: d:\FRAMES\SAU\scsau_v5\SCSAU_v5
CPlan file: none selected
NHA modifier: NHAM
exclusion region: CRFT_HEATH
exclusion region: CRFT_RF
exclusion region: CRFT_RNC
exclusion region: CRFT_Rock
exclusion region: CRFT_Wet
exclusion region: EPAFILTER1
exclusion region: NPWSFILTER
exclusion region: FMZ1
exclusion region: FMZ2
exclusion region: FMZ3UNAV
exclusion region: FMZ7
exclusion region: IHAZ4LT50
exclusion region: ROADS
exclusion region: SWD_PL
exclusion region: HWD_PL
exclusion region: UNMERCH

Total area of each exclusion zone

This estimate presents the impact of individual exclusions without incremental effects. Gross area represent the total area of this exclusion. Net area shows the reduction for the net harvest area modifier.

Exclusion	Gross Area	Net Area
CRFT_HEATH	50	38
CRFT_RF	14,332	7,765
CRFT_RNC	2,213	1,353
CRFT_Rock	2,694	1,938
CRFT_Wet	5,815	4,038
EPAFILTER1	46,226	25,278
NPWSFILTER	43,955	24,363
FMZ1	4,745	3,335
FMZ2	141,687	102,443
FMZ3UNAV	2,559	2,114
FMZ7	1,493	1,096
IHAZ4LT50	18,701	12,035
ROADS	2,052	1,624
SWD_PL	9,434	6,503
HWD_PL	40	27
UNMERCH	63,463	46,324

Net Harvest Area Estimate

This estimates the incremental impact of adding exclusions one at a time. Gross area represents the total area remaining after the cumulative effect of all previous exclusions. Net area includes reductions for the net harvest area modifier.

Exclusion	Area
Gross Area	384,855
CRFT_HEATH	-50
CRFT_RF	-14,332
CRFT_RNC	-2,205
CRFT_Rock	-2,631
CRFT_Wet	-5,266
EPAFILTER1	-39,292
NPWSFILTER	-5,461
FMZ1	-3,677
FMZ2	-110,152
FMZ3UNAV	-2,120
FMZ7	-1,251
IHAZ4LT50	-5,588
ROADS	-1,582
SWD_PL	-8,653
HWD_PL	-10
UNMERCH	-7,264
Net Mapped Area	175,324
Net Area Modifier	-39,269
Strike rate reduction	-8,435
Net Harvestable Area	127,620

Marginal impact of each exclusion zone

This estimates the marginal impact of individual exclusions. The estimate shows the increase in area from removing a single exclusion from the total set. Gross area represent the total harvestable area including all other exclusions. Net area shows the reduction for the net harvest area modifier.

Exclusion	Gross Area	Net Area
CRFT_HEATH	0	0
CRFT_RF	1,295	511
CRFT_RNC	15	10
CRFT_Rock	120	90
CRFT_Wet	282	209
EPAFILTER1	3,710	1,655
NPWSFILTER	1,796	936
FMZ1	3,061	2,279
FMZ2	73,352	54,897
FMZ3UNAV	1,152	977
FMZ7	614	469
IHAZ4LT50	5,384	3,401
ROADS	1,351	1,094
SWD_PL	4,990	3,594
HWD_PL	6	4
UNMERCH	7,264	5,888

TABLE 6.N: AUFILE.CSV *SPECTRUM* ANALYSIS UNIT FILE

Analysis Unit ID	TC_TPZ	TSZ	Strata Number	Forest Type	Disturbance Intensity	Blank	Blank	Area (ha)
0	0_0	0	11	Moist	heavy			0.01
1	1_1	604	1	Moist	heavy			0.49
2	1_1	604	4	Moist	heavy			29.77
3	1_1	604	6	Moist	heavy			0.78
4	1_1	604	7	Moist	heavy			2.47
5	1_1	604	10	Moist	heavy			1.3
6	1_1	604	11	Moist	heavy			1.26
7	1_1	604	12	Moist	heavy			0.03
8	1_1	604	13	Moist	heavy			4.68
9	1_1	604	16	Moist	heavy			7.29
10	1_1	604	18	Moist	heavy			0.56
11	1_1	604	19	Moist	heavy			3.07
12	1_3	4201	3	Moist	heavy			10.63
13	1_3	4201	4	Moist	heavy			24.07
14	1_3	4201	5	Moist	heavy			134.24
15	1_3	4201	7	Moist	heavy			18.65
16	1_3	4201	8	Moist	heavy			10.09
17	1_3	4201	9	Moist	heavy			75.82
18	1_3	4201	11	Moist	heavy			473.12
19	1_3	4201	13	Moist	heavy			153.45
20	1_3	4201	20	Moist	heavy			109.32

TABLE 6.O: STATFILE.CSV NHA AREA STATISTICS FILE

Gross Area	Net Area	Strata	TC	TSZ	CRFT_HEATH	CRFT_RF	CRFT_RNC	CRFT_Rock	CRFT_Wet	Epafilter1	NPWSFILTER	FMZ1	FMZ2
0.6	0.49	1	1_1	604	0	0	0	0	0	0	0	0	0
36.97	29.77	4	1_1	604	0	0	0	0	0	0	0	0	0
1.1	0.78	6	1_1	604	0	0	0	0	0	0	0	0	0
5.29	2.47	7	1_1	604	0	0	0	0	0	0	0	0	0
1.67	1.3	10	1_1	604	0	0	0	0	0	0	0	0	0
1.53	1.26	11	1_1	604	0	0	0	0	0	0	0	0	0
0.05	0.03	12	1_1	604	0	0	0	0	0	0	0	0	0
6.47	4.68	13	1_1	604	0	0	0	0	0	0	0	0	0
10.25	7.29	16	1_1	604	0	0	0	0	0	0	0	0	0
0.78	0.56	18	1_1	604	0	0	0	0	0	0	0	0	0
4.44	3.07	19	1_1	604	0	0	0	0	0	0	0	0	0

Gross Area	Net Area	Strata	TC	TSZ	FMZ3UNAV	FMZ7	IHAZ4LT50	ROADS	SWD_PL	HWD_PL	UNMERCH	priority	
0.6	0.49	1	1_1	604	0	0	0	0	0	0	0	0	
36.97	29.77	4	1_1	604	0	0	0	0	0	0	0	0	
1.1	0.78	6	1_1	604	0	0	0	0	0	0	0	0	
5.29	2.47	7	1_1	604	0	0	0	0	0	0	0	0	
1.67	1.3	10	1_1	604	0	0	0	0	0	0	0	0	
1.53	1.26	11	1_1	604	0	0	0	0	0	0	0	0	
0.05	0.03	12	1_1	604	0	0	0	0	0	0	0	0	
6.47	4.68	13	1_1	604	0	0	0	0	0	0	0	0	
10.25	7.29	16	1_1	604	0	0	0	0	0	0	0	0	
0.78	0.56	18	1_1	604	0	0	0	0	0	0	0	0	
4.44	3.07	19	1_1	604	0	0	0	0	0	0	0	0	

TABLE 6.P: TPIFILE.CSV TIMBER PRIORITY INDEX RAW DATA FILE

pluid	sfpunit	tc	tsz	sfno	Compno	Gross Area	Net Area	net2gr	domYa	HQ_L_ current	HQ_S_ current	LQ_ current	Pulp_ current
20103	102501	1_5	4401	426	1025	192.36	0	0	0	0	0	0	0
20104	102502	1_5	4401	426	1025	26.1	17.49	0.67	1	12.26	0.45	26.94	13.26
20105	103302	1_5	4402	148	1033	165.41	117.08	0.71	4	4.83	0.58	9.05	7.3
20106	103801	1_5	4402	148	1038	182.46	141.85	0.78	2	8.65	0.5	11.28	8.18
20107	103903	1_5	4402	148	1039	217.7	175.41	0.81	2	8.3	0.5	10.36	7.5
20108	103202	1_5	4402	148	1032	3.87	0.86	0.22	4	4.58	0.6	9.04	7.47
20109	103102	1_5	4402	423	1031	0.67	0	0	0	0	0	0	0
20110	103203	1_5	4402	148	1032	6.12	0	0	0	0	0	0	0
20111	103103	1_5	4402	423	1031	1.85	0	0	0	0	0	0	0
20112	103403	1_5	4402	148	1034	180.43	100.54	0.56	2	8.7	0.47	13.32	8.73

pluid	sfpunit	tc	tsz	sfno	Compno	HQ_L_20	HQ_S_20	LQ_20	Pulp_20	HQ_L_ 100	HQ_S_ 100	LQ_100	Pulp_ 100
20103	102501	1_5	4401	426	1025	0	0	0	0	0	0	0	0
20104	102502	1_5	4401	426	1025	14.29	0.82	38.66	20.23	76.13	10.95	87.07	100.03
20105	103302	1_5	4402	148	1033	7.83	1.16	15.77	13.86	37.92	5.95	31.42	50.37
20106	103801	1_5	4402	148	1038	16.58	1.31	20.45	16.99	133.9	13.79	45.06	98.83
20107	103903	1_5	4402	148	1039	15.07	1.17	18.03	15.22	115.58	12.28	42.17	88.88
20108	103202	1_5	4402	148	1032	7.08	1.17	15.72	13.98	25.85	4.94	29.73	44.24
20109	103102	1_5	4402	423	1031	0	0	0	0	0	0	0	0
20110	103203	1_5	4402	148	1032	0	0	0	0	0	0	0	0
20111	103103	1_5	4402	423	1031	0	0	0	0	0	0	0	0
20112	103403	1_5	4402	148	1034	14.38	1.09	22.24	16.57	103.38	11.66	51.87	89.3

TABLE 6.Q: DETAIL.CSV COMPARTMENT DETAILS FILE

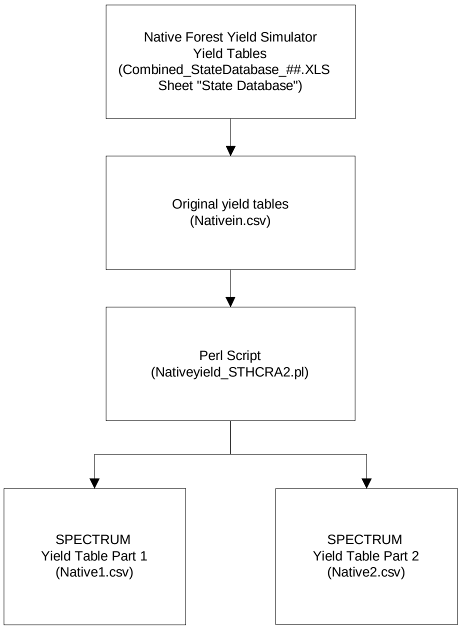
'pluid	sfpunit	tc_tpz	Sfno	compno	strata	net Area	m^3_ha	m^3_total
20027	888803	0_0	0	8888	11	0	4.58	0
20074	100109	1_5	0	1001	3	47.15	17.29	815.19
20074	100109	1_5	0	1001	9	1.99	17.29	34.41
20074	100109	1_5	0	1001	11	5.84	4.58	26.74
20074	100109	1_5	0	1001	15	90.03	9.88	889.53
20074	100109	1_5	0	1001	17	1.62	0.46	0.74
20075	100402	1_5	0	1004	3	2.02	17.29	34.92
20083	102003	1_5	0	1020	2	37.47	14.03	525.77
20083	102003	1_5	0	1020	3	0.2	17.29	3.48
20083	102003	1_5	0	1020	8	2.16	14.04	30.34
20083	102003	1_5	0	1020	9	0.53	17.29	9.15
20083	102003	1_5	0	1020	11	0.11	4.58	0.51
20086	102101	1_5	0	1021	2	14.63	14.03	205.28
20086	102101	1_5	0	1021	3	0.18	17.29	3.13
20089	102105	1_5	0	1021	2	28.34	14.03	397.58
20089	102105	1_5	0	1021	11	0.02	4.58	0.1

6.11.2 Native yield.pl

A PERL script that reads in the FRAMES yield simulator native forest yield table data and reformats them into the appropriate *Spectrum* CSV import file format.

The script also summarises productivity information into a "C" programming language structure for inclusion into the NHAQUERY program.

FIGURE 6-3: DIAGRAMMATIC REPRESENTATION OF NATIVEYIELD.PL FUNCTIONALITY



6.11.3 Rewrite_SR.pl

The program reformats the *Spectrum* output (wood supply volume and harvested area by land attribute for each log product and period) into files which have a format suitable for use in the EXCEL application SUMMARY_#.xls.

Rewrite.dbf reads in data from the *Spectrum* Commadel.txt file, and translates the file into a more versatile and universal data structure. The conversion uses *Spectrum* Attr.dbf and AU.dbf record files which correspond to data fields in Commadel.txt.

The two files created with the Rewrite Perl script are:

(a) the file Rewrite.csv which summarise the harvesting records by land attributes for use in the Summary.xls program, and

(b) the file Productivity.csv which keeps a track of the 20 year and 100 year volumes of high quality logs by stratum. This is used in computing the Timber Priority Index,

FIGURE 6-4: DIAGRAMMATIC REPRESENTATION OF REWRITE.PL FUNCTIONALITY

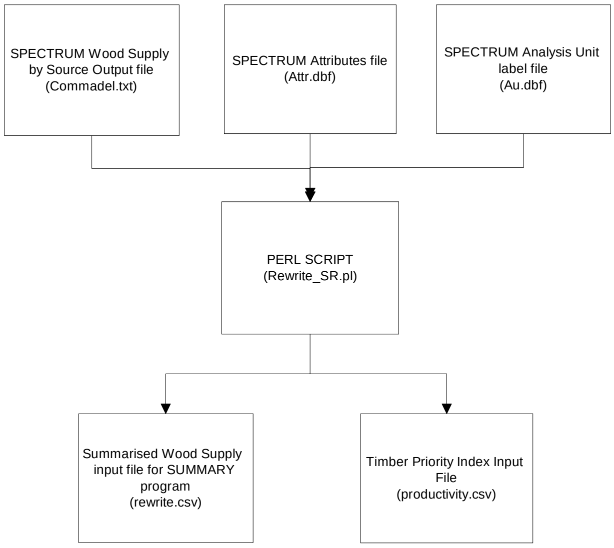


TABLE 6.R: REWRITE.CSV EXCERPT

TC_TPZ	TSZ	STRATA	PRACTICE	INTENSITY	PERIOD	AREA	HQ_L	HQ_S	LQ	PULP
2_7	621	18	AGS	Heavy	1	0	0	0	0	0
2_7	621	18	AGS	Heavy	2	34	0	3	60	1244
2_7	621	18	AGS	Heavy	3	0	0	0	0	0
2_7	621	18	AGS	Heavy	4	34	2	0	1	228
2_7	621	18	AGS	Heavy	5	34	1	1	123	387

6.11.4 Summary_##.pl

The summary program is a post-*Spectrum* modelling report writer. Summary.xls activates the Perl script rewrite.pl to transform and format the *Spectrum* model output file comadel.txt into the Rewrite.csv file. The summary spreadsheet model then produces summary tables and histograms of the long term forecast by period summarise by:

- silvicultural practice
- log product
- timber catchment
- timber price zone
- timber supply zone
- species volume
- species proportions

The summary program also calculates the volumes of commercial species by timber catchment, timber price zone, timber supply zone and stratum. The volumes of High Quality large (HQL) logs by species are calculated from the total forecast multiplied by the proportion of commercial species groups in each stratum. The stratum HQL commercial species proportions are derived from the strategic inventory data.

FIGURE 6-5: DIAGRAMMATIC REPRESENTATION OF SUMMARY REPORT FUNCTIONALITY

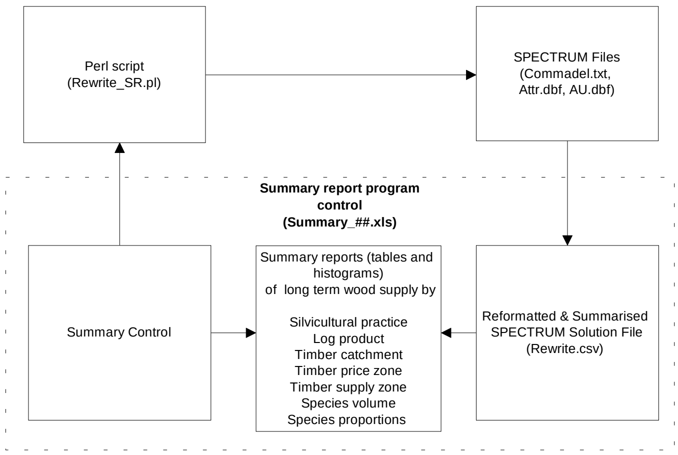
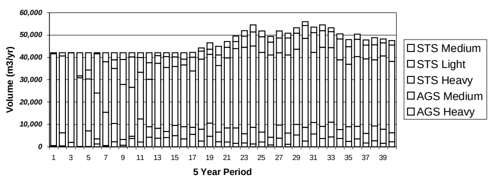


FIGURE 6-6: EXAMPLES OF SUMMARY REPORTS

South Coast Long Term Wood Supply by Silvicultural Practice

Average Annual Large High Quality Sawlog

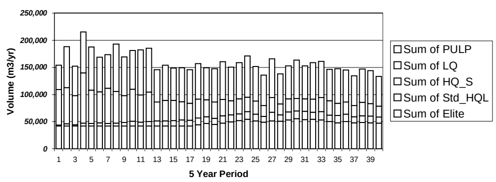


Catchment	(All)
Price Zone	(All)
TSZ	(All)
STRATA	(All)

Sum of HQ_L	PRACTICE	INTENSITY				
	AGS		STS			Grand Total
PERIOD	Heavy	Medium	Heavy	Light	Medium	
1	422	84	41,097	0	468	42,071
2	387	5,925	34,357	0	1,402	42,071
3	11	1,920	40,131	9	0	42,071
4	38	110	30,791	903	10,230	42,071
5	79	7,095	23,143	3,984	7,772	42,073
6	1,265	2,310	20,425	17,606	463	42,070
7	207	295	14,961	22,545	4,063	42,071
8	2,221	8,204	24,720	3,760	3,165	42,070
9	640	2,644	24,697	11,113	2,976	42,070
10	3,669	1,080	21,934	13,503	1,886	42,072
11	2,138	10,295	20,963	6,607	2,069	42,071
12	4,266	4,727	21,204	7,395	4,478	42,070
13	3,813	4,541	29,060	3,321	1,335	42,070
14	4,204	2,673	28,583	4,913	1,700	42,073
15	5,077	4,569	26,232	4,278	1,914	42,071
16	3,603	5,383	27,701	2,531	2,854	42,072
17	5,552	3,192	25,191	6,169	2,083	42,187
18	2,550	5,239	31,415	3,550	1,540	44,294
19	4,781	5,820	30,743	2,297	2,868	46,510
20	2,301	4,248	29,786	4,686	3,856	44,877
21	2,118	6,353	31,348	4,729	2,575	47,123
22	1,597	6,890	35,511	3,082	2,399	49,479
23	1,675	4,253	38,606	4,902	2,517	51,953
24	1,291	7,470	36,353	6,340	3,095	54,550
25	2,106	4,476	35,648	7,042	2,551	51,823
26	810	3,489	36,870	5,654	2,527	49,350
27	3,950	5,736	32,464	6,436	3,231	51,817
28	1,151	5,010	34,953	7,522	2,101	50,737
29	5,332	4,685	33,568	7,159	2,528	53,274
30	2,525	6,232	39,814	5,709	1,657	55,938
31	5,732	5,097	31,342	8,883	2,535	53,588
32	3,672	5,538	35,354	7,348	2,549	54,461
33	4,362	6,588	33,391	7,273	1,595	53,208
34	3,707	3,948	31,189	9,374	2,326	50,545
35	2,508	6,509	27,833	7,898	3,269	48,017
36	3,577	5,651	31,104	7,741	2,258	50,332
37	1,673	4,340	33,276	6,180	2,345	47,814
38	2,731	6,537	29,682	6,659	3,183	48,792
39	1,526	6,326	32,799	5,912	1,621	48,184
40	2,222	4,031	31,916	7,387	2,022	47,578

South Coast Long Term Wood Supply by Product

Average Annual Wood Supply

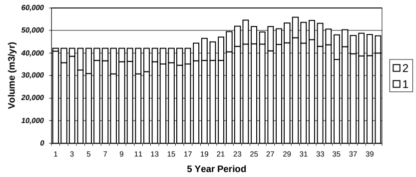


Catchment	(All)
Price Zone	(All)
TSZ	(All)
STRATA	(All)

	Data					
PERIOD	Sum of Elite	Sum of Std_HQL	Sum of HQ_S	Sum of LQ	Sum of PULP	Sum of Total
1	0	42,071	2,035	65,052	45,173	154,330
2	0	42,071	3,931	66,557	75,460	188,019
3	0	42,071	2,669	53,545	54,236	152,521
4	0	42,071	5,247	92,532	75,307	215,157
5	0	42,073	4,427	61,414	80,099	188,013
6	0	42,070	5,983	56,998	64,102	169,152
7	0	42,071	4,627	64,878	62,033	173,609
8	0	42,070	5,379	58,455	86,926	192,830
9	0	42,070	6,305	49,415	71,890	169,679
10	0	42,072	8,679	58,907	71,488	181,146
11	0	42,071	7,183	49,835	83,185	182,273
12	0	42,070	7,958	54,713	80,565	185,306
13	0	42,070	9,225	35,182	59,229	145,706
14	0	42,073	9,551	37,863	64,829	154,316
15	0	42,071	9,996	37,114	59,740	148,922
16	0	42,072	11,040	33,774	62,578	149,465
17	0	42,187	10,344	31,500	61,776	145,806
18	0	44,294	12,492	34,906	65,604	157,297
19	0	46,510	12,705	31,212	59,110	149,537
20	0	44,877	11,128	30,236	61,342	147,583
21	0	47,123	13,886	30,202	69,664	160,874
22	0	49,479	13,387	26,001	61,683	150,550
23	0	51,953	12,677	27,669	66,243	158,543
24	0	54,550	13,986	26,901	75,511	170,948
25	0	51,823	11,883	24,556	63,310	151,572
26	0	49,350	10,365	20,277	55,637	135,628
27	0	51,817	15,520	27,378	71,341	166,056
28	0	50,737	11,882	20,139	55,442	138,200
29	0	53,274	14,531	24,555	60,840	153,199
30	0	55,938	13,585	22,964	71,082	163,568
31	0	53,588	15,540	23,068	60,678	152,874
32	0	54,461	13,177	23,834	67,176	158,648
33	0	53,208	15,496	25,569	66,979	161,251
34	0	50,545	11,851	26,185	57,690	146,271
35	0	48,017	13,386	22,443	63,889	147,735
36	0	50,332	13,334	22,843	58,939	145,448
37	0	47,814	11,181	20,599	54,868	134,461
38	0	48,792	12,060	24,554	61,603	147,009
39	0	48,184	12,553	22,825	60,685	144,247
40	0	47,578	10,790	20,329	54,765	133,463

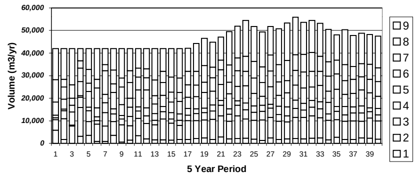
South Coast Long Term Wood Supply by Catchment

Average Annual Large High Quality Sawlog



South Coast Long Term Wood Supply by Price Zone

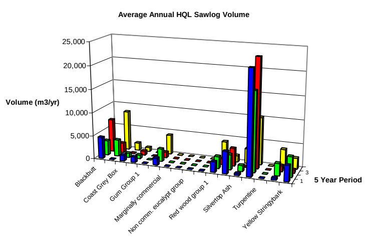
Average Annual Large High Quality Sawlog



Sum of HQ_L	Catchment		
PERIOD	1	2	Grand Total
1	40,809	1,262	42,071
2	35,781	6,290	42,071
3	38,572	3,499	42,071
4	32,396	9,675	42,071
5	30,895	11,178	42,073
6	36,725	5,345	42,070
7	36,623	5,448	42,071
8	30,770	11,301	42,070
9	36,225	5,845	42,070
10	36,270	5,801	42,072
11	30,803	11,268	42,071
12	31,762	10,308	42,070
13	36,122	5,949	42,070
14	35,101	6,971	42,073
15	35,760	6,311	42,071
16	34,496	7,576	42,072
17	35,105	7,082	42,187
18	36,488	7,806	44,294
19	36,775	9,735	46,510
20	36,675	8,202	44,877
21	36,735	10,387	47,123
22	40,549	8,930	49,479
23	43,014	8,939	51,953
24	43,946	10,604	54,550
25	44,072	7,752	51,823
26	43,958	5,392	49,350
27	41,026	10,791	51,817
28	43,793	6,944	50,737
29	44,529	8,745	53,274
30	46,753	9,185	55,938
31	44,377	9,211	53,588
32	45,911	8,551	54,461
33	43,011	10,197	53,208
34	43,587	6,958	50,545
35	37,078	10,938	48,017
36	42,871	7,461	50,332
37	39,713	8,101	47,814
38	38,756	10,036	48,792
39	38,879	9,306	48,184
40	39,919	7,659	47,578

Sum of HQ_L	Price Zone									
PERIOD	1	2	3	4	5	6	7	8	9	Grand Total
1	10	102	5,758	4,585	888	1,159	5,886	9,871	13,811	42,071
2	3	1,726	9,252	3,533	627	4,435	5,397	3,435	13,663	42,071
3	1	30	7,631	452	5,858	2,843	3,183	6,005	16,069	42,071
4	12	3,147	12,794	4,574	584	6,261	5,933	3,284	5,481	42,071
5	2	3,539	6,087	4,916	1,494	7,007	3,622	6,161	9,246	42,073
6	18	899	7,553	1,583	1,700	4,108	8,665	3,911	13,632	42,070
7	94	838	6,742	5,970	4,401	3,708	10,441	2,676	7,200	42,071
8	2	3,610	6,136	3,339	2,276	7,204	3,788	6,062	9,654	42,070
9	15	648	7,553	2,650	1,499	4,872	7,713	3,947	13,173	42,070
10	42	1,431	6,359	4,140	4,134	3,856	7,082	5,194	9,833	42,072
11	13	3,377	7,625	3,320	1,814	7,473	5,709	4,030	8,711	42,071
12	21	1,965	6,812	3,378	3,665	7,779	5,462	3,943	9,045	42,070
13	6	1,512	6,799	1,919	3,043	4,219	3,624	6,972	13,978	42,070
14	15	1,604	9,233	3,268	2,269	4,958	5,553	5,050	10,122	42,073
15	8	1,506	7,430	1,884	2,888	4,560	4,486	6,620	12,689	42,071
16	4	1,759	6,271	2,238	2,837	5,464	4,064	6,290	13,143	42,072
17	18	1,687	8,402	2,438	2,930	5,046	5,483	5,896	10,286	42,187
18	13	2,106	7,951	3,082	2,178	5,365	5,124	6,052	12,424	44,294
19	8	2,421	7,982	3,304	1,955	6,926	4,597	7,347	11,970	46,510
20	10	1,739	8,982	3,681	2,595	6,079	6,053	4,640	11,099	44,877
21	22	2,827	9,392	4,682	2,098	7,063	6,546	4,254	10,238	47,123
22	12	2,011	7,784	3,120	2,436	6,620	5,158	7,560	14,778	49,479
23	19	2,164	9,982	4,649	2,086	6,338	6,954	5,631	14,130	51,953
24	28	2,285	8,536	4,053	2,986	7,678	6,399	6,664	15,921	54,550
25	22	1,796	8,479	3,448	2,926	5,468	6,763	7,335	15,588	51,823
26	10	1,299	9,099	3,819	2,666	3,893	6,200	6,890	15,473	49,350
27	20	2,473	9,082	4,015	1,772	7,768	6,898	7,095	12,695	51,817
28	19	1,679	8,163	2,976	3,590	4,864	5,982	7,635	15,828	50,737
29	15	2,065	7,442	2,640	4,006	6,264	5,407	8,863	16,571	53,274
30	13	2,136	9,392	3,998	3,582	6,655	6,596	6,903	16,664	55,938
31	14	2,061	9,415	3,321	2,982	6,814	7,049	7,733	14,199	53,588
32	23	2,267	9,934	3,789	3,074	5,904	6,977	8,243	14,250	54,461
33	26	2,427	8,883	4,006	3,076	7,318	6,251	6,591	14,631	53,208
34	22	1,607	8,597	2,879	5,030	4,986	6,609	6,493	14,320	50,545
35	26	2,757	7,679	3,774	2,141	7,544	6,915	6,078	11,103	48,017
36	17	1,744	8,074	2,878	3,625	5,436	6,108	7,055	15,395	50,332
37	12	1,748	8,164	3,622	2,651	5,950	6,316	5,670	13,680	47,814
38	13	2,456	7,321	3,665	3,130	7,080	5,816	5,889	13,421	48,792
39	13	2,307	8,856	2,911	1,720	6,640	6,018	6,561	13,157	48,184
40	18	1,930	7,968	2,683	2,875	5,334	6,676	6,021	14,071	47,578

South Coast Large High Quality Sawlog Supply by Species Distribution



Catchment	(All)
Price Zone	(All)
TSZ	(All)
STRATA	(All)

	Data													
PERIOD	Blackbutt	Brown Barrel Group	Coast Grey Box	Coastal peppermint group	Gum Group 1	Gum Group 2	Marginally commercial	Mountain Gum	Non comm. eucalypt group	Non eucalypt group	Red wood group 1	Red wood group 2	Silvertop Ash	Spotted Gum
1	4,621	50	1,248	1,160	0	1,493	0	0	0	0	2,245	4,701	395	21,927
2	3,160	3,573	892	795	0	2,708	0	0	0	0	2,533	3,242	1,247	16,932
3	7,109	2,077	79	859	0	1,172	0	0	0	0	1,233	3,742	177	23,135
4	1,715	8,472	1,622	879	0	4,217	0	0	0	0	4,119	1,398	3,158	10,153
5	2,767	9,954	755	1,014	0	2,851	0	0	0	0	2,007	2,194	1,088	13,717
6	4,173	2,483	419	910	0	1,306	0	0	0	0	2,658	2,826	5,556	17,389
7	4,765	5,422	475	387	0	2,555	0	0	0	0	4,072	1,766	3,831	12,516
8	3,632	8,862	1,249	1,131	0	3,545	0	0	0	0	2,772	2,070	635	14,819
9	3,796	3,545	648	858	0	1,896	0	0	0	0	2,531	2,568	3,864	17,268
10	5,466	4,762	451	435	0	1,925	0	0	0	0	2,999	2,368	2,244	16,191
11	3,313	7,529	846	1,113	0	3,824	0	0	0	0	2,523	1,992	2,815	13,143
12	5,136	7,621	1,333	729	0	3,491	0	0	0	0	3,171	1,773	2,082	12,560
13	5,107	3,876	326	578	0	2,181	0	0	0	0	1,805	2,978	1,402	20,610
14	4,075	4,124	1,180	766	0	2,712	0	0	0	0	3,214	2,265	2,898	16,213
15	4,862	4,253	993	743	0	2,245	0	0	0	0	2,744	2,138	1,123	19,717
16	5,353	5,434	1,032	870	0	2,498	0	0	0	0	1,830	2,576	976	18,159
17	5,005	4,514	184	605	0	2,603	0	0	0	0	2,048	2,402	2,501	17,825
18	4,277	5,169	420	730	0	2,928	0	0	0	0	2,343	3,044	1,795	18,717
19	4,372	6,796	1,057	986	0	3,590	0	0	0	0	2,568	2,875	1,165	19,251
20	3,876	6,003	1,637	1,055	0	2,864	0	0	0	0	3,334	2,234	1,974	16,842
21	3,602	6,558	1,049	1,139	0	4,239	0	0	0	0	2,652	2,507	2,567	16,397
22	5,765	6,110	639	1,259	0	3,055	0	0	0	0	1,966	3,665	1,331	21,279
23	4,221	5,980	1,515	1,259	0	3,714	0	0	0	0	3,516	3,310	2,418	20,560
24	5,338	7,611	1,307	1,316	0	3,764	0	0	0	0	2,483	3,225	1,435	23,332
25	5,720	5,304	629	1,134	0	3,061	0	0	0	0	2,650	3,601	2,417	22,357
26	4,989	3,134	1,760	1,339	0	2,755	0	0	0	0	2,742	3,502	1,935	22,044
27	5,035	7,171	735	1,118	0	4,592	0	0	0	0	3,084	3,350	2,233	19,735
28	6,149	4,914	326	943	0	2,951	0	0	0	0	2,645	3,783	1,807	22,723
29	7,266	5,473	399	864	0	3,778	0	0	0	0	2,163	3,848	1,441	23,890
30	6,442	6,105	1,364	1,210	0	3,174	0	0	0	0	3,264	3,872	1,712	23,849
31	7,164	5,374	335	1,008	0	3,756	0	0	0	0	2,623	3,791	2,374	21,243
32	6,297	5,808	897	1,303	0	3,327	0	0	0	0	2,747	3,483	2,417	22,979
33	5,165	6,231	878	941	0	4,187	0	0	0	0	3,013	3,185	1,862	22,329
34	7,824	5,022	737	745	0	2,273	0	0	0	0	3,124	3,666	2,422	19,994
35	4,472	8,374	1,009	1,144	0	3,607	0	0	0	0	2,714	2,611	1,594	17,825
36	6,881	5,070	651	1,137	0	2,719	0	0	0	0	2,251	3,302	1,991	21,945
37	4,712	5,228	1,175	1,024	0	3,139	0	0	0	0	2,566	3,157	1,862	19,878
38	5,361	7,201	1,159	985	0	3,966	0	0	0	0	2,816	2,852	1,625	18,719
39	4,900	5,712	673	1,214	0	3,588	0	0	0	0	2,426	3,678	2,342	18,881

7. WOOD SUPPLY MODELLING PROCESS

7.1 OVERVIEW

During the CRA negotiations multiple wood supply scenarios were modelled with *Spectrum* to ascertain the impacts of changing variables on future wood volumes, log product composition and location of harvesting. The process culminated in the formulation of a Final State Position for the South Coast and Tumut CRA sub-regions.

The multiple scenarios were aimed at exploring the trade-off between conservation reserve designs aimed at achieving JANIS targets and wood supply areas particularly of large high quality sawlogs.

Spectrum results (the level of High Quality Large sawlog wood supply) were evaluated in terms of:

- ability to meet the Term & Wood Supply Agreement level of large high quality log production until 2020 and the maximum level of future sustainable wood supply;
- ensuring the commercial species composition produced in the next 20 years would be satisfactory for industry;
- harvestable area located in the more productive forest strata and geographical areas;
- harvestable area concentrated in economic blocks (large blocks and closer to industrial processing plants);
- industry requirements with minimal inter-timber catchment log haulage;
- the amount of volatility in timber catchment production levels; and
- preference to exclude smaller, landlocked and remote blocks from the production estate.

7.2 MODELLING SCENARIOS

CRA negotiations focussed on identifying a forest reserve design which best met the conservation criteria and large high quality log (quota) contractual commitments.

The wood supply modelling scenarios included modelling the effects of changes to one or more of the following variables:

7.2.1 Net forest area available for harvesting.

Factors affecting the net harvestable area (NHA) which were evaluated included:

- conservation reserve designs from C-PLAN. A wide range of options were evaluated. Conservation reserves are a direct reduction in the State Forest gross forest area, not the area available for harvesting;
- in/exclusion of Provisionally Identified Wilderness (South Coast and Tumut), and Identified and Declared Wilderness (Tumut only)
- in/exclusion of Candidate Old Growth areas (South Coast only)

7.2.2 Revised native forest yield tables

Revised yield tables based on redefined population of strategic inventory plots. As the proposed reserve system was increased or changed, the population of plots within the net harvestable area changed, necessitating a recalculation of the yields expected from the newly defined production area. This was necessary to account for the reservation of a disproportionate amount of either more productive or less productive planning units within a given strata, which changes the strata average volume predictions.

7.3 MODELLING APPROACH

The modelling process depends on the resource characteristics, management objectives, and nature of constraints. The general approach involved in the CRA negotiation for the Southern CRA sub-regions involved the following steps:

7.3.1 Importation of data files

The analysis unit file (net harvest area of native forest and plantation strata) was imported and where applicable the plantation and native forest yield tables were imported into a base *SPECTRUM* model template.

Separate templates were created for the different yield tables. This was done to minimise the time involved in data importing and record sorting, and to minimise erroneous use of model templates. A change to the net harvestable area of native forest was the primary factor evaluated in new scenarios.

7.3.2 Define management objectives and constraints

Objectives and constraints defined were:

- attempt to meet the minimum contractually committed volume of large high quality logs for a 20 year term or to determine the maximum even flow, followed by the secondary objective of identifying the maximum long term sustainable yield of large high quality logs;
- constrain the maximum permissible intensity of silvicultural regimes (AGS, STS) assigned to native forest strata; and
- constrain the preferred silvicultural options to specific sites.

The silvicultural specifications remained largely unchanged amongst the options determination process.

7.3.3 Run *Spectrum* model

The yield scheduling model was run to generate a solution. In this process a LP matrix is created, then the LP solver searches for an optimal solution if a feasible solution. The LP solver selects the best mix of silvicultural treatments per strata to meet the objective function of maximising the high quality timber volume from the whole forest, and nominates the proportions and timing of each stratum to be harvested over the model planning horizon.

7.3.4 Evaluate results and re-define area inputs, silvicultural options, wood supply targets & constraints.

The wood supply results from each *Spectrum* run were evaluated to ascertain the need for further modifications in order to arrive at a scenario which maximises the conservation benefits, maintains sufficient resource to meet industry objectives, and satisfies other socio-economic impacts. The modifications included changes to the areas available for harvesting (via forest reserve design based on NPWS C-PLAN model), yield tables (these were recalculated periodically as the NHA was reduced or changed for the creation of conservation reserves), NHA exclusions (Old Growth, Wilderness definitions), and the wood supply constraints.

Changes to the area available for harvesting was the primary modification to *SPECTRUM* model runs, and the secondary factor was the minimum wood supply constraint for the initial 20 year commitment period. The yield tables were recalculated periodically to reflect the impact of changes to the extent and composition of the NHA as the conservation reserves were determined. Since the yield tables were based on inventory plots located within the NHA, as the NHA population definition changed (plots were no longer part of the production estate, but became part of the reserve), it was necessary to recalculate future yields based on the redefined population to maintain the representativeness and validity of the yields.

For each scenario modelled, the process of determining an optimal solution involved multiple runs. The precise modelling approach varied depending on the area and location of formal reserves, the resource characteristics, and level and profile of the wood supply target levels sought. For a given scenario the wood supply was frequently modelled in two phases. This involved changing the objective function, general constraints and harvest policy sequential constraints in S*pectrum*. while the objective function was always maintained at maximising the volume of high quality large logs, the constraints were modified to achieve the desirable wood supply profile.

First phase:
Aim: To ascertain if the Term and Wood Supply Agreement Contract target could be achieved for 20 years, or the maximum achievable level of production.

Objective function: set to maximise the volume of large high quality logs harvested in Periods 1 to 4 and to permit nil variation in production level over this period

Harvest policy constraints: set sequential constraint so that no increase or decrease in large high quality logs production level between periods is permitted. Set the maximum permissible decrease to 0.000 and the maximum permissible increase to 0.000.

General constraints: no general wood supply constraints were applied to periods 5 – 40.

Second Phase:
Aim: Determine the maximum sustainable level of HQL production for periods 5 – 40.

Redefinition of targets and constraints based on the first phase outcomes. Define 20 year volume as constraint then determine maximum sustainable yield (smoothed) for balance of planning horizon.

Objective function: set to maximise the volume of large high quality logs harvested in Periods 5 to 40 and to permit nil variation in production level over this period

Harvest policy constraints: set sequential constraint so that no increase or decrease in large high quality logs production level between periods is permitted. Set the maximum permissible decrease to 0.000 and the maximum permissible increase to 0.000.

General constraints: set the general wood supply constraint at the Term and Wood Supply Agreement Contract levels or maximum HQL production level achievable for periods 1 – 4, whichever is the lesser.

APPENDIX 1: YIELD ASSOCIATION GROUPS, SILVICULTURE, AND YIELD TABLES

APPENDIX 1.1: NATIVE FOREST YIELD ASSOCIATION GROUPS USED IN INVENTORY AND YIELD SIMULATION

YIELD ASSOCIATION CLASSIFICATION BY STRATA

Stratum No.	Structure Class	Yield Association	Southern Yield Association No.	Simulator Yield Association Group
1	Late Mature	Brown Barrel/Messmate	9	5
2	Mixed Age Mature	Blackbutt/Sydney Blue Gum	1,2	1
3	Mixed Age Mature	Spotted Gum	3	2
4	Mixed Age Mature	Silvertop Ash	4	3
5	Mixed Age Mature	Stringybark/Coast Grey Box/Forest Red Gum/Woollybutt	5,6	4
6	Mixed Age Mature	Brown Barrel/Messmate	9	5
7	Mixed Age Mature	Gum	10	6
8	Mixed Age Young	Blackbutt/Sydney Blue Gum	1,2	1
9	Mixed Age Young	Spotted Gum	3	2
10	Mixed Age Young	Silvertop Ash	4	3
11	Mixed Age Young	Stringybark/Coast Grey Box/Forest Red Gum/Woollybutt	5,6	4
12	Mixed Age Young	Brown Barrel/Messmate	9	5
13	Mixed Age Young	Gum	10	6
14	Regrowth Dominant	Blackbutt/Sydney Blue Gum	1,2	1
15	Regrowth Dominant	Spotted Gum	3	2
16	Regrowth Dominant	Silvertop Ash	4	3
17	Regrowth Dominant	Stringybark/Coast Grey Box/Forest Red Gum/Woollybutt	5,6	4
18	Regrowth Dominant	Brown Barrel/Messmate	9	5
19	Regrowth Dominant	Gum	10	6
20	Regrowth Dominant	Apples/Peppermint/Scribbly Gum	7,11	7
21	Bago Ash	Alpine Ash	18	8
22	Maragle Ash	Alpine Ash	18	8
23	Bago/Maragle Hardwood	Bago/Maragle Hardwoods	20	9
24	Mixed Age Young	Buccleuch Alpine Ash/HQ and LQ Hardwoods	19,21,22	9
25	Mixed Age Mature	Buccleuch Alpine Ash/HQ and LQ Hardwoods	19,21,22	9

YIELD ASSOCIATION DESCRIPTION

Southern Yield Association No.	Southern Yield Association Name
1	Blackbutt
2	Sydney Blue Gum
3	Spotted Gum
4	Silvertop Ash
5	Stringybark
6	Coast Grey Box/Forest Red Gum/Woollybutt
7	Apples
8	Alpine Ash east of the Main Divide
9	Brown Barrel/Messmate
10	Gum
11	Peppermint/Scribbly Gum
12	Western Box
13	Snow Gum
14	Rainforest
15	Cypress Pine
16	Non Eucalypt Forest
17	Non Forest
18	Bago/Maragle Alpine Ash
19	Buccleuch Alpine Ash
20	Bago/Maragle Hardwoods
21	Buccleuch HQ Hardwoods
22	Buccleuch LQ Hardwoods
23	Non-Commercial Forest west of the great divide

NATIVE FOREST YIELD SIMULATOR YIELD ASSOCIATION GROUPS

Simulator Yield Association Group No.	Southern Yield Association Groups	Southern Yield Association Name
1	1 & 2	Blackbutt/Sydney Blue Gum
2	3	Spotted Gum
3	4	Silvertop Ash
4	5 & 6	Stringybark/Coast Grey Box/Forest Red Gum/Woollybutt
5	9	Brown Barrel/Messmate
6	10	Gum
7	7 & 11	Apples/Peppermint/Scribbly Gum
8	18	Bago/Maragle Alpine Ash
9	19-22	Riverina Hardwoods

APPENDIX 1.2: NATIVE FOREST SILVICULTURE

Silvicultural Options

The Southern Region NSW native uneven aged forests are managed according to two primary silvicultural systems – Single Tree Selection (STS) and Group Selection (GS). The yield tables simulated were based on the following silvicultural prescriptions.

Single Tree Selection

The management of uneven aged native forest under Single Tree Selection (STS) operations involves periodic selective harvesting of individual or small clusters of commercially mature trees.

The level of tree removal under STS is limited by a maximum level of basal area that can be removed. The maximum proportion of the basal area removed varies with the operation intensity. Three intensity levels (light, moderate, heavy) were modelled.

A harvesting event can occur when the merchantability conditions (stand end-point) are reached – a condition of stand where it is sufficiently mature for the extraction of a minimum economic volume of high quality logs while ensuring an adequate basal area is retained for future wood production and habitat retention.

The proportion of eligible trees removed in a harvest event is constrained to ensure there is adequate recruitment into larger diameter classes, and to preserve adequate seed and habitat trees in the residual stand.

STS silviculture is applied to stands where the regeneration and productive capacity of the stand can be maintained under a mixed structure. The STS silviculture enables a greater proportion of the mature (commercially viable and merchantable) resource to be accessed from a forest estate within a shorter time frame than with group selection options. Another benefit of STS relates to the lower cost of extraction of merchantable timber. When mixed age forest is converted to even-aged regrowth using GS, this results in the removal of clusters of uneven aged forest often with sub-merchantable and unmerchantable species, increasing the unit harvesting costs.

The specifications used to define the STS operation are defined in following tables.

SINGLE TREE SELECTION (STS) BASAL AREA REMOVAL

Specification	Silvicultural Regime Intensity		
	STS Light	**STS Medium**	**STS Heavy**
Maximum % BA removal	25%	35%	45%

SPECIFICATIONS FOR STS REGIME HARVEST OPERATION IN NATIVE FOREST (YA 1 – 5)

Variable	Simulator Yield Association Group				
	Blackbutt / Sydney Blue Gum (1)	Spotted Gum (2)	Silvertop Ash (3)	Stringybark / Coast Grey Box / Forest Red Gum / Woollybutt (4)	Brown Barrel / Messmate (5)
Min. HQ large volume for harvest (m^3/ha) *(not selected)*	12	15	10	10	12
Min. combined HQ/LQ large volume for harvest (m^3/ha) *(selected)*	15	15	15	15	15
Min. diameter to calculate HQ/LQ volume for harvest (cm)	60	55	55	55	60
Min. retained BA (m^2/ha)	10	10	10	10	10
Do not cut LQ / Pulp trees if LQ / Pulp volume is greater than (m^3/ha)	100	100	100	100	100
Min. harvest return time (years)	15	15	15	15	15

SPECIFICATIONS FOR STS REGIME HARVEST OPERATION IN NATIVE FOREST (YA 6 – 9)

Variable	Simulator Yield Association Group			
	Gum (6)	Apples / Peppermint / Scribbly Gum (7)	Bago / Maragle Alpine Ash (8)	Riverina Hardwoods (9)
Min. HQ large volume for harvest (m^3/ha) *(not selected)*	10	10	12	12
Min. combined HQ/LQ large volume for harvest (m^3/ha) *(selected)*	15	15	15	15
Min. diameter to calculate HQ/LQ volume for harvest (cm)	55	55	60	60
Min. retained BA (m^2/ha)	10	10	10	10
Do not cut LQ / Pulp trees if LQ / Pulp volume is greater than (m^3/ha)	100	100	100	100
Min. harvest return time (years)	15	15	15	15

MAXIMUM PROPORTIONS OF DIAMETER CLASS REMOVED IN LOW PRODUCTION YIELD ASSOCIATIONS

Low Production Yield Association Groups (3,4,7,9)				
Tree Quality Type	Maximum Percentages Removed by Diameter Class			
	10-30cm	30-50cm	50-70cm	70cm+
High Quality	0%	20%	90%	100%
Low Quality	0%	75%	100%	100%
Pulpwood	15%	15%	15%	15%
Waste	15%	15%	10%	10%

MAXIMUM PROPORTIONS OF DIAMETER CLASS REMOVED IN HIGH PRODUCTION YIELD ASSOCIATIONS

High Production Yield Association Groups (1,2,5,6,8)				
Tree Quality Type	Maximum Percentages Removed by Diameter Class			
	10-30cm	30-50cm	50-70cm	70cm+
High Quality	0%	10%	85%	100%
Low Quality	0%	85%	100%	100%
Pulpwood	15%	15%	15%	15%
Waste	15%	15%	10%	10%

Group Selection (GS) Management

Group Selection is a harvesting system where a management unit is progressively harvested as small clusters of trees in a staggered sequence over time, creating a spatial pattern of even-aged clusters of regrowth forest and gaps where the trees have been completely removed.

Group selection is initiated through the harvesting of small areas of mature stands creating fully cleared gaps. Natural regeneration will establish in the gap. Eventually a sequence of gaps is established across the whole management unit. Ideally the gaps should be circular with diameters ranging from 40 to 100 metres (Florence, 1996. Ecology and Silviculture of Eucalypt Forests). A number of small areas, referred to as gaps are simultaneously harvested within a management unit. The total area harvested within an operation is determined by the maximum allowable gap size, maximum proportion of the management unit which can be harvested in a given harvest event, the proportion of the management unit which must be retained and the minimum return time before the management unit can be revisited to create additional gaps, thinning or re-resets.

After a defined period the management units are revisited (return time) and adjacent gaps (not necessarily immediately adjacent, but within the same general area) will be formed until the maximum proportion of the area is completely gapped. At each return visit to a management unit, the previously formed gaps (now clusters of older regenerated trees) are evaluated in terms of their suitability for thinning to promote growth on the larger better form trees and remove smaller less desirable trees. These clusters are thinned as required. When the stands mature (adequate volume of merchantable trees with sawlog dimensions) they will be harvested (re-reset) again and the whole cutting cycle will be repeated. The result of this silvicultural system is an uneven-aged forest comprised of numerous even aged small clusters of regrowth forest and gaps.

Group selection silviculture is applied to stands where a complete canopy opening is required for regeneration and stand growth. GS can be used to enhance the productivity of stagnant stands which have a large component of poor quality or older trees suppressing regeneration and the growth of commercial quality trees. GS is typically applied to either moist mixed age mature stands (reset stands) or regrowth stands. Reset forests are often characterised by trees with large crowns and have dense moist understoreys and moist groundcover. Successful regeneration and growth of these forests following harvesting requires large gaps provided by GS. This is particularly important in moist forest which does not have the lignotuber pool that provides a large proportion of the regeneration on the drier sites. GS is suitable for regrowth forest characterised by a relatively uniform structure which has a size class distribution suited to commercial thinning and ultimately a reset harvesting.

The specifications used to define the GS operation are defined in following tables.

SPECIFICATIONS FOR THE GS SILVICULTURE GAP CREATION IN NATIVE FOREST

Specification (All yield associations)	Silvicultural Regime		
	AGS Light	**AGS Moderate**	**AGS Heavy**
Gap Size (m)	40	70	100
Proportion of net area gapped in harvesting event	22.5%	22.5%	22.5%
Proportion of net area reserved from harvesting	10%	10%	10%
Number of gapping event cycles undertaken	4	4	4
Return time (years)	20	15	10

SPECIFICATIONS FOR GS REGIME RESET OPERATION IN NATIVE FOREST (YA 1 – 5)

Variable	Simulator Yield Association Group				
	Blackbutt / Sydney Blue Gum (1)	Spotted Gum (2)	Silvertop Ash (3)	Stringybark / Coast Grey Box / Forest Red Gum / Woollybutt (4)	Brown Barrel / Messmate (5)
Min HQ large volume for reset (m^3/ha) *(not selected)*	12	12	10	10	12
Min HQ/LQ large volume for reset (m^3/ha) *(selected)*	15	15	15	15	15
Min diameter to calculate HQ/LQ volume for reset (cm)	55	55	55	55	55
Prescriptions for trees growing on gaps					
T1 Retained BA (m^2/ha)	12	12	18	12	12
T1 Volume required (m^3/ha)	50	50	50	50	50
T2 Retained BA (m^2/ha)	15	15	18	15	15
T2 volume required (m^3/ha)	35	40	40	40	40
Min. HQ large volume for gap rereset (m^3/ha)	35	30	30	25	35
Min. diameter for HQ large volume for gap rereset (cm)	60	55	55	55	60
Prescriptions for stand thinning before gapping					
Pre-gap first thin retained BA (m^2/ha)	12	12	18	12	12
Pre-gap first thin volume required (m^3/ha)	50	50	50	50	50
Pre-gap second thin retained BA (m^2/ha)	15	15	18	15	15
Pre-gap second thin volume required (m^3/ha)	35	40	40	40	40

SPECIFICATIONS FOR GS REGIME RESET OPERATION IN NATIVE FOREST (YA 6 – 9)

Variable	Simulator Yield Association Group			
	Gum (6)	Apples / Peppermint / Scribbly Gum (7)	Bago / Maragle Alpine Ash (8)	Riverina Hardwoods (9)
Min HQ large volume for reset (m^3/ha) *(not selected)*	10	10	12	12
Min HQ/LQ large volume for reset (m^3/ha) *(selected)*	15	15	15	15
Min diameter to calculate HQ/LQ volume for reset (cm)	55	55	55	55
Prescriptions for trees growing on gaps				
T1 Retained BA (m^2/ha)	12	12	12	12
T1 Volume required (m^3/ha)	50	50	50	50
T2 Retained BA (m^2/ha)	15	15	15	15
T2 volume required (m^3/ha)	40	40	35	35
Min. HQ large volume for gap rereset (m^3/ha)	30	25	35	35
Min. diameter for HQ large volume for gap rereset (cm)	55	50	60	60
Prescriptions for stand thinning before gapping				
Pre-gap first thin retained BA (m^2/ha)	12	12	12	12
Pre-gap first thin volume required (m^3/ha)	50	50	50	50
Pre-gap second thin retained BA (m^2/ha)	15	15	15	15
Pre-gap second thin volume required (m^3/ha)	40	40	40	40

GS REGIME THINNING REGIME OPTIONS NATIVE FOREST

Strata	Pre-Group Selection Stand Thinning		Group Selection Stand Thinning	
	By-pass pre-gap first thin (true/false)	By-pass pre-gap second thin (true/false)	By-pass pre-gap first thin (true/false)	By-pass pre-gap second thin (true/false)
1	True	True	False	True
2	True	True	False	True
3	True	True	False	True
4	True	True	True	True
5	True	True	True	True
6	True	True	False	True
7	True	True	True	True
8	True	True	False	True
9	True	True	False	True
10	True	True	True	True
11	True	True	True	True
12	True	True	False	True
13	True	True	True	True
14	False	False	False	True
15	False	False	False	True
16	False	False	False	True
17	False	False	False	True
18	False	False	False	True
19	False	False	False	True
20	True	True	True	True
21	True	True	False	True
22	True	True	False	True
23	True	True	False	True
24	True	True	False	True
25	True	True	False	True

The recruitment models were calibrated with different proportions of tree vigour classes to reflect the different gap sizes under each silvicultural regime intensity. The proportion of co-dominant trees were increased by the adjustment factors, while the dominant, sub-dominant and suppressed tree vigour classes were reduced by the equivalent proportion on a pro-rata basis.

CO-DOMINANT TREE VIGOUR CLASS RECRUITMENT ADJUSTMENT FACTORS

Specification (All yield associations)	Silvicultural Regime		
	AGS Light	AGS Moderate	AGS Heavy
Co-dominant tree vigour class increase	0%	15%	15%
Gap Size (m)	40	70	100

APPENDIX 1.3: COMPOSITE NATIVE FOREST SILVICULTURE – TUMUT ONLY

Tumut CRA sub-region Silvicultural Prescriptions

Wood supply forecasts for the Tumut subdivision of the Southern CRA were based on yield tables developed on multiple silvicultural regimes across identified strata. These comprised a mixture of Group Selection (GS) and Single Tree Selection (STS) with different intensities of harvesting within each primary silvicultural system.

The Strata
The strata were based on a combination of species dominance (Alpine Ash), and stand condition. Stand condition reflects the history and intensity of disturbance and forest management intervention, particularly past harvesting and silvicultural treatment and fire. The Alpine Ash forests of Bago and Maragle have significant differences in past history and age classes so warranted a separate stratum for each. For simplicity the lesser area of Alpine Ash type within Buccleuch area, which also has a lengthy history of disturbance, was included in the Mixed Aged Young Hardwood Stratum. The mixed age mature hardwood stratum is generally devoid of Alpine Ash and is situated in the Buccleuch / Bungongo area ie outside the Bago / Maragle geographic area.

Choice of Silviculture
Several field inspections were undertaken by State Forests to verify the need for the silvicultural options for the various strata. These inspections involved the Foresters who prepare and implement the harvesting plan, the Managers who review the Harvesting Plans and also, importantly, the Supervising Forest Officers who conduct the tree marking and supervise the logging operation.
These inspections involved the taking of measurements of the existing (past logging) and planned canopy openings (gaps) to be created to achieve the desired silvicultural outcomes.
The field inspections confirmed the need to have a blend of AGS and STS and a choice of intensities within each silvicultural method (eg AGS canopy opening/gap), as well as the thinning options. The choice of silviculture is appropriate for the range of stand conditions encountered during the field inspections.

Stratum 21 - Bago Alpine Ash

As the Mean Annual Increment (MAI) for Alpine Ash peaks at age 80-90 years this is the ideal age to harvest the tree and promote regeneration on the site. Consequently the rotation length of the Alpine Ash forests has been set at 80 years with approximately four cutting cycles each consisting of 20years. One quarter of the Net Harvest Area should be subject to AGS[1] silviculture every cutting cycle to allow the forest to regenerate and grow efficiently. The tables below set the proportion of AGS to be applied to the NHA at 22.5% for each cutting cycle. Over the 80 year rotation length, 10% of the forest will not be subject to AGS silviculture ie habitat tree prescriptions etc.

Each year AGS is applied to harvest groups of trees that have reached maturity (80 years +) within the compartments scheduled for harvest. This method is applied to a little less than 1/80th of the total NHA each year. However the resultant sawlog yields do not match the sustained yield. To make up the difference the remainder of the compartment is harvested using STS silviculture. This silvicultural method conserves vigorously growing trees which are producing maximum increment growth for future sawlog yields (ie less than 80 years of age) and eliminates potential mortality by removing partially suppressed unhealthy trees, or trees that show significant defect. The STS method is also implemented to harvest mature stems (80years +) where a regeneration harvest is not necessary as regeneration of acceptable composition and age resides underneath or immediately adjacent to the tree designated for removal.

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[1] Australian Group Selection (AGS) involves the removal of all merchantable basal area from the designated area selected for a regeneration harvesting event.

Stratum 22 - Maragle Alpine Ash

The current annual sawlog commitments for Bago/Maragle Ash combined are set below the sustained yield to allow the growing stock to increase to about 100m^3/ha for the majority of Maragle. The majority of the currently non-merchantable stands are within the Maragle stratum, which was clear felled with seed trees in the 1960's and 1970's, hence a shortfall exists in the larger diameter merchantable size classes for this stratum. Therefore the Maragle stratum should not be scheduled for harvesting until after the year 2011 to allow the growing stock to increase to about 100m^3/ha. This is in accord with the Bago/Maragle Management Plan 1986.

The silvicultural regime indicated for Stratum 21, Bago Alpine Ash, should also be applied to Stratum 22.

A thinning operation will need to be simulated prior to applying AGS to allow the stand to grow a higher proportion of larger diameter size classes.

Strata 23 & 24 Bago/Maragle & Buccleuch/Bungongo Mixed Age Young Hardwood

These stands were traditionally subjected to heavy STS silviculture with removal of all merchantable sawlogs leaving mainly non-commercial over-mature trees and young regeneration. Only a very limited component of regeneration of suitable age exists in the 30 – 60 cm diameter classes[2]. To improve the quality of the stand, AGS will be applied to remove trees that have reached the end of their rotation age in selected locations (gaps) in order to create conditions for regeneration to develop. Although the average growth rate of the combined species within this stratum is expected to be about 1/5th of the Bago/Maragle Alpine Ash, it has been assigned the same rotation and cutting cycle length in line with the information available and for ease of compartment scheduling. As for other strata, the STS method is also implemented to harvest mature stems (80years +) where a regeneration harvest is not necessary as regeneration of acceptable composition and age resides underneath or immediately adjacent to the tree designated for removal.

Stratum 25 Buccleuch / Bungongo Mixed Age Mature Hardwood

This stratum has previously only experienced STS light harvesting. Therefore due to the consequently large standing volume this Stratum should be scheduled for harvest before Stratum 24. The silviculture will be the same as for Strata 23 & 24.

[2] Diameter class refers to the tree diameter classes at breast height ie DBHOB.

Silvicultural Composition by Strata

Bago Ash Stratum No. 21

YIELD SIMULATOR SILVICULTURE SETTINGS

Description	% of NHA
STS with a maximum BA removal of 35% Min HQ large Vol for harvest (m3/ha) = 20 Min Dia at BHOB for HQ large Vol for harvest (cm) = 60 Min retained BA (m2/ha) + 10 Min harvest return time (yrs) = 20	77.5
AGS with 80m gaps No. of gapping event cycles undertaken = 4 Return Time (yrs) = 20 T1 retained BA (m2/ha) = 15 T1 Min. Vol required (m3/ha) = 40 Min HQ large Volume for reset (m3/ha) = 15 Min Diameter at BHOB for HQ large volume for reset (cm) = 60 Apply Pre – Gap first Thin = FALSE Apply First Thin on Gaps = TRUE	4.5
AGS with 40m gaps No. of gapping event cycles undertaken = 4 Return Time (yrs) = 20 T1 retained BA (m2/ha) = 15 T1 Min. Vol required (m3/ha) = 40 Min HQ large Volume for reset (m3/ha) = 15 Min Diameter at BHOB for HQ large volume for reset (cm) = 60 Apply Pre – Gap first Thin = FALSE Apply First Thin on Gaps = TRUE	18

YIELD SIMULATOR - MAXIMUM PERCENTAGES REMOVED BY DIAMETER CLASS IN BAGO ASH STS OPERATIONS

Tree Quality Type	10 – 30cm	30 – 50cm	50 – 70cm	70+ cm
High Quality	0	12	50	99
Low Quality	0	75	90	90
Pulpwood	15	15	15	15
Waste	15	15	10	10

Note = % BA removal was calculated by measuring the proportions of all High Quality logs that were removed by either Single Tree Selection or Thinning from Below from the total BA of all stems above 10cm DBHOB.

Maragle Ash Stratum No. 22

This stratum should not be scheduled for harvest until after the year 2011, to allow the growing stock to increase to 100m^3/ha (as per the Bago/Maragle Management Plan instructions). The same silvicultural prescriptions as listed for Stratum 21 apply to this stratum. However, a Pre- group selection stand thinning will be applied.

Bago/Maragle Hardwood Stratum No. 23

YIELD SIMULATOR SILVICULTURE SETTINGS

Description	% of NHA
STS with a maximum % BA removal of 35% Min HQ large Vol for harvest (m3/ha) = 15 Min Dia at BHOB for HQ large Vol for harvest (cm) = 55 Min retained BA (m2/ha) 10 Min harvest return time (yrs) = 20	77.5
AGS with 80m gaps No. of gapping event cycles undertaken = 4 Return Time (yrs) = 20 T1 retained BA (m2/ha) = 15 T1 Min. Vol required (m3/ha) = 20 Min HQ large Volume for reset (m3/ha) = 40 Min Diameter at BHOB for HQ large volume for reset (cm) = 55 Apply Pre – Gap first Thin = FALSE Apply First Thin on Gaps = TRUE	4.5
AGS with 40m gaps No. of gapping event cycles undertaken = 4 Return Time (yrs) = 20 T1 retained BA (m2/ha) = 15 T1 Min. Vol required (m3/ha) = 20 Min HQ large Volume for reset (m3/ha) = 40 Min Diameter at BHOB for HQ large volume for reset (cm) = 55 Apply Pre – Gap first Thin = FALSE Apply First Thin on Gaps = TRUE	18

YIELD SIMULATOR - MAXIMUM PERCENTAGES REMOVED BY DIAMETER CLASS IN BAGO/MARAGLE HARDWOOD STS OPERATIONS

Tree Quality Type	10 – 30cm	30 – 50cm	50 – 70cm	70+ cm
High Quality	0	40	70	99
Low Quality	0	90	90	90
Pulpwood	15	15	15	15
Waste	15	15	10	10

Buccleuch /Bungongo Mixed Age Young Hardwood Stratum No. 24

The same silviculture as specified above for Stratum 23 should also apply for Stratum 24. Ideally no harvesting should be scheduled in this stratum until after the first cutting cycle in Stratum 25 (Buccleuch /Bungongo Mixed Age Mature) is complete.

Buccleuch /Bungongo Mixed Age Mature Hardwood Stratum No. 25

The same silviculture as specified above for Stratum 23 should also apply for Stratum 25.
This stratum should be scheduled for harvest before Stratum 24.

APPENDIX 1.4: NATIVE FOREST YIELD SIMULATOR AND YIELD TABLES

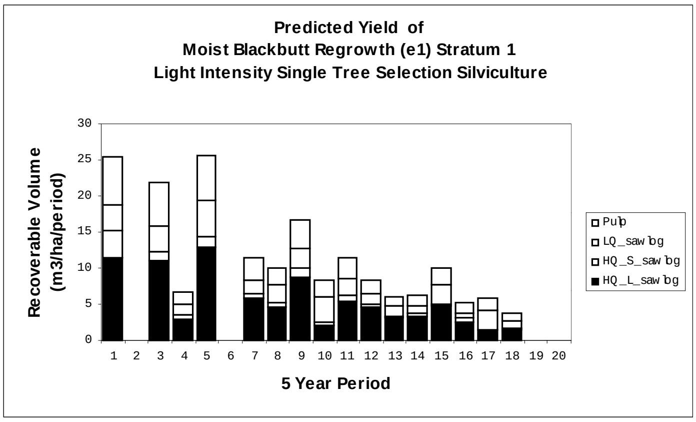
The FRAMES yield simulator is a model designed to simulate the future growth and silvicultural management of the native eucalypt forest, and generates the expected per hectare log yields when managed according to defined silvicultural prescriptions.

The yield simulator uses strategic inventory plot and tree level data. The growth of each tree in each plot is simulated using a range of tree and stand level growth, mortality and recruitment models. Each plot is modelled according to the range of silvicultural regimes (light, moderate, heavy intensity GS and STS) and for a range of transition (5 year delay) periods before a regulated harvest cycle commences defined by the user. The natural dynamics and forest management of each plot are simulated independently.

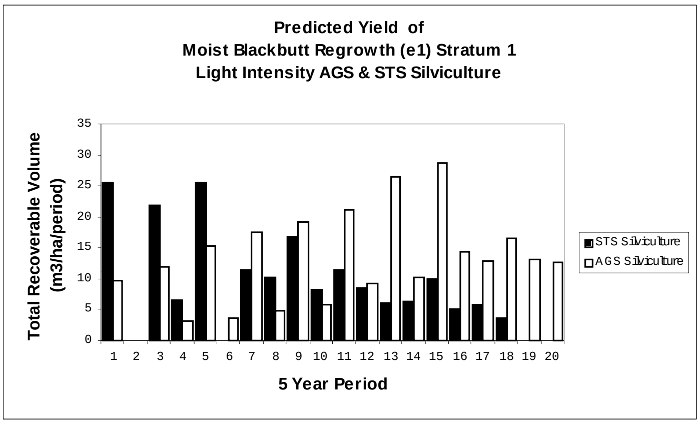
Each plot is independently evaluated as to its suitability for harvesting each year, by comparing the plot parameters (volume of different log grades, basal area, and stocking) against predefined sets of threshold harvesting criteria for each year of the simulation period. If these harvest criteria are met the simulator will remove those trees in the plots according to the harvesting prescriptions (single tree removal, thinning from below or group selection; and light, moderate and intensive operations). Following the harvesting, the model simulates tree recruitment, incremental growth and mortality of the retained trees in a plot. This sequence of events is repeated each year for the simulation period defined by the user.

The annual yields arising from the simulated harvesting of plots within each stratum are combined and divided by the number of plots within the strata to provide average strata yields per year. The yields from each stratum are reported on a m^3 / hectare per 5 year period basis for the 200 year simulation period.

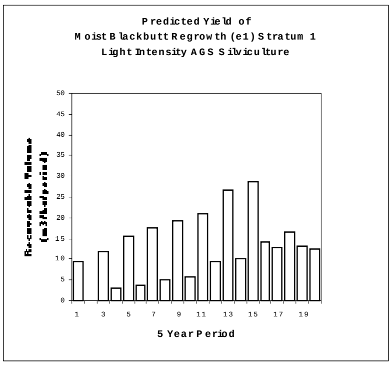
EXAMPLE OF NATIVE FOREST PERIODIC "YIELD CURVE"

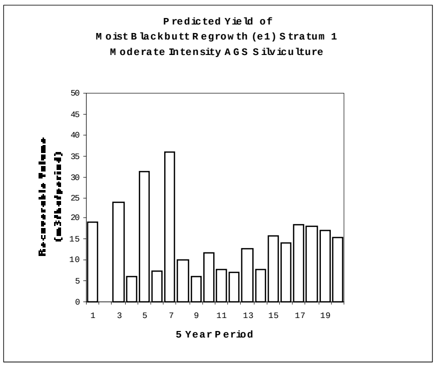


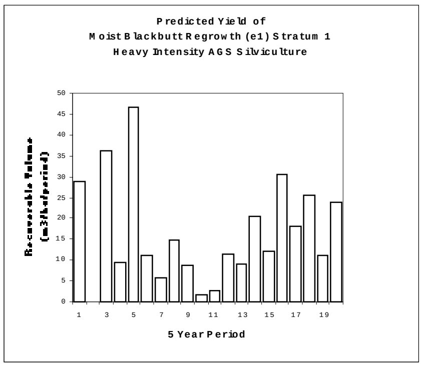
EXAMPLE OF NATIVE FOREST AGS AND STS PER HECTARE YIELD FLOW PROFILE



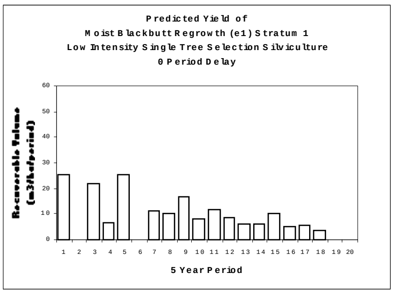
EXAMPLE OF EFFECTS OF SILVICULTURAL INTENSITY ON YIELD PROFILE

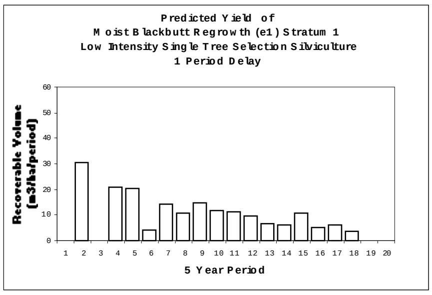


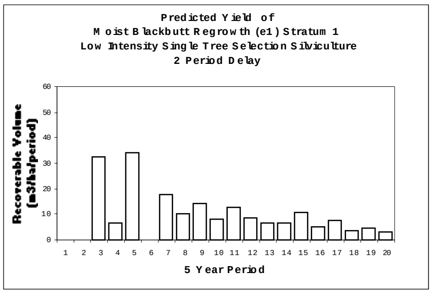


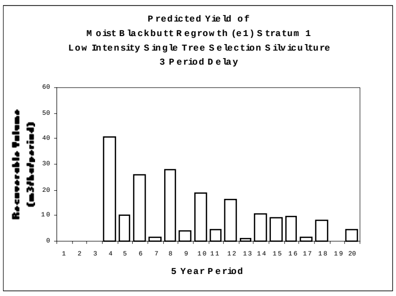


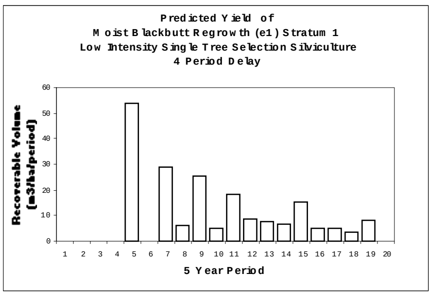
EXAMPLE OF INITIAL HARVEST DELAY OPTIONS ON NATIVE FOREST YIELD PROFILE











Appendix 1.5: Yield Table Log Products

The native forest yield tables comprise volumes of 4 generic log grade groups:

- high quality large (HQL) logs
- high quality small logs (HQS)
- low quality (LQ) logs
- pulpwood logs

The specific log grades were not identified separately in the yield tables. The relationships between the market grades and the generic modelling grades are.

The High Quality Large (HQL) logs consist of:
- veneer logs (≥40cm cdub)
- girder logs (≥40cm cdub)
- piles (≥40cm cdub)
- quota quality sawlogs (≥40cm cdub)

The High Quality Small (HQS) logs consist of:
- veneer logs (<40cm cdub)
- girder logs (<40cm cdub)
- piles (<40cm cdub)
- quota quality sawlogs (<40cm cdub)

Low Quality (LQ) logs consist of:
- ungraded (salvage) sawlogs
- pulpwood logs

Quota Quality Sawlogs:

Quota quality sawlog volumes are based on fixed commitments arising from the Government's Forestry Reform Agenda in September 1996 which was designed to ensure reservation of high conservation value forests whilst maintaining a sustainable and economically viable native forest timber industry. This includes Term Agreements, Wood Supply Agreements and "Top-Up" allocations.

Veneer logs:

Veneer log volumes include those logs defined in the wood supply agreements and the additional volumes traditionally sold from plantations and regrowth resource under annual supply agreements.

Hardwood poles:

Pole volumes have been based on traditional average volumes sold in industry in annual supply agreements since 1995 less 20% to account for the level of quota quality harvesting activity.

Girders and Piles:

Girder and pile volumes have been based on traditional average volumes sold in industry in annual supply agreements since 1995 less 20% to account for the level of quota quality harvesting activity.

Small sawlogs:

Small log volume which are largely produced as a by-product of quota quality harvesting have been based on an average of traditional supplies to significant small purchasers since 1995.

Ungraded Sawlogs:

Ungraded (salvage) sawlogs have been based on average traditional ungraded sawlog volumes sold to industry since 1995 as a proportion (0.55) of the volume of total quota sawlogs sold.

Pulpwood:

Volumes of pulpwood sold have traditionally been market dependent and have always been considerably less than maximum volumes capable of being produced as a silvicultural by-product of quota quality harvesting. Volumes reflect anticipated sale volumes.

The software package MARVL was used to calculate the proportions of log products. MARVL uses the log specifications defined in terms of small end diameter under bark (sedub), while in practice industry transactions are currently based on logs defined in terms of centre diameter under bark (cdub). The log cutting strategy used in MARVL for determining the volume of HQL is a composite of multiple log length sed combinations. For example, a 3.6m log had 38 cm sed (2 cm allowance for taper over half log length from 40 cm cdub). HQL = sum of large high value logs.

LOG SPECIFICATIONS FOR TUMUT CRA SUB-REGION

Product	Acceptable qualities	Value	Minimum SED	Maximum SED	Maximum LED	Minimum length	Maximum length	Acceptable species
Large high value1	AE	52.00	390	1000	2999	2.4	15.4	ALA,BPM,EUR,FAS,MAG,MMT,MTG,NPM
Large high value2	AE	52.00	380	1000	2999	3.6	15.4	ALA,BPM,EUR,FAS,MAG,MMT,MTG,NPM
Large high value3	AE	52.00	370	1000	2999	5.0	15.4	ALA,BPM,EUR,FAS,MAG,MMT,MTG,NPM
Large high value4	AE	52.00	360	1000	2999	7.0	15.4	ALA,BPM,EUR,FAS,MAG,MMT,MTG,NPM
Large high value5	AE	52.00	350	1000	2999	9.0	15.4	ALA,BPM,EUR,FAS,MAG,MMT,MTG,NPM
Large high value6	AE	52.00	340	1000	2999	11.0	15.4	ALA,BPM,EUR,FAS,MAG,MMT,MTG,NPM
Small high value	AE	25.00	200	390	500	2.4	15.4	ALA,BPM,EUR,FAS,MAG,MMT,MTG,NPM
Low value	BAE	12.00	300	700	2999	3.6	15.4	ALA,BPM,EUR,FAS,MAG,MMT,MTG,NPM
Pulp	PBAE	7.50	100	700	2999	3.6	15.4	ALA,BPM,EUR,FAS,MAG,MMT,MTG,NPM,RSB,SBK,SNG

LOG SPECIFICATIONS FOR SOUTH COAST CRA SUB-REGION

Product	Acceptable qualities	Value	Minimum SED	Maximum SED	Maximum LED	Minimum length	Maximum length	Acceptable species
Large high value1	AE	52.00	380	1000	2999	3.6	15.4	ASB,BAN,BBG,BBT,BSB,CBX,FAS,FRG,GBX,GIB,GPM,GYG,IBK,MAG,MDG,MKG,MMT,NPM,RBW,RIB,RMY,RPM,RSB,SBG,SHG,SPG,SPM,STA,TRP,WBT,WHA,WSB,YER,YSB
Large high value2	AE	52.00	375	1000	2999	5.0	15.4	(as above)
Large high value3	AE	52.00	365	1000	2999	7.0	15.4	(as above)
Large high value4	AE	52.00	355	1000	2999	9.0	15.4	(as above)
Large high value5	AE	52.00	345	1000	2999	11.0	15.4	(as above)
Small high value	AE	25.00	250	380	500	3.6	15.4	ASB,BAN,BBG,BBT,BSB,CBX,FAS,FRG,GBX,GIB,GPM,GYG,IBK,MAG,MDG,MKG,MMT,NPM,OCE,PPM,RBW,RIB,RMY,RPM,RSB,SBG,SHG,SPG,SPM,STA,TRP,WBT,WHA,WSB,YER,YSB
Low value	BAE	12.00	300	1000	2999	2.4	15.4	ABX,ASB,BAN,BBG,BBT,BPM,BSB,CBX,FAS,FRG,GBX,GIB,GPM,GYG,IBK,MAG,MDG,MKG,MMT,MTG,NPM,OCE,PPM,RAP,RBW,RIB,RMY,RPM,RSB,SAP,SBG,SHG,SPG,SPM,STA,TBX,TRP,WAT,WBT,WHA,WSB,YER,YSB
Pulp	PBAE	7.50	100	1000	2999	3.0	15.4	ABX,ASB,BBG,BBT,BPM,BSA,BSB,CBX,FAS,GPM,MAG,MDG,MKG,MMG,MMT,MTG,NPM,PPM,RPM,RSB,SBG,SHG,SNG,SPG,SPM,STA,WHA,WSB,YER,YSB

LOG QUALITY CODE DESCRIPTIONS

MARVL Inventory Quality Codes	Product	General Log Grades
A	High value product	quota sawlogs, small graded sawlogs, sleeper logs, veneer logs, larger poles, piles and girders
B	Low value product	salvage sawlogs, non-compulsory logs, small sawlogs
E	Elite wood	Existing or potential veneer, piles, poles, or girders (subset of A quality Code)
P	Pulp	pulp
W	Waste	stump, long butts, dockings

The yield table log product volumes are realisable volumes - the volume which will be harvested and removed from the site. The native forest realisable volume is the merchantable sawlog volume adjusted downwards to account for internal defects and utilisation standards (sub-optimal cross-cutting, breakages, mis-grading) based on a SFNSW defect and utilisation study.

APPENDIX 1.6: UNEVEN-AGED YIELD TABLES FORMAT

UNEVEN-AGED YIELD TABLE FILE 1

Yield Table Name	Output Name (Group)	Layer 1 Attribute Unused	Layer 2 Attribute Unused	Layer 3 Attribute Stratum No.	Layer 4 Attribute Silvicultural Practice	Layer 5 Attribute Management Intensity Group	Layer 6 Attribute Unused	Blank	Management Emphasis Attribute	Management Intensity Attribute	Yield Table Type	Regulated Period	Entry Period	Unique ID No. which links to Yield Table File 2	Regulated Cycle Length (in periods)	Contributes to LTSY (T or F)
Uneven STS S1.1, 0 delay	wood			1	Any	gp_lmn			Stimb	light	uneven	1	1	S1.1	1	T
Uneven STS S1.2, 0 delay	wood			1	Any	grp_mn			Stimb	medium	uneven	1	1	S1.2	1	T
Uneven STS S1.3, 0 delay	wood			1	Any	heavy			Stimb	heavy	uneven	1	1	S1.3	1	T
Uneven AGS S1.4, 0 delay	wood			1	Any	gp_lmn			Gtimb	light	uneven	1	1	S1.4	1	T
Uneven AGS S1.5, 0 delay	wood			1	Any	grp_mn			Gtimb	medium	uneven	1	1	S1.5	1	T
Uneven AGS S1.6, 0 delay	wood			1	Any	ignore			Gtimb	heavy	uneven	1	1	S1.6	1	T
Uneven STS S1.7, 1 delay	wood			1	Any	gp_lmn			Stimb	light	uneven	2	2	S1.7	1	T
Uneven STS S1.8, 1 delay	wood			1	Any	grp_mn			Stimb	medium	uneven	2	2	S1.8	1	T
Uneven STS S1.9, 1 delay	wood			1	Any	heavy			Stimb	heavy	uneven	2	2	S1.9	1	T
Uneven AGS S1.10, 1 delay	wood			1	Any	gp_lmn			Gtimb	light	uneven	2	2	S1.10	1	T

Treatment Types:

Sel-F: For first harvest volume

Sel-L: For all later or subsequent harvest volumes

Selinv: To track the standing inventory volume, before harvest in each time period.

UNEVEN-AGED YIELD TABLE FILE 2

Unique ID Number Which Links to Yield Table File 1	**Activity / Output**	**Treatment Type**	**Qualifier**	**Period of first coefficient**	**Merchantable Yield (m^3/ha) (coefficient)**																			
S1.1	HQ_L_sawlog	Sel-F	Amount	1	5.93																			
S1.1	HQ_L_sawlog	Sel-L	Amount	2	0	0	2.45	2.94	0	3.12	0	13.26	4.06	5.98	6.61	5.13	9.49	3.93	0	3.26	0	4.83	1.83	
S1.1	HQ_L_sawlog	Selinv	Amount	1	6.58	10.75	13.69	16.11	18.64	25.25	30.04	35.77	29.83	31.18	31.31	30.88	30.88	24.79	23.76	26.18	26.59	28.73	26.22	27.81
S1.1	HQ_S_sawlog	Sel-F	Amount	1	1.26																			
S1.1	HQ_S_sawlog	Sel-L	Amount	2	0	0	1.22	0.45	0	0.3	0	1.56	0.7	0.9	1.51	1.15	1.47	0.54	0	0.55	0	0.63	0.42	
S1.1	HQ_S_sawlog	Selinv	Amount	1	20.61	25.56	31.96	34.81	36.29	39.33	37.35	37.08	31.37	29.02	26.21	21.81	19.18	16.73	16.04	16.09	14.17	13.27	12.07	10.71
S1.1	LQ_sawlog	Sel-F	Amount	1	2.22																			
S1.1	LQ_sawlog	Sel-L	Amount	2	0	0	0.99	1.19	0	1.09	0	4.94	1.51	3.19	2.59	4.37	3.78	1.32	0	1.06	0	2.01	3.87	
S1.1	LQ_sawlog	Selinv	Amount	1	8	9.94	12	13.09	14.56	17.47	19.81	23.51	23.17	26.62	27	27.12	25.15	23.98	24.59	27.19	28.56	31.67	31.31	30.46
S1.1	Pulp	Sel-F	Amount	1	3.11																			
S1.1	Pulp	Sel-L	Amount	2	0	0	2.11	1.53	0	1.47	0	6.25	2.07	3.46	3.65	2.67	4.93	1.76	0	1.59	0	2.6	2.62	
S1.1	Pulp	Selinv	Amount	1	45.72	52.87	57.72	56.96	57.57	61.65	62.15	65.09	59.14	58.91	58.41	56.28	56.28	53.41	55.46	58.31	61.07	61.71	60.44	61.21

APPENDIX 2: SOLUTION REPORT CODES

SOLUTION REPORT - CUSTOM ACTIVITIES AND OUTPUTS

Report Name	Activity & Output	Emphasis	Intensity	Report Name	Activity & Output	Emphasis	Intensity
AGH	netarea_ue	gtimb	heavy	PGH	Pulp	gtimb	heavy
AGM	netarea_ue	gtimb	medium	PGM	Pulp	gtimb	medium
AGL	netarea_ue	gtimb	light	PGL	Pulp	gtimb	light
ASH	netarea_ue	stimb	heavy	PSH	Pulp	stimb	heavy
ASM	netarea_ue	stimb	medium	PSM	Pulp	stimb	medium
ASL	netarea_ue	stimb	light	PSL	Pulp	stimb	light
AM1	netarea_ue	mtimb	Mix1	HM1	HQL Sawlog	mtimb	Mix1
AM2	netarea_ue	mtimb	Mix2	HM2	HQL Sawlog	mtimb	Mix2
AM3	netarea_ue	mtimb	Mix3	HM3	HQL Sawlog	mtimb	Mix3
AM4	netarea_ue	mtimb	Mix4	HM4	HQL Sawlog	mtimb	Mix4
AM5	netarea_ue	mtimb	Mix5	HM5	HQL Sawlog	mtimb	Mix5
FWL	HQL Sawlog	all	all	SM1	HQS Sawlog	mtimb	Mix1
FWS	HQS Sawlog	all	all	SM2	HQS Sawlog	mtimb	Mix2
HGH	HQL Sawlog	gtimb	heavy	SM3	HQS Sawlog	Mtimb	Mix3
HGM	HQL Sawlog	gtimb	medium	SM4	HQS Sawlog	Mtimb	Mix4
HGL	HQL Sawlog	gtimb	light	SM5	HQS Sawlog	Mtimb	Mix5
HSH	HQL Sawlog	stimb	heavy	LM1	LQ Sawlog	Mtimb	Mix1
HSM	HQL Sawlog	stimb	medium	LM2	LQ Sawlog	Mtimb	Mix2
HSL	HQL Sawlog	stimb	light	LM3	LQ Sawlog	Mtimb	Mix3
SGH	HQS Sawlog	gtimb	heavy	LM4	LQ Sawlog	Mtimb	Mix4
SGM	HQS Sawlog	gtimb	medium	LM5	LQ Sawlog	Mtimb	Mix5
SGL	HQS Sawlog	gtimb	light	PM1	Pulp	Mtimb	Mix1
SSH	HQS Sawlog	stimb	heavy	PM2	Pulp	Mtimb	Mix2
SSM	HQS Sawlog	stimb	medium	PM3	Pulp	Mtimb	Mix3
SSL	HQS Sawlog	stimb	light	PM4	Pulp	Mtimb	Mix4
LGH	LQ Sawlog	gtimb	heavy	PM5	Pulp	Mtimb	Mix5
LGM	LQ Sawlog	gtimb	medium				
LGL	LQ Sawlog	gtimb	light				
LSH	LQ Sawlog	stimb	heavy				
LSM	LQ Sawlog	stimb	medium				
LSL	LQ Sawlog	stimb	light				

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