

USE OF FRAMES DATA IN OPTIONS DEVELOPMENT FOR EDEN

This paper outlines issues which the Steering Committee and the Options Development Group should consider in relation to the use of FRAMES data for Eden.

The FRAMES Technical Committee (TC) has overseen projects to :

1. review State Forests data on multi-aged forest and regrowth wood resources;
2. develop growth models and other models for the regrowth resource;
3. develop a site productivity index;
4. identify the areas of forest available for harvesting given current constraints;
5. develop a yield simulator and scheduler

Following review of these projects the FRAMES TC has estimated wood flows through time given current land use. The certainty of these estimates varies with time period. The relevant time periods are:

- From 1997 to 2020 estimated yields are drawn primarily from the multi-aged forest (MAF) and have a confidence level of +/- 30%;
- From 2020 to 2040 estimated yields are largely drawn from fire regrowth and thinning of logging regrowth. There is some uncertainty regarding areas and growth models and no confidence limits can be assigned;
- Beyond 2040 estimated yields are drawn primarily from logging regrowth which has not been well sampled. Estimates are indicative only.

An independent review of State Forests' wood resource data, and subsequent investigations, have identified a number of concerns with the data which are expected to be addressed before options development. These generally apply to expected yields for the period 2020 to 2040 and include :

- estimated areas of regrowth and multi-aged forest are being checked against growth-stage mapping and regeneration surveys;
- issues with the mathematical form of growth models require clarification with Dr Bi;

A number of other issues are not likely to be addressed before the Eden RFA will be signed. The issues mainly affect parts of the resource which would only become available for sawlog harvesting beyond around 2040 and include:

- large parts of the regrowth resource (mainly logging regrowth) have not had adequate plot data collected to enable estimation of current stand variables;
- an objective statistical basis for growth predictions for logging regrowth needs to be developed;
- information on the growth of non-silvertop ash dominated forests, (approximately 40% (*State Forests to revise*) of State Forest) is very limited.
- the level of defect in regrowth sawlogs from fire and logging regrowth needs to be better understood;
- thinning and regrowth models may be informed by Victorian information when this can be provided by Victoria.

The FRAMES TC therefore considers that the data available beyond around 2040 is not adequate to define the progressive levels of sawlog yield that are available beyond 2040. (Nonetheless, pessimistic assessments of this long term yield indicate sawlog availability significantly in excess of the calculated yields between 1997 and 2040. The FRAMES TC considers that the data on yields expected between now and 2040 will be adequate to enable RFA decisions to be made.)wording still to be resolved at Technical Committee.

The FRAMES TC is of the view that considerable work on strategic inventory, and development of growth models should be continued by State Forests in the years following the signing of the Eden RFA, and should be a requirement of the RFA. Work should be carried out according to principles to be agreed

by the TC and consistent with the general FRAMES structure used elsewhere in the State. A commitment should be made by State Forests to fund this work.

The attached report details the approach which was taken to developing FRAMES information for Eden, describes the issues and concerns raised by the independent review, and sets out the process for subsequent analyses to address the issues and concerns.

Stuart Davey
Commonwealth co-chair
FRAMES TC

Rex Bowen
State co-chair
FRAMES TC

Eden Woodflow Estimates

Introduction

The purpose of this paper is to describe the wood resource data which is expected to be used in the Eden integration and options development process, to outline FRAMES TC issues and concerns with this data, and to make recommendations on the use of the data in arriving at an RFA for the Eden Region.

In setting out to establish woodflows over time for the Eden RFA region, the FRAMES TC decided in January that there would not be sufficient time to complete a full strategic inventory for Eden, as is being carried out for the rest of the State. In any case, a strategic inventory approach to Eden would have been a very inefficient use of limited resources, given the type of historic yield information available. A review was conducted of all multi-aged forest (MAF) wood resource data,. An inventory, and growth and yield modelling process for the regrowth resource was undertaken, focussing on that part of the regrowth resource which is expected to supply quota sawlogs before 2040.

The FRAMES TC has since developed and overseen projects to :

1. review and describe State Forests data on MAF and regrowth wood resources;
2. document databases*;
3. inventory retained trees;
4. develop growth models for the regrowth resource;
5. develop modifier models (for mortality, recruitment, response to thinning etc)*;
6. develop a site productivity index;
7. identify the areas of forest available for harvesting given current constraints; (net harvestable area);
8. develop a yield simulator and scheduler;
9. assess sawlog species mix for the MAF.

*projects still to be completed.

Projects were developed with the assistance of an independent expert, Dr Jerry Leech. Because the deadline for the Eden RFA has changed a number of times, the scope of the assessment work has changed slightly over time. For example State Forests have continued to measure plots in the regrowth resource, which will continually improve the reliability of yield estimates from regrowth forests.

Independent Review of Wood Resource data (Incoll 1997)

An independent review of State Forests' data for the MAF and regrowth parts of the resource was carried out by Bill Incoll (Independent expert), Oliver Chikumbo (BRS), and Robert Bertram (NCC FRAMES TC member). The reviewers reported that :

1. methodology used to collect data for the multi-aged forests was considered to be appropriate; however a reduction in sawlog yields since 1994 was observed and is of some concern;
2. the regrowth API had successfully identified areas of regrowth on the area for which it was carried out, but had not been successful in stratifying the regrowth according to stand variables ascertained from aerial photos;
3. sampling of the regrowth resource had not been adequate, and plot measurement should continue;
4. some of the mathematical calculations behind the growth models should be checked with Dr Bi.

State Forests is continuing to address these issues with the aim of improving the wood resource data for use in options development. The FRAMES TC decided that these concerns would be addressed by carrying out some further analyses, including a sensitivity analysis.

The review also included a comparison of predicted versus actual yields for the multi-aged forest. This comparison indicated +/-30% confidence limits for yields from the multi-aged forest resource. The

reduction of sawlog yield since 1994 is well within these confidence limits. The limits are currently being refined (see below).

Further Analysis (including sensitivity analysis)

The FRAMES TC met on 17 September to outline further analysis which should be undertaken to address issues raised in the review and issues raised by stakeholders. The following analyses were proposed:

- detailed checking of multi-aged forest resource estimates for Murrah and Bermagui State Forests;
- checking of the areas of multi-aged and regrowth resource against growth stage mapping;
- comparison of the net harvestable area layers produced separately by State Forests and BRS;
- mapping of 1952, 64 and 68 fire regrowth from 1968/69 air photos to more accurately define the areas of regrowth likely to be available for harvest in the 2020 to 2040 period;
- refining the analysis of predicted versus actual yields to refine confidence limits relating to expected yields from the multi-aged forests;
- improving the stratification of the regrowth by including site productivity measures.

A comparison of net harvestable area layers separately developed by BRS and State Forests has been carried out. A 5% difference between the two layers was found. Some further validation of the net harvestable area will be carried out using actual coupe records.

Many of the above analyses are currently being finalised. The results will be viewed by the FRAMES TC and used to validate estimates prior to options development.

remaining results to be inserted by State Forests

There are a number of issues which cannot be addressed before options development:

- large parts of the regrowth resource (mainly logging regrowth) have not had adequate plot data collected to enable estimation of current stand variables;
- an objective statistical basis for growth predictions for logging regrowth needs to be developed;
- information on the growth of non-silvertop ash dominated forests, (approximately 40% (*State Forests to revise*) of State Forest) is very limited.
- the level of defect in regrowth sawlogs from fire and logging regrowth needs to be better understood;
- thinning and regrowth models may be informed by Victorian information when this can be provided by Victoria.

The significance of these issues needs to be placed in context. As is inevitably the case, calculated woodflows for the Eden CRA region become less certain with time. There are three broad time categories, each with their own reliability for volume estimates:

- (1) 1997-2020. Yields during this period are drawn from the MAF. It was assumed that this forest has zero net sawlog growth, an assumption that has been verified by a small scale study. Precision is known for expected yields based on comparisons of predicted and actual sawlog yields over a period of 20 years (1976-1996). The precision averaged $\pm 30\%$ of the mean, although individual years varied from $\pm 20\%$ to $\pm 100\%$. As noted above, a project is underway to refine these confidence limits, which was not complete at the time of writing. It should be noted that Bill Incoll indicated that estimates of this precision are reasonable for a resource of this type. Bill also pointed out that the area of MAF is a crucial variable in the volume calculation. The actual area of uncut forest remaining is not known with certainty, and as is noted above, being validated via comparison with the growth stage mapping.
- (2) 2020-2040. Expected sawlog yields are based on STANDSIM modelling of fire regrowth from wildfires between 1952 and 1980 and sawlog thinning from logging regrowth. Inventory plot measurement has concentrated on this part of the regrowth forest (around 1000 plots). Variations in the sampling methodology, a sampling design which was targeted to particular parts of the resource and lack of documentation of procedures mean that confidence limits cannot be assigned to these estimates. Nonetheless, sensitivity analysis can be used to assign approximate error bounds. Again,

Bill Incoll notes that area estimates have much greater impact on estimated yields than possible errors in inventory data through the sampling system used. Area estimates are being validated through comparison with the growth stage mapping and mapping of the 1952, 1964 and 1968 fires from old photographs.

- (3) Beyond 2040. Expected sawlog yields are not well known because of incomplete inventory data and growth models. To a large extent these forests are regrowth from logging operations dating from the early 1970s. The growth rates applied are based on fire regrowth, and will need to be further developed. Yields can only be taken as indicative, but, by using a pessimistic estimate of growth rates and area, a reasonable assessment can be made as to whether the long term sawlog yield will be any less than the short to medium term yield.

Estimated Yields

Quantification of sustained yield volumes over time can only be calculated with all the available data covering the whole resource with scheduling carried out far enough into the future to show the probable consequences of management actions. Generally this is over a period of one rotation of the forest resource, but normally anything from 50 years (which provides a tangible goal) to 100 years. Beyond 100 years projections have little meaning. Any resulting harvest plan should be subject to review every five to ten years (Ferguson 1996). Not all cumulative effects of management actions can be foreseen but there are definitely some effects that can be projected, based on available data. The frequency and magnitude of losses due to fire are similarly unquantified but must be part of a risk assessment.

Current calculations show a yield of around 28 500 m³/yr of quota sawlog to the year 2020, which largely consists of multi-aged forest. From 2020 to 2040 calculations indicate that the older fire regrowth (largely from silvertop ash dominated forest types) and thinnings from logging regrowth, are likely to provide quota sawlog yields that will cover the period from 2020-2040 at approximately 28,500m³/yr. It is difficult to furnish the expected yield with precision limits, but rather a sensitivity analysis process will define *best* and *worst* scenarios about the expected yield. The potential risk of fire affecting the regrowth resource is unknown, but is of concern, as this regrowth is located in a fire prone area. Work is underway using NPWS fire history data to determine how best to consider such risk.

Beyond 2040, yield estimates are based on limited plot data. However, estimates of quota sawlog yields (exclusive of fire risk) are expected to be higher than estimated yields for the earlier periods. It is important that inventory work continues to cover this part of the resource to refine the yield estimates.

Other Issues

Conservation representatives on the FRAMES TC have raised a series of concerns with the process and the project progress, as follows:

- concern that only limited information has been provided to FRAMES TC members on the progress of projects, and particularly on the methodology and locations of continuing regrowth plot measurements;
- concern that reports are not yet available reporting project outcomes;
- unrealistic timelines compromise effective and comprehensive assessment of data (this point was also supported by industry representatives).

As with many parts of the process the timeframe has necessitated the completion of datasets, as a first priority and completion of reports as a second priority. It is expected that CRA project reports on the methodology and results from the FRAMES projects for Eden will be available in October.

Issues to be addressed post RFA

During the independent review for the Eden wood resources data it was clear that a particular problem with evaluating the regrowth resource inventory data was the lack of documentation on methodology for both the API stratification and the methods used in the plot measurements. The field methods manual available was not sufficiently detailed for specific tasks. The continual inventory in Eden needs to be clearly documented and provide: (Wood 1988):

- (a) a list of objectives;

- (b) use of aerial photography or other remote sensing technique (to secure accurate area information and preliminary estimates for forest composition);
- (c) forest classification (to permit the subdivision of a heterogeneous forest into smaller, easily comprehensible and more homogenous units for modelling);
- (d) maps and mapping (for planning surveys, ground sampling etc);
- (e) sampling design (which should yield the desired information within specified limits of error);
- (f) field measurement procedures;
- (g) quantity relationships (transformation of measurements made in the course of the inventory into terms of quantity of timber);
- (h) personnel and training (organisation and selection of personnel);
- (i) calculations (methods including statistical procedures for treatment of inventory data);
- (j) referred statistical methods by which the degree of confidence which can be placed in the estimates can be objectively shown.

The above information would make it possible to audit the data and help in generating trust from stakeholders in the reliability of sustained yield calculations. There is a strong indication from conservation NGO's that the authority for the overseeing of a continuing inventory should be vested with an independent body. State Forests and other FRAMES TC members consider that inventory is a core State Forests' function and responsibility that should be reviewed by a Committee such as the FRAMES TC. State Forests should develop an inventory plan with the assistance of an independent consultant, that is consistent with the project proposals in place for FRAMES projects for other parts of the State and is reviewed by the FRAMES TC. A commitment to undertake this task including establishment of broad principles for the inventory, a commitment to funding and stakeholder review mechanisms should be in place before the RFA is signed.

Concerns for Consideration in relation to the RFA

Taking into account the concerns described above, the following recommendations are made for Steering Committee endorsement:

1. The FRAMES TC should develop principles for a continuous inventory plan to be designed by State Forests with the assistance of an independent expert. The inventory should cover the regrowth and MAF resource and be overseen by the FRAMES TC, or a similar group including stakeholders. Initial results of this inventory should be reviewed by this group within 2 years of the signing of the Eden RFA.
2. While identifying that industry needs certainty during the RFA period, it is crucial to have additional data to enhance confidence in sustained yield calculations. The basis for sustained yield calculations should be further developed in the period leading up to the first 5 yearly review of the RFA, using improved inventory information.
3. Each 5 yearly RFA review should include a detailed, objective and transparent review of wood flows and sustained yield calculations based on the results of the continuous inventory.
4. The Steering Committee should consider the need for some conservatism to be built into wood supply commitments arising from the yield estimates to take into account the precision of estimates and the risk of fire.
5. The regrowth which will provide yields between 2020 and 2040 are extremely vulnerable to wildfire. Fire protection of the regrowth forest should be afforded a high priority in the RFA.
6. The Steering Committee should note that the term "sustained yield" only refers to wood flows and not necessarily the wider concept of "sustainable yield". The sustained yield needs to be constrained through applying ESFM considerations.

APPENDIX Summary of Methodologies

The central focus of the FRAMES TC has been the calculation of sawlog and pulpwood yields from the Eden Management Area based on the wood resources data and the concerns that surround the calculation. Timber output estimates are characterised by a process that requires a description of:

1. the productive forested area;
2. estimates of volumes and other variables of standing trees; and
3. estimates of growth rates.

This information is used to simulate future events in the forest. That is to project forward the growth of the forests, the likely volumes which could be harvested, and to predict how they might be scheduled for harvesting over the long term to provide woodflows on an annual basis. Part of the exercise is to examine the effects of different silvicultural approaches. (Silvicultural prescriptions are still to be defined by the ESFM Technical Committee). The effects of various harvesting prescriptions, for example buffer strip widths, will also be able to be modelled.

Eden forested area (Net Harvestable Area Project)

To determine the available volume through time, one of the important parameters is area available for harvesting. This is being undertaken by BRS as the net harvestable area project. The area statement falls into two categories i.e. the multi-aged forest (MAF) and regrowth areas. The net harvestable area is being derived from GIS layers by considering:

- (a) slope exclusions;
- (b) non-harvest areas (eg rainforest, swamp, rock etc);
- (c) management exclusions (eg visual retention, wildlife corridors and reserves); and
- (d) streamside protection to current EPA prescriptions.

This information is overlaid on the management unit layer to produce a table of compartment and coupe identification against gross and net available area. A similar process is being undertaken to determine the area information for the regrowth forest but with different slope specifications (to take account of operational thinning constraints). The predicted net harvestable area calculations are still to be validated against a sample of harvested compartments with actual net harvestable area determined from digitised aerial photographs.

In addition a validation of the overall gross area of MAF and regrowth forest is being undertaken using growth stage mapping to determine how well the area of regrowth identified by API matches the historical records of logging areas.

Estimates of volume and other stand variables (Review of Wood Resource Data Project and Yield Estimator and Scheduler Project)

(a) Multi-aged Forest

Current standing volumes have been estimated by analysing actual yields per hectare from logged coupes, and applying these yields to the adjacent multi-aged forest. This process is facilitated by the adjacent coupe system of harvesting which is applied to the Eden forest resource. The multi-aged forest is assumed not to be growing, and therefore no yield simulation or growth modelling is required in relation to this part of the resource.

In his independent review of the data, Bill Incoll noted that this methodology was appropriate, however there was an observed reduction in yields since 1994 which is of some concern. This reduction could have a number of causes, including logged coupes not being representative of adjacent unlogged coupes, disturbance history and changes in prescriptions over time. It is difficult to quantify these causes.

(b) Regrowth

Information on the regrowth resource has been developed from plots measured over a period of time. Plot measurements were originally established to identify resource suitable for thinning, and are

concentrated in older regrowth areas, particularly in 1952 fire regrowth. The regrowth forest has been divided into strata on the basis of type of regrowth (logging or fire), age classes, basal area, and site productivity with diameter distributions available only for a proportion of plots. The numbers of plots in each strata are shown on table x. *SF TO FILL IN*

To determine yield for regrowth, a simulator is required with the capability of growing a diameter distribution, harvesting a diameter distribution into sawlog and pulpwood products at the specified harvest age, and a scheduler capable of scheduling compartments at the optimal time while producing similar annual yields.

Given the current time lines, the Victorian STANDSIM DSS was adopted as a simulator. Eden growth and yield models were incorporated into STANDSIM and simulations were run to provide quantitative yield estimates for scheduling. Reliability can only be guaranteed if there is independent data for validation. Mr. Bill Incoll has revised the models provided by SFNSW for use in STANDSIM and has completed a validation with independent data from a restricted resource area. STANDSIM is a time-based, non-stochastic empirical DSS for simulating in considerable detail the growth for even-aged regrowth stands of *E. regnans*, *E. delegatensis* and *E. sieberi*. The model simulates stand growth from any nominated age, diameter distribution and site index. The Eden fire regrowth is here assumed to be single-aged stands. The realism of this assumption, or the accuracy with which STANDSIM models mixed stands is not known. Information being provided by Victoria will be used to validate and modify models if necessary. This information will be useful in improving the precision of the thinning responses. The following thinning regimes are being applied in STANDSIM to the Eden forests:

State Forests to fill in

For each of the strata, a yield table has been developed through running STANDSIM for use in the scheduling exercise. Plot measurements are continuing in regrowth to refine the stratification and validate the yield tables of the different strata with independent data. The scheduler was developed on a the database MS-Access which enables basic rules to be modelled fairly easily. The SF 'CRICKET' database of management history and resource data resides in ACCESS which means a seamless link of the scheduler to data fields for the predicted yield tables of the multi-aged and regrowth forests. However, given the crucial nature of the problem of identifying the time when regrowth sawlog becomes available and the level of harvest that can be sustained over long periods of time, an ideal situation would be to develop different management prescriptions for the regrowth component. It is possible that the use of SPECTRUM by the ESFM TC can inform this issue, but its capacity to do so has not been demonstrated.

Estimates of growth (Growth Modelling and Modifier Model Projects)

There is still more work to be carried out in this area with regard to the philosophy behind some of the modelling approaches and validation with independent Victorian data of the models. Models do not exist for forest types which are not associated with *E. sieberi* (Silvertop ash) or *E. fastigata* (Brown barrel). Models are therefore not available for approximately 40% of the resource. It is anticipated that use of the existing models in association with a site productivity index for stands which are not associated with *E. sieberi* or *E. fastigata* will produce a conservative estimate of growth. *S Davey to confirm with Bill Incoll*

Literature cited

Ferguson, I.S. (1996) Sustainable Forest Management. Oxford University Press, Melbourne, Australia.

Incoll, W. (1997) Validation of the Eden Wood resources Data.

Wood, G. (1988) Forest Measurement II; Course Manual. Australian National University, Dept. of Forestry, Canberra.