VALIDATION OF EDEN WOOD RESOURCES DATA

Carried out for RACAC and State Forests of NSW

by
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SUMMARY

A review of the procedures used in the estimation of wood resources in the Eden Management Area was carried out under three main categories; the multi-aged forest, the regrowth forest and the preparation of growth models for the regrowth forest. The Terms of Reference for the work are listed in Attachment 1 and the work was carried out at Eden between 4th and 15th August 1997. Discussions with State Forests staff were open and consultative throughout. The following conclusions were reached.

Multi-aged forest

1. The methods used to assess utilisable volumes in MAF are appropriate for these variable forests.

2. Notwithstanding conclusion (1), the reasons for recent reduction in utilisable volumes per hectare need to be investigated urgently, because they could have a significant impact on the estimation of sustainable yield.

Regrowth forest

3. The API stratification used was unsuccessful in achieving its objective of providing useful stem stocking and stand mean diameter information. It did however successfully delineate boundaries for the part of the regrowth resource where it was applied.

4. Simplified API methods, that may be able to use existing photography, should be developed and applied to the whole of the resource to accurately determine the area available.

5. Changes in objectives and methodology during the course of the inventory have detracted from the usefulness of the plot measurements carried out in regrowth stands.

6. Inventory work needs to continue, aimed at sampling the full range of stands in the resource. Measurement procedures need to be clearly documented. It is essential to resume the measurement of tree diameters.

Regrowth growth modelling

7. The general approach is appropriate, aiming at the construction of single tree models. However, some concerns relating to some functions and the use of detailed individual tree growth ring measurements need to be clarified.

INTRODUCTION

This work was carried out between the 4th and 15th August 1997, under Terms of Reference listed in Attachment 1. The following people greatly assisted the work through discussion and provision of information. The assistance of other departmental staff Eden is also gratefully acknowledged.

Robert Bertram, South East Conservation Council
Mark Blecher, South East Conservation Council
Bob Bridges, Regional Planning Officer, State Forests of NSW
Mike Bullen, District Forester, Eden, State Forests of NSW
Oliver Chikumbo, Bureau of Resource Science
Vic Jurskis, Research Manager, State Forests of NSW
Joe O'Gara, Planning Officer, Eden, State Forests of NSW
Bob Wilcox, Photo interpreter, State Forests of NSW

1. INVENTORY OF THE MULTI-AGED FOREST (MAF)

Methodology used

A significant problem with evaluating the methodology was the lack of documentation on techniques at the time when the inventory was planned and executed. The following description of methods was obtained by discussion with staff at Eden.

Compartment boundaries for the Eden Management Area (EMA) were delineated in the early 1970s, and coupe boundaries were determined for all productive forest in 1977 They were revised to comply with Preferred Management Priorities (PMPs) in 1981.

The assessment of the MAF currently used for the Area was carried out in 1987. At this time, the EMA included three Districts. This division of responsibility resulted in differences in approach and contributed to a lack of adequate documentation.

The merchantable volumes of both sawlog and pulpwood available on all uncut coupes were estimated in the 1987 assessment by comparison with actual yields from the neighboring utilised coupe. A cruise of the uncut coupe was carried out by an experienced supervisor to confirm or modify the estimate that had been based on utilisation yield. Where yield information from a utilised coupe was not available to assist estimation, an estimate was made from cruising alone. In work since, the estimated yields for unpaired coupes have been amended as utilisation data became available.

In operations up to about 1985, selective logging was carried out in some (a total of 198 out of the 3076 coupes cut at that time) adjacent uncut coupes to supplement yields from integrated logging. Adjustment for this reduction in yield was made during the cruise of the uncut coupe.

The information obtained was stored in a Dbase III+ coded database, since updated to the current Access coded 'Cricket' database.

Comments

The method has the advantages that it is cheap, requiring minimal field work compared with a traditional plot-based inventory, and is directly associated with the real world, through comparison with actual utilisation of the neighboring coupe. The disadvantages are that the method assumes the same products will be removed, using the same technology and in the same conditions of market demand, as the first coupe, all conditions that may have considerable influence on the yields obtained. The considerable time separation between the two operations (up to fourteen years) accentuates these disadvantages.

The method also depends heavily on the presence of an adjoining utilised coupe for reference purposes. When a nearby coupe is not available. the method becomes just another cruise estimate.

A further disadvantage is the requirement that the cruise be carried out by a person, usually a logging supervisor, who must have sufficient experience to make a reliable estimate of merchantable volumes in the highly variable forests concerned.

The reliability of the data has been assessed using a comparison of the predicted and actual yields per hectare obtained using the method over a long time period, shown in Figure 1 for sawlog and Figure 2 for pulpwood. For the period between about 1977 and 1994, there is a consistent relationship, particularly for sawlog volumes, of underestimation. For that period, sawlog volume was underestimated by 8% and pulpwood volumes by 22%. However, from 1994, the relationship appears to break down, with sawlog yields dropping to about the same level as predictions and pulpwood production also dropping substantially. A range of theories have been proposed for these changes including increases in stream buffer width, the beginning of utilisation in the uncut coupes of alternate coupes (which are the very small coupes of the late 1970s), changes in market conditions etc. However, there is no way to determine which if any of these alternatives is the real reason for the change.

While the graphs of mean yield per hectare for the many coupes (about 50) utilised per year shown in Figures 1 and 2 are relatively smooth and level, they represent relatively consistent means that have large variations. Confidence limits (95%) have been calculated for the actual and estimated yields and they are shown as vertical error bars on Figures 1 and 2. They indicate that the sawlog estimates were significantly different in only one year (1982) and that pulpwood yields were significantly greater than estimated for five years (1982-93). The confidence range in most years was around 30% of the mean, although individual years varied from 20% to 100%. These results are good for forests of this type.

Alternatives to the above method

Plot based inventories can be used to estimate potential yields in similar irregular forests. One approach is the traditional one using either fixed area or variable probability estimates that measure samples comprising the sections of standing trees judged to contain merchantable products according to current specifications. The assessments provide estimates of merchantable yields per hectare usually for strata that may be defined using air photos or some similar appropriate means. An assessment of this type would be substantially more expensive to carry out than the current technique and would take a long time to apply to the large resource area involved. While some useful extra information may be obtained about such things as species mixtures and presence/absence/volumes of regrowth material, they may not in fact produce more precise estimates of the most important variable - merchantable yields of products. This is primarily because they are attempting to measure a population that is highly variable. Larger samples cannot increase the precision of the mean any more than the level implied by the variance of the population - and that may be at least 50% of the mean.

Another approach is that adopted by the early 1990s Jarrah assessment in West Australia and the Victorian SFRI; measurement of dimensions of trees and location of defects on trees, followed by office based analysis to ascribe parts of trees to products whose specifications can be varied at will. Thus this methodology will (at significant extra cost in work involved) avoid the problem of assuming current technology, and it may improve the ability to model the high variability of internal defect in the log sized trees of multi-aged regrowth.

Conclusion

Given that the alternative methods available may produce some extra benefits, but at significant extra cost, without appreciably improving the precision of estimates of merchantable yields, the current method is considered to be an appropriate way to estimate wood volumes in the multi-aged forest concerned.

However, attention needs to be directed towards finding the reasons why the yields obtained since 1994 have been less than those in previous years. If the yields continue to be low, there may be a need to refine the existing predictions. A reliable estimate of the remaining utilisable volume in the MAF is a crucial requirement in estimating the sustainable yield for the Regional Forest Agreement.

Cruising estimates made in future could be improved by the application of simple basal area count methods that allocate count trees to categories such as regrowth, advance regrowth, overwood trees and merchantability classes. The methodology for these surveys needs to be developed, tested and documented before widespread application.

INVENTORY OF THE REGROWTH FOREST

A major problem with evaluating the regrowth inventory was the lack of documentation on methodology for both the API stratification and the methods used in plot measurement. An outline of the proposed work dated August 1993 was examined. This provided general instructions only; it did not, for example, describe procedures for selecting which stands of regrowth should be sampled and how plots should be located in the stands. Guidance as to methods was also obtained from the State Forests Field Methods Manual. While this document is excellent for basic methodology, it does not provide sufficient detail for specific tasks such as this inventory. The following description of methods was obtained by discussion with staff at Eden.

Objectives

As given in the August 1993 outline:

- To measure the volume of regrowth available for thinning, and the volumes of sawlog and potential sawlog available in each stratum, in order to determine the priority of regrowth stands for thinning.

- To determine whether enough thinning resource exists to sustain another tree harvester in Southern region.

An unstated objective that has become more important since 1993 and is implied by projects within the current RFA process is the need for information to calculate a reliable sustainable yield for the resource as a whole.

Aerial photo interpretation (API) was used to locate and delineate boundaries of regrowth. Judging from the strata chosen (categories of number of stems/ha, stand mean diameter, mature tree density and shrub density), it was expected that some stand data could also be obtained from API. Plot measurements were carried out both before and after the strata were delineated.

Selecting stands for sampling

Colour aerial photographs (1:15,000 scale) taken in 1993, were available for the southern part of the EMA. Two different techniques were used to select stands for plot sampling; one technique used before the API stratification of the resource was complete and a different technique subsequent to that.

The first technique concentrated sampling effort into regrowth known to be the oldest available in the eastern part of the EMA, because, as specified in the 1994 EIS, these would be the first stands to be thinned. Maps showing the regrowth in the nominated compartments were prepared from the 1993 airphotos and the sampling crew was directed to sample these stands.

When the API stratification became available, the plots measured to date were allocated to the API strata and sampling effort was then directed to strata that had not been sampled or where the coefficient of variation of mean total stand volume was greater than 30% of the mean.

Plot measurement procedure

The measurement crew walked through the patch of regrowth selected to gain an appreciation of the variability involved. The crew then established plots to represent the patch, with a minimum number of two plots per patch. No instructions were given as to how they were to adequately cover the variation involved or what the maximum number of plots per patch should be. Examination of maps recording the estimated location of plots showed that they were established at approximately 100-200m intervals.

Having selected a sample point, basal area gauges were used to select 'in' trees and the diameters of the 'in' trees were measured. A gauge of either 1, 2, or 4 m^2/ha factor was selected to provide a total tree count between 10 and 20 trees per plot. 'In' trees were categorised as either 'retain' or 'remove' for the regrowth component of the stand, or 'overwood' or 'unmerchantable species'. The bole height was estimated for typical codominant trees near the sample point.

These instructions were changed when it was recognised that mean dominant height, not bole height, was required to estimate the stand productivity index. Mean dominant height was estimated from the average height of the two tallest regrowth trees within the 'plot' created by the location of 'in' trees. Mean dominant heights were estimated for plots that had been measured by revisiting those measured within the last twelve months. For those measured prior to this, mean dominant heights were estimated using Dr Bi's relationship between tree diameter and tree height.

Analysis

The measurement data were stored in Access tables for analysis as required.

Comments

API stratification

The inclusion of stand variables into the API stratification provides the opportunity to derive estimates of area for the different strata directly. However, if in fact the strata cannot be effectively separated using API, then a significant amount of work will have been done with no useful result. The separation of strata was examined (during this review), by comparing mean stand variables obtained from plot measurements within the designated strata. Table 1 gives the results of this comparison.

The table shows that the stem stocking results in all strata except one (4a), were outside the nominated target ranges and that the mean values are mostly not significantly different (the confidence ranges overlap). For mean diameter, six out of eight sample mean diameters fell outside the target ranges and only one mean, in the la stratum, was different from the other ranges in the same stocking class. While retrieval of useful data may be possible through pooling of some categories, the API stratification can only be regarded as unsatisfactory in providing useful stand data. It does however effectively delineate the boundaries of regrowth stands.

An alternative approach would be to select simpler API categories that were demonstrably able to be delineated successfully. This will achieve the main task of API - deriving a reliable estimate of location and area with a simple subdivision into density categories. Stand variables can then be estimated using plot measurements. Using simpler API strata may also make possible the use of smaller scale airphotos, that may provide complete coverage of the area of interest without the delay involved in new photography.

Table 1. Comparison of designated strata with mean stand variables of plots established in the strata.

Stratum	Number of samples	Target stocking range stems/ha	Sample results stems ha	Target mean diameter range (cm)	Sample results mean diameter (cm)	Mean total volume (m^3/ha)
1a	2	<400	1205±340	0-15	18.1±0.1	139±0.6
1b	9	<400	1016±497	15-25	23.0±2.0	138±43.4
1c	10	<400	1128±722	25-40	24.2±3.1	266±45.5
2a	16	401-900	1924±1720	0-15	19.1±1.3	176±66.1
2b	165	401-900	1639±214	15-25	20.2±0.5	291±43.0
2c	13	401-900	1192±679	25-40	22.0±1.8	220±41.0
3a	37	901-1800	1990±537	0-15	18.0±0.7	287±41.0
3b	79	901-1800	1863±260	15-25	18.9±0.6	306±33.3
4a	28	>1800	1595±204	0-15	18.1±0.4	259±29.5

Plot measurement techniques

Matters for concern are listed below.

l . The lack of a documented plot measurement technique is a significant omission that can result in unreliable inventory results. For example:

- The selection of stands for measurement is open to bias if there is no objective methodology for sampling all regrowth stands,
- The method used to deal with gaps that are encountered within areas of regrowth needs to be specified and consistently applied to avoid significant variation in results.

- The lack of documentation can lead to uncertainty among measurement crews as to correct methodology, difficulty in passing on techniques to new staff, difficulty in monitoring measurement standards and difficulty in demonstrating to State Forests executives and outside interests that data collection is scientifically based with consistent quality control.

2. In collection of plot data, different techniques have been used at different times, resulting in the following sets of plot data.

- Plots where diameters of 'in' trees and bole heights of dominant trees were measured (202 plots). Subsequently, mean dominant heights were measured by returning to the plots. These plots are acceptable samples.

- Plots where diameters of 'in' trees and bole heights of dominant trees were measured (366 plots). Subsequently, mean dominant heights were estimated using Dr Bi's diameter/height model. These plots may not be acceptable samples because of possible bias in the height/diameter model (see later). Methodology used in constructing the model needs to be clarified to accept or reject the samples.

- Plots where 'in' trees were counted and top heights were measured, but diameters were not measured (286 plots). The decision not to measure diameters was taken to speed up collection of data - at the time it was believed that basal area and top height data would be sufficient to estimate future stand development. These plots do not provide the data about diameter distributions that is now recognised as necessary and the data should be obtained either by re-visiting the plots or by discarding the plots and establishing new ones.

Plot measurement techniques can be improved in the following ways.

- The gauge factors currently used are selected by the measurement teams in the field. This is an inappropriate practice, while gauge factor can be varied between different strata to achieve efficient sampling, the same factor gauge must be used within strata. The appropriate gauge to use needs to be determined by trial survey and then used consistently. In addition, the gauge factors used have been too low, leading to average counts per sample between 10 and 20 and a loss of efficiency in the rate of plot establishment. The recommended average count is between 7 and 12.

- Selection of mean dominant height trees is currently done within the 'plot'. In different stands, with different gauge factors being used, the 'plot' size will vary, resulting in a different number of tallest trees per hectare being measured. The proper technique is to measure the height trees within a constant radius of the sample point, regardless of gauge factor. To select the 50 tallest trees per hectare this radius should be 6.3m.

- Collection of resource data for regrowth stands needs to be a continuing task that merits proper design, testing and documentation. It is essential that appropriate documentation should be prepared.

Effectiveness of the plot sampling scheme is representing the resource

The resource includes a range of different forest types, age classes, productivity classes, types of regrowth origin and geographic locations. An appropriate sampling scheme must efficiently sample the variation in each of these categories. There has been no formal consideration of these requirements, sampling has been directed towards the older stands because it is recognised that information is most urgently required for these stands, since these will be available for utilisation first.

An indicative examination of the coverage of the resource by the current set of regrowth plots was carried out using maps of forest type, date of coupe utilisation and plot location (Figures 3 to 5 respectively). The compartments sampled to date are indicated on Figure 3, shaded red. The samples cover the limits of geographic spread of the resource. However, there are gaps in the coverage within these limits, for example, in Yambulla, Nullica, State Forests. Forest types in the resource include Dry Shrubby, Dry Grass, Moist and Intermediate Shrubby (Figure 3). Dry Shrubby, dominated by *E. sieberi*, covers the largest area, occurring in the south east of the EMA and including the majority of plots established so far. Moist forest occurs in the northwest of the EMA and includes the next largest number of plots. Dry Grass forest occurs in the south west of the EMA and contains only a few plots.

Figure 4, indicating regrowth age, shows when compared with Figure 5, that stands logged between 1980 and 1990 are not well represented by sample plots. This, and other gaps in representation, should be corrected by the continuing measurement of sample plots.

The site productivity layer is not yet available and distribution of plots within it cannot be determined.

The number of plots by categories of regrowth type and time since logging (assumed equal to age) are given in Table 2.

Table 2. Numbers of regrowth plots in different types and ages of regrowth

Type of regrowth	Regrowth age	Number of plots
Fire	14	5
Fire	17	75
Fire	29	94
Fire	45	262
Fire	58	3
Logging	10	3
Logging	11	3

Logging	14	24
Logging	15	52
Logging	16	12
Logging	17	21
Logging	18	26
Logging	19	37
Logging	20	137
Logging	21	16
Logging	22	19
Logging	23	7
Logging	24	7
Logging	26	12
Logging	32	10

Table 2 indicates a majority of plots in the fire regrowth, in accord with the expressed priority to gather data in those stands first. Future sampling should redress this imbalance, since all stands will eventually take part in production and this must be considered in the calculation of sustainable yield. The distribution of regrowth plots to stands needs to be done in proportion to resource area, with some modification if necessary to achieve similar precision for measurements in different strata. This allocation of plots to strata cannot be done until a detailed area statement for the regrowth resource has been prepared. It is currently assumed that, because regeneration is usually successful, logged area is equal to new regrowth area. This may or may not be an accurate assumption.

Quality of baseline inventory information provided by the regrowth inventory

In this context, 'baseline inventory information' is interpreted to mean data that is necessary for predicting the development of regrowth and estimating merchantable outturn from it for a minimum of one rotation. This will provide data to determine how long the MAF resource needs to last before production from the resource can be reliably provided from regrowth stands.

To meet this criteria, inventory plots need to be established in appropriate strata, as described above, and the plot measurement techniques need to provide appropriate and reliable data.

It is difficult to quantify the effect on data reliability that the shortcomings outlined above will cause. Because the methodology has not been clearly specified, operators have the latitude to develop their own techniques that may or may not be appropriate (it is not suggested that they have, merely that it is unknown). An assessment carried out with trialed and documented methods will have greater precision, but it is impossible to say how much greater. With the qualifications expressed above, subsets of the existing data set are suitable for use, provided they are supplemented with new data that is representative of currently unsampled strata. The existing data can be reallocated to any new API stratification that is developed for the resource as a whole.

GROWTH MODEL DEVELOPMENT

Quality and integrity of growth plot data used

The data available for growth model development for the coastal forests include the following.

- Mumbulla spacing trial, established in good quality 1964 *E. sieberi* fire regrowth near Bega in 1968.

- A commercial thinning trial in 1952 *E. sieberi* fire regrowth in East Boyd SF, established in 1977.

- The Edrom Rd thinning/fertiliser trial in 1952 *E. sieberi* fire regrowth, established in 1988.

- Thinning plots in 1939 *E. sieberi* fire regrowth, established in the Bruces Ck SF in 1970.

- Thinning plots in 1952 *E. sieberi* fire regrowth, established near the Old Edrom Rd/Princes Highway junction (East Boyd SF) in 1969.

- Some 29 permanent plots in logging regrowth across ages from 16 to 26 years in the Nadgee, East Boyd, Timbillica, Yambulla and Yurramie State Forests.

- An extensive set of temporary plots established in Tablelands forests (Glenbog SF).

Briskin and Horne (1990) reported that there were data available from 28 experiments (394 plots) that provided information about fire and logging regrowth and thinning response in fire regrowth. In subsequent discussion however, they reported that wildfires had affected many plots, making them unusable, and that measurements of many plots had been irregular and incomplete. Data from only 132 plots were used 'during some portion of the analysis' and only 18 fire regrowth plots were useable for defining diameter growth functions. They did not provide a breakdown of the data into groups of regrowth origin.

This set of permanent plot data gives a reasonable coverage of age and thinning response in fire regrowth stands and of age in logging regrowth stands. While permanent plot data is the best for testing and evaluating growth models in specific situations, it is very expensive and time consuming to obtain. Information about growth can be obtained using growth ring measurements on temporary plots and because this data can be gathered much more cheaply, and does not require the wait for data involved with permanent plots, a much more representative sample of the resource can be obtained. The current situation of using both types of data should be continued.

Data screening procedures

The screening process used was discussed with Dr Bi, who indicated that the following checks were used.

- checks for individual trees missing from measurements through time,

- scatterplot examination (scatterplots direct attention to outliers from groups of data, which can then be checked in detail) of diameter and height measurements, growth of individual trees, growth within dominance classes and tree size for nominated age, all for trees on individual plots.

- Scatterplots were also used to examine stand density relationships with age.

- Problems were encountered with previous data conversions from imperial to metric and from one storage system to another. These problems were resolved by referring back to original field measurements.

These checks are considered to be adequate to produce a data set as free of measurement inconsistencies as practicable.

General approach in growth model development

The South East Regrowth Forest Growth and Yield Modelling Project was initiated in 1991 and the growth models produced so far are listed as follows.

1. Single tree volume functions for a range of tablelands and coastal species.
2. Taper functions predicting stem diameter at any height on the tree stem.
3. Tree height as a function of tree diameter for a range of species in tablelands and coastal forests.
4. Maximum tree height/age functions for tablelands forests.
5. Maximum tree height/age functions for coastal forests.
6. Total stocking as a function of age and overwood stocking for tablelands forests.
7. Stocking of upper canopy trees as a function of age, overwood stocking and site productivity index for coastal forests.
8. Stand volume as a function of age, site productivity index, overwood stocking, and regrowth stocking for tablelands forests.
9. Stand volume as a function of age, site productivity index, overwood stocking, and regrowth stocking for coastal forests.
10. Stand basal area as a function of age, site productivity index and overwood stocking.
11. Current annual increment of stand volume as a function of age, site productivity index and overwood stocking for tablelands forests.
12. Relationships between under and overbark DBH measurements

Functions 4, 6, 8, 11 have been published in the scientific literature, some have appeared in State Forests Research Papers and the remainder in draft papers for the information of potential users. The work done has not been examined exhaustively because much of it is in draft form, but in the course of the review, some concerns have arisen, listed as follows.

- In Bi and Jurskis (1997), (function 4) the proposals for the estimation of site productivity index appear to include some inconsistencies. Further discussions with Dr Bi will be necessary to clarify these matters.

- Similarly, the methodology given in the draft report for the height diameter functions (#3) needs clarification.

- When the height age function given for coastal species (#4) is plotted on the same axes as the tablelands function (#5), it is evident that coastal forests are expected to be taller at some ages than tablelands species. Again, the methodology needs to be clarified.

- The proposals for tree ring analysis outlined in Bi (1994) do not indicate how the ring measurements will be used to synthesise the dynamics of the stands concerned. Because the trees studied are the survivors of competition to that date, (trees that died in the past being unavailable for study) they can only be synthesised into a stand at the time of measurement or for some short period, say five to ten years, prior to that. Given this situation, it would be simpler to take ring measurements for the last five years only, and sample stands to cover a range of ages, stand densities and site productivities. Such short term measurements could be taken using increment borers, at substantially lower cost than the destructive sampling proposed.

With these reservations, the general approach indicated in the Future Directions section of Bi (1994) is considered to be appropriate and logical. Item 10, the construction of single tree models, is particularly appropriate for the mixed species and variable density stands involved. Such models will be the only way to predict the behaviour of stands containing a mixture of age classes, or those treated by methods such as strip thinning or heavy early non commercial thinning.

Benchmarking tests and short term reality checking

These techniques are appropriate ways to test models for the resource in question, where the amount of permanent plot data for testing is limited. The use of data from outside the EMA resource is not recommended, because it can always be questioned on this basis. For this reason, outside data could only be useful to indicate general trends.

CONCLUSIONS

Multi-aged forest

1. The methods used to assess utilisable volumes in MAF are appropriate for these variable forests.

2. Notwithstanding conclusion (1), the reasons for recent reduction in utilisable volumes per hectare need to be investigated urgently because they could have a significant impact on the estimation of sustainable yield.

Regrowth forest

3. The API stratification used was unsuccessful in achieving its objective of providing useful stem stocking and stand mean diameter information. It did however successfully delineate boundaries of the part of the regrowth resource where it was applied.

4. Simplified API methods, that may be able to use existing photography, should be developed and applied to the whole of the resource to accurately define the area available.

5. Changes in objectives and methodology during the course of the inventory have detracted from the usefulness of the plot measurements carried out in regrowth stands.

6. Inventory work needs to continue, aimed at sampling the full range of stands in the resource. Measurement procedures need to be clearly documented. It is essential to resume the measurement of tree diameters.

Regrowth growth modelling

7. The general approach is appropriate, aiming at the construction of single tree models. However, some concerns relating to some functions and the use of detailed individual tree growth ring measurements need to be clarified.

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Bi Huiquan 1994. South-East Regrowth Forest Growth and Yield Modelling: Design, Methods and Progress. Research Paper 24, State Forests of NSW.

Briskin S and Horne R 1990. An Analysis of Growth Data from Eucalypt Stands in the Coastal Forest of the Eden Region. Technical Paper 53, State Forests of NSW.

Bi Huiquan and Jurskis V 1997. Yield equations for irregular regrowth forests of *Eucalyptus fastigata* on the south-east tablelands of New South Wales. Australian Forestry 59 (3), 151 - 160.

ATTACHMENT 1. TERMS OF REFERENCE

1. Review the methodology used to generate total standing volume and total available volume estimates for the multi-aged forest component of the wood supply zone with Eden Management Area. Comment on the appropriateness of the methodology, the quality and, to the extent practical, the reliability of the resulting volume estimates.

2. Review the stratification used for the regrowth resource, the geographic location of inventory plots and the extent of coverage of regrowth plots. Comment on the utility of the stratification and the quality of baseline inventory information for the regrowth resource for future volume prediction.

3. The Eden regrowth growth models were developed within a very restricted time frame. To complete the work, further improvement and validation is intended but cannot be completed with the deadline required for model availability (the final outcome will be a paper of publication standard). Within this context, the following processes should be undertaken:

- the quality and integrity of growth plot data used;
- data screening procedures;
- the general approach in growth model development;
- the planned benchmarking tests;
- the proposed approach for short term reality checking, including comparable predictions such as Victoria's STANDSIM calculation.

Also within the context of the discussion above, recommend as appropriate any additional tasks to provide acceptable regrowth growth models. This could include such tasks as securing additional data (eg Victoria or CSIRO) or measuring additional plots within and outside the range of those used in the model, to validate model volume predictions.