# MODIFICATION OF THE STANDSIM MODEL FOR THE EDEN MANAGEMENT AREA

Carried out by Forest Essentials P/L

for

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and

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**Summary**

Allowable cut calculations for the Eden Management Area (EMA) require the use of a growth model to estimate yield tables specifying future yields of wood products from the forests. STANDSIM is suitable for the purpose and work was carried out during August and September 1997 to modify the model for use in the EMA. The work utilised growth and yield research work carried out by State Forests over recent years at Eden.

The STANDSIM model was modified by including height age, tree volume and maximum stocking functions into the model and changes to the existing function estimating basal area at age fifteen. Testing was carried out progressively to isolate the changes resulting from the introduction of each new function and the results produced by the modified model were assessed by comparison with temporary and permanent plot data measured in the EMA.

The limited time available for the work meant that:

- Functions for tablelands species have not been included,
- Taper functions have not been included,
- The model underestimates growth for understocked stands younger than fifteen years of age,
- Estimation of growth in stands thinned after age fifteen is conservative.

Despite these shortcomings the work has produced a growth model that can be used to provide conservatively based yield tables for the estimation of allowable cuts in the current planning exercise.

Further work is recommended to improve the accuracy of the model and to fully utilise the comprehensive research programs in progress in the EMA.

## Introduction

During a recent investigation (early August l997) to validate the methodology used in providing wood resources data for the Eden Management Area (EMA), it became apparent that yield tables estimating future merchantable production from the resource were not available. It was proposed (Update on Eden Project 16, dated 7 August l 997) that the Victorian STANDSIM model for *E. sieberi* should be adapted for use in the EMA by Bill Incoll. This report describes the work carried out to achieve this objective between 11 August and 17 September 1997.

## Objectives

- To modify the Victorian STANDSIM model for use in the Eden Management Area.

- To test the model using growth data from permanent or temporary plots measured in the EMA and modify the model further if necessary to achieve realistic results.

## The STANDSIM model

STANDSIM is a deterministic FORTRAN coded growth simulation model originally designed (Opie 1972) for evenaged, single species stands (it has since been modified to accommodate two aged stands). It is unnecessary to specify the arrangement of trees, making it possible to use standard inventory information as inputs to the model, although to make this possible, it is assumed that tree spacing is reasonably even (with the exception of response to strip thinning). The FORTRAN program includes a set of fifteen growth and mensurational functions that apply to one species. The program structure is not species specific, thus to modify the model for a new species, it is only necessary to insert the functions necessary for that species. Functions currently in the model apply to Victorian stands of *E. regnans, E. delegatensis, E. nitens* and *E. sieberi*.

The model can simulate growth from age zero, requiring specification of stem stocking and site index (stand height at age 20). To simulate growth from ages greater than 15, .it is necessary to specify stem stocking, site index and standing basal area, or instead of basal area, a distribution of stem diameters. The estimation of growth is most accurate if diameter distributions are specified.

The model can estimate the consequences of thinning from below or thinning in strips, from age fifteen onwards. For *E. sieberi*, the effects of four intensities of burning on mortality and stand growth can be estimated.

The conversion of gross bole volume to merchantable product volumes can be simulated by relationships between product cutoff points and tree DBHOB, tree height or product small end diameter, and the specification of defect percentage. Maximum and minimum dimensions can be specified for product pieces.

A more detailed description of the model and its operation is given by Incoll (1983)

**Functions used in the SFNSW model**
The functions available for use came from work carried out by the South East Regrowth Forest Growth and Yield Modelling Project (Bi 1994) since 1991, listed as follows:

1. Single tree volume functions for a range of tablelands and coastal species (Bi undated, probably early 1997). This function, with coefficients for *E. sieberi*, was used unaltered.

2. Taper functions predicting stem diameter at any height on the tree stem. The taper functions described (Bi 1997a) are formulated to estimate diameter at any point on the tree stem as a function of relative height at the desired point and total height. For use in STANDSIM, it is also necessary to estimate height for a nominated diameter on the tree stem. Bi's function could be used iteratively to achieve this, but there was not enough time to code this capability in the current work.

3. Tree height as a function of tree diameter for a range of species in tablelands and coastal forests. This function is described in Bi 1997b, but because the functions do not include stand variables, it is unclear whether they are suitable for inclusion in STANDSIM. This will need to be clarified with Dr Bi.

4. Maximum tree height/age functions for tablelands forests. This function was not included during the current work because *E. sieberi* forests were of higher priority.

5. Maximum tree height/age functions for coastal forests (Bi et al 1997c). This function was used in a modified form. When plotted on the same axes as function 4, the maximum height of *E. sieberi* between age ten and age 33 was expected to be greater than for tablelands forests, thereafter becoming less again. Additionally, the maximum height at age 20 was expected to be about 33m, considerably in excess of this author's experience in high site quality Orbost stands. The function was therefore modified to provide a maximum height at age 20 of 25m and this function was used in the model. A further reason for modifying this function is that the variable required by STANDSIM is mean dominant height, not the maximum tree height provided by Bi's function. The relationship between maximum and mean dominant height is unclear, but mean dominant height would be expected to be less than maximum height, as in the modified function. The functions concerned are shown on Figure 1, including the Victorian function (for a site index of 25m).

6. Total stocking as a function of age and overwood stocking for tablelands forests. This function was not included during the current work because *E. sieberi* forests were of higher priority.

7. Stocking of upper canopy trees as a function of age, overwood stocking and site productivity index for coastal forests (Bi et al 1997c). This function was inserted unchanged in the model, but was subsequently modified as a result of test runs (see later).

8. Stand volume of age, site productivity index, overwood stocking, and regrowth stocking for tablelands for tablelands forests. This function was not included during the current work because *E. sieberi* forests were of higher priority.

9. Stand volume as a function of age, site productivity index, overwood stocking, and regrowth stocking for coastal forests. This function was not necessary since STANDSIM requires a single tree volume table, provided as function 1 above.

10. Stand basal area as a function of age, site productivity index and overwood stocking and mean annual increment of basal area as a function of the same variables. STANDSIM requires a function estimating current annual increment of gross basal area, thus this function was not appropriate.

11. Current annual increment of stand volume as a function of age, site productivity index and overwood stocking for tablelands forests. This function was not included during the current work because *E.sieberi* forests were of higher priority.

Figure 1. Maximum height vs age curves for *E.sieberi*, Eden

The functions described above were inserted in the STANDSIM source program, SSIMNU.FOR. Comments have been inserted in the source code where alterations have been made and these can be located by searching on part or whole of the line:

"C E. sieberi SFNSW aug97"

**Testing the Modified program**

*Inserting functions*

Testing of the single tree volume function was carried out externally to the STANDSIM model. A series of DBHOB classes and their estimated tree heights were obtained from a typical fire regrowth STANDSIM run. Volumes were calculated for the sets of diameters and heights using the Victorian and Eden functions. The difference between the estimates was expressed as a percentage of the Eden estimate. Figure 2 shows the results of this comparison, with the percentage difference plotted against DBHOB2*Height. The figure shows that the differences are appreciable for small, short trees, but fall below 5% when $D^2H$ is greater than 10,000 (ie DBHOB about 14 cm) and less than 2% when $D^2H$ is greater than 22,000 (DBHOB about 22 cm). The differences should not be regarded as an error in either function, since the trees may well be different shapes. Whatever the source of the differences, they are regarded as unimportant for the purposes of estimating yields of merchantable material.

Figure 2. Comparison of Victoria and Eden volume tables

Further testing was carried out following the insertion of each function into the STANDSIM model and the effects evaluated by comparison with runs of an unaltered version of STANDSIM. The model was run using an initial stocking of l0,000 trees/hectare at age 5, with a site index of 20m, equivalent to a stand productivity index of 0.6. Functions were inserted as follows.

1. The height age function. Figure 3 indicates the gross bole volume (gbv) estimated by the two different STANDSIM models. The figure shows that differences are minor until about age 50, when gbv for the Eden model has fallen about 10% behind. By age 80, the difference is about 20%. These differences approximate the differences in stand height, see Figure l.

Figure 3. Effect of replacing height age and volume functions
on gross bole volume prediction

2. The maximum stocking function. Figure 4 indicates the gross bole volume (gbv) estimated by the two different STANDSIM models. The figure shows that differences now remain minor throughout the age range simulated. However, when the stem stocking predictions are examined (Figure 5), it is apparent that the Eden function results in very heavy mortality up to age 20, followed by very little subsequent mortality. This seems an anomalous situation, since regrowth stands in the real world can be observed to have continuing mortality well past age 20. Various modifications to the Eden model were tried without changing the situation
X much and eventually a different model form was used, resulting in a function intermediate in shape between the Eden and Victorian models. The model used

was:

$N = 25000\ (1-e^{(-4.7*spi/age)})$

where

N = maximum stocking, stems per hectare
spi = site productivity index
age = stand age in years

This model resulted in prediction of stem stockings intermediate between the two curves shown in Figure 5.

*Testing with temporary plot data*

While data from permanent plots were being prepared) the model was tested against the available temporary plot data by running the model from typical initial stem stockings through to ages similar to the temporary plots The simulated volumes were then compared with the volumes on the temporary plots. When this was done simulation of typical fire regrowth stockings (5,000 stems/ha) produced standing gross bole volumes within the top half of the spread of temporary plot standing volumes at age 45. This is considered a sensible result, considering that most real world stands will have been burnt several times severely enough to have retarded their growth rates. Time was not available to investigate the effects of burning in the simulation runs, although the model could have accommodated this. Simulation of the growth of logging regrowth (initial stocking 1,000 stems/ha) resulted in higher standing volumes at age 45, and although there were no temporary plot data of this age resulting from logging, it seems sensible that the lower density (but still fully stocked) logging regrowth stands would produce higher volumes than fire regrowth.

Figure 4. Effect of replacing height age, volume and maximum stocking functions on simulation of gross bole volume prediction

Figure 5. Effect of replacing maximum stocking functions on stem stocking predictions

*Testing with permanent plot data - stand variables only*

The STANDSIM model was initially tested using data from a report describing the response to a range of early thinning for a series of plots in the Mumbulla State Forest. Input data (stem stocking and standing basal area) were obtained from the report for stem stocking at age four. The simulation was then run from age four to age 28, the last age for which data were given in the report. Diameter distributions were not given in the report, making the simulation task less likely to be accurate, and the unthinned plots were of restricted area.

The estimates made by the STANDSIM model considerably underestimated growth in the real world, probably because the functions estimating basal area at age 15 and the corresponding diameter distributions are inappropriate for the test material. The (Victorian) function estimating basal area at age fifteen was modified in an attempt to correct this problem, but there was insufficient time available in the present study to complete the modifications.

The model must therefore be regarded as currently unreliable in estimating growth for understocked stands from initial ages before fifteen years.

*Testing with permanent plot data - diameter distributions*

The model was used to estimate growth between the initial and final measurements of :,the commercial thinning trial in East Boyd State Forest (trial L374). The trial included six unthinned plots and six plots thinned from below. These two sets of plots were pooled to provide composite thinned and unthinned sample plots, each 0.36 ha in area. The growth of the unthinned plots was simulated from age 25 to 36 and the thinned plots from age 27 to 36. The factor of most interest was how accurately the model would simulate the final diameter distributions and this is illustrated in Figures 6 and 7 for the unthinned and thinned plots respectively.

Figure 6 indicates that the simulation of growth on unthinned plots has been reasonably successful. However, for thinned plots, the growth of small trees appears to have been underestimated in that the simulated distribution has more small trees than the actual stand. The simulated stand also has more live trees than the real stand? so it may also be that mortality has been underestimated. While the accuracy of the model in this area can be improved by further work, the conservative nature of the inaccuracy means that the model can still be effectively used in its current state for the current planning exercise.

Figure 6. Simulation of growth on unthinned plots trial L374

Figure 7. Simulation of growth on thinned plots, trial L374

**Future modifications**

Further work is necessary on the model to refine the simulation of growth and mortality to better reflect real world observations. This work was not possible in the current study because of time restrictions. Testing also needs to be extended to include the other permanent plot data available.

Further modifications, when carried out, need to be inserted into the source program, compiled and the object code renamed SSIMCORE.EXE. This file should be used to replace the current file of the same name in the STANDSIM directory. The program STANDSIM.EXE calls SSIMCORE.EXE as necessary to carry out simulation of the games designed by the user.

The current version of the source program, ssimnu.for and the object code ssimnu.exe are supplied on the floppy disk with the original of this report.

References

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

Bi Huiquan (undated). Total stem volume and bole volume equations for regrowth eucalypts of the Southern Region. Internal report to the Southern Region.

Bi Huiquan (1997a). Taper equations for regrowth eucalypts. Internal report to the Southern Region No 2.

Bi Huiquan (1997b). Height and diameter equations for regrowth eucalypts 1: Predicting tree height from DBHOB. Internal report to the Southern Region No l .

Bi Huiquan, Chikumbo O, Jurskis V (1997c). Yield equations for regrowth forests regenerated from fire on the southeast coast of New South Wales. Draft report to the FRAMES Committee.

Incoll W D 1983. STANDSIM user manual. Research Branch Report No 234. • Unpublished.

Opie J E O 1972. STANDSIM. A general model for simulating the growth of unevenaged stands. Third Conference, Advisory Group of Forest Statisticians, IUFRO, Paris, 1970 *In* Institute Nationale de la Recherche Agron. Publ. 72-3: 217-39