FRI/INDUSTRY RESEARCH COOPERATIVES

MANAGEMENT OF EUCALYPTS COOPERATIVE

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HEIGHT GROWTH OF *EUCALYPTUS SALIGNA*

Sergio Calderon

Report No. 5 February 1989

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EXECUTIVE SUMMARY

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The objective of the study is the definition of site index. These curves are an efficient means to express site productivity and are also valuable in predicting the height development of a young stand.

The sample 80 plots assessed represent 170 measurements well balanced by age and well scattered in the geographical distribution of the species.

Two functions are tested, the Schumacher and the Bertalanffy-Richards model. The first is adjusted by the guide curve method. The second is adjusted by the guide curve method as well as being optimised by a parameter prediction method. The best result is obtained by the latter method with the equation for different site indices being presented.

HEIGHT GROWTH OF *EUCALYPTUS SALIGNA*

by Sergio Calderon

INTRODUCTION

Eucalyptus saligna Sm. is one of the designated special purpose species in New Zealand. Its role in the manufacture of furniture, veneers and turnery make it a potentially valuable species when grown in the right environment.

The demand for species for specific end uses is always present and actually growing. The supply of indigenous timbers is scarce and the cost of imported timbers is increasing. *E. saligna* (Sydney Blue Gum) has a likely niche in the market and the definition of suitable sites constitutes one of the priority studies.

Site index, the relationship of Age and Top Height, has long been recognized as an efficient means of expressing site productivity.

Height is usually correlated to volume production; although this is not always true. However, it is regarded as a fair indicator of the timber production potential of a site.

A different use of site index curves is the selection of the height development pattern that a particular stand can be expected to follow in the remainder of its life. This prediction can also be used with young stands. The development of many growth models for basal area or mortality prediction are driven first by the prediction of height of the dominant trees. It is in this context that the age/height relationship selected in this analysis would be the first component in a growth model for Sydney Blue Gum and 'constitutes a self contained submodel that can be developed separately' (Garcia, 1979).

This study investigates the adequacy of the Schumacher and the Bertalanffy-Richards models for expressing the relation of age and height for *E. saligna.*

BASIC DATA

To define the timber production potential for sites around New Zealand a good set of Site Index Curves are needed. The sample 80 plots assessed in the study represent 170 measurements which are scattered fairly well balanced through the age groups (with a maximum of 31 years old) and are confined to the most suitable geographic range for the species; Northland-Auckland and Rotorua regions. A preliminary study is presented here and with new plots and/or remeasurements coming on stream a validation and generalization of results can be planned in the future.

Data for the study came from 38 temporary (one measurement) and 42 permanent sample plots that were established within 2 distinct geographical regions. Northland-Auckland included 94 measurements and Rotorua region, 76. Plots were located within plantations under the auspices of the Managements of Eucalypts Cooperative in appropriate stands planted by member organisations. Site preparation method and initial stocking were many and varied.

To eliminate the effect of planting density and subsequent thinnings on average height the mean top height "MTH", defined as the average height of the 100 largest trees (in DBH) per hectare is preferred. This has the advantage of being little affected by stocking.

Site preparation and establishment techniques vary from pure planting in cutover plantation or farming country to mixed species plantation. The number of plots in each treatment are not sufficient to warrant an independently stratified analysis of the data.

The distribution of plots measurement by Age and MTH classes are shown for the two regions separately in Table 1.

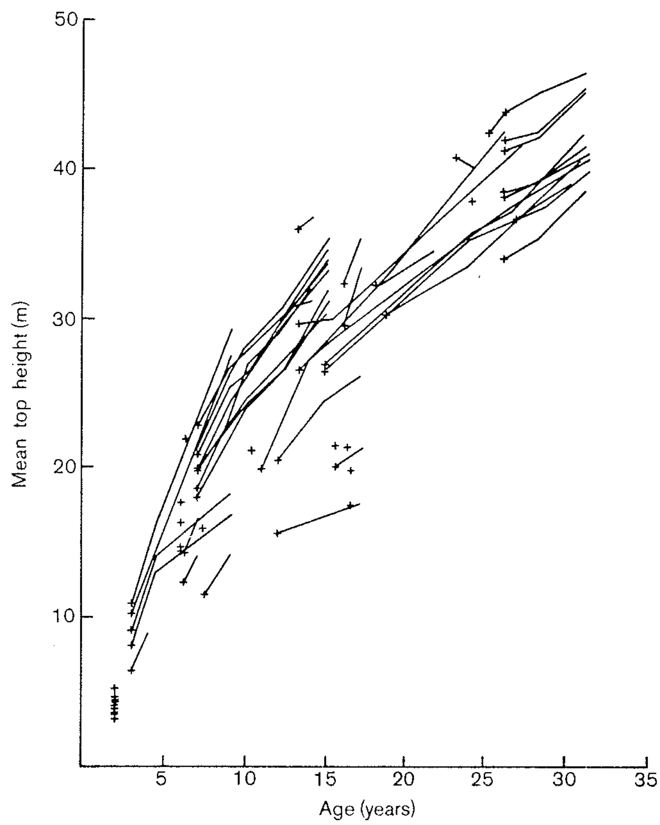
TABLE 1 - Distribution of plots measurement between regions by age and MTH classes

Age Class years	Northland-Auckland Region Mean Top Height classes (m)									
	16	20	24	28	32	36	40	44	48	Total
6		1								1
8	1	8	6	2						17
10		2	3	5						10
12	1	1		6	2					10
14			1	4						5
16	1	4		1	5	3				14
18	1	1	1	1	1					5
20										0
22						1				1
24						3				3
26						5	3	2		10
28						2	3	3		8
30							1			1
32							5	3	1	9
	4	17	11	19	8	14	12	8	1	94

Age Class years	Rotorua Region Mean Top Height classes (m)											
	4	8	12	16	20	24	28	32	36	40	44	Total
2	26											26
4		4	3	3								10
6			1	6								7
8			1	2								3
10				2	1		2					5
12												0
14							2	4	2			8
16							1	2				3
18								3	1			4
:												:
24								1	1	2		4
26											3	3
28										1	1	2
30										1		1
	26	4	5	13	1	0	5	10	4	4	4	76

Although the geographical spread of sample plots is suitable, an analysis by groups is not intended. The amalgamated data cover the range of site qualities and ages. In other words, each site quality class will be fairly well represented (Figure 1).

Figure 1 - Data base from 80 plots



REGRESSION AND PARAMETERIZATION ANALYSIS

The models in the study are two of the most commonly used by previous researchers. The first, was originally suggested by Schumacher (1939) and relates ln(H) with the reciprocal of age. This approach assumes a family of height/age curves of the form:

$$H = e^{**}(a+b/A)$$

Where:

H = mean top height (m)
A = stand age (years)
a,b = parameters to be calculated.

The second model is the Bertalanffy-Richards proposed by von Bertalanffy (1949) and studied by Richards (1959).

The function has the following form:

$$H = a^{*}[1-\exp(-b^{*}A)]^{**}(1/c)$$

Where:

H = mean top height (m)
A = stand age (years)
a,b,c = parameters to be calculated.

The site quality curves assume that the variation among height-age patterns for a particular species and region are described by one-parameter family of curves.

Therefore, one or two parameters are 'global' (same value for all the plots) and one parameter is 'local' (varying freely across sites).

The analysis tested two different methods for finding the parameters:

1. The Guide Curve Method with a Least Square fitting procedure. This can use permanent or temporary plot data. It involves the fitting of any of the equations introduced previously to all the top height and age data.

The result is an 'average' curve for all the sample data used. Individual height/age data for a plot or stand generate curves that diverge from the guide curve. These curves form a family of curves with one parameter varying across sites. In the study, this method is applied to the two models described above.

2. The Parameter prediction Method (Clutter, J.L., *et al.*, 1983) where stochastic differential equation are used and a search is performed of parameters that maximise the likelihood function.

The procedure is applicable only to permanent plots with two or more measurements. In this study, it has been applied only to the Bertalanffy-Richards model. A site index and corresponding parameters are found for each plot by fitting the height age function on a plot-by-plot basis. The parameters of the fitted curves may be different for different plots. In a particular version of the model parameters again may be fixed, globals or locals.

The results obtained for each equation and method are presented in Table 2.

Table 2 - Results of the regression and parameterization analysis

Model Method	Schumacher Guide Curve	Bertalanffy-Rich Guide Curve	Bertalanffy-Rich Parameter Prediction
PARAMETER			
A	3.8739	48.79745	70.1810
B	-6.6631	0.06551	0.0250
C	-	1.00869	1.3490
ESTIMATED STAND. ERROR			
A	0.02774	15.4905	6.9310
B	0.39768	0.00914	0.0056
C	-	0.07389	0.0667
R.M.S.	19.7097	17.4290	-
R^2	0.87567	0.9807	-
MAX. LIKELIHOOD	-	-	-302.2

DISCUSSION OF RESULTS

To judge the goodness of the adjustment by the three different methods it must be taken in to account that in the models adjusted by the guide curve method, the data are fitted to the regression in a one stage approach and each site index curve is situated in a fixed percentage above or below the guide curve. This assumption is not always valid (Appendix 1).

To decide the best fit for the two models (guide curve adjusted), the Residual Mean Square (RMS) and the Coefficient of Determination (R^2, proportion of the variation explained) are expected to be "good indicators of the predictive performance of the final regression when it is applied in the population" (Clutter *et al.*, 1983). The Bertalanffy-Richards model is the best of both models when these selection criterion are applied.

Moreover, when the two methods to find the parameters for the Bertalanffy-Richards model are compared, the one with the smallest standard errors is preferred, although these statistics are not strictly comparable. Therefore, the optimisation of the likelihood function gives the best results. In this method, the independent variable chosen in the first stage regression is time and in his solution Garcia assumes that the correlation among residuals of each plot may be modelled as a first-order autoregressive process (West, Ratkowsky and Davis, 1984).

THE SITE INDEX CURVES

The parameter prediction method using the Bertalanffy-Richards model was calculated and the maximum likelihood was obtained when parameter "a" was left to vary freely (local) and "b" and "c" were global. This means there are different asymtotes for each site index curve. Curves for the various site indices are obtained by varying "a", holding "b" and "c" constants.

The parameter "a" varies as necessary to achieve the required mean top height value when the age equals the index age (20 years in this case).

The equation of the curve for different site indices is therefore:

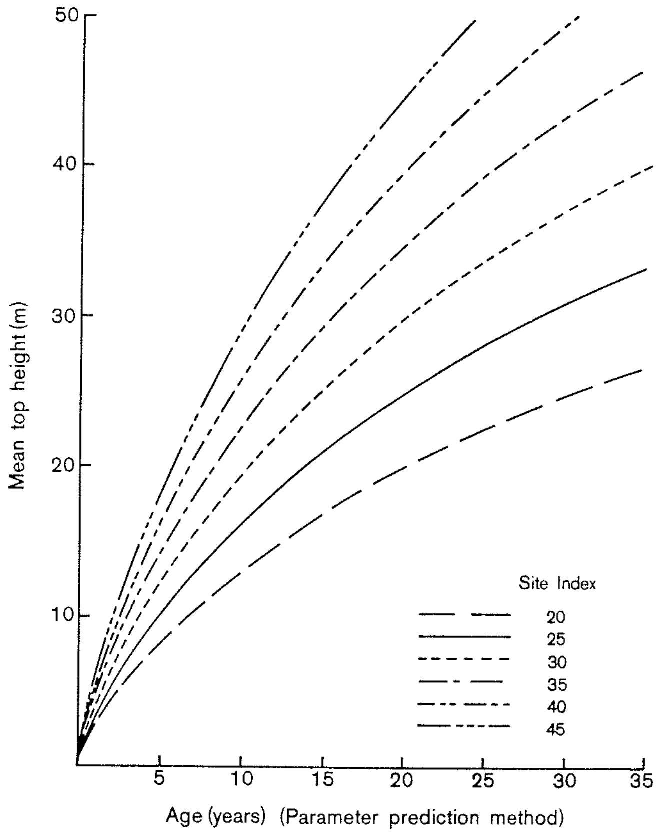
MTH = S*[(1-exp(-0.02501*A))/(1-exp(-0.02501*20))]**(1/1.349)

Where:

MTH = mean top height (m)
A = Age (years)
S = Site index (m)

Figure 2 presents the MTH obtained for different Site Index Curves.

Figure 2 - Site index curves for E. saligna
(Bertalanffy-Rich. Model)



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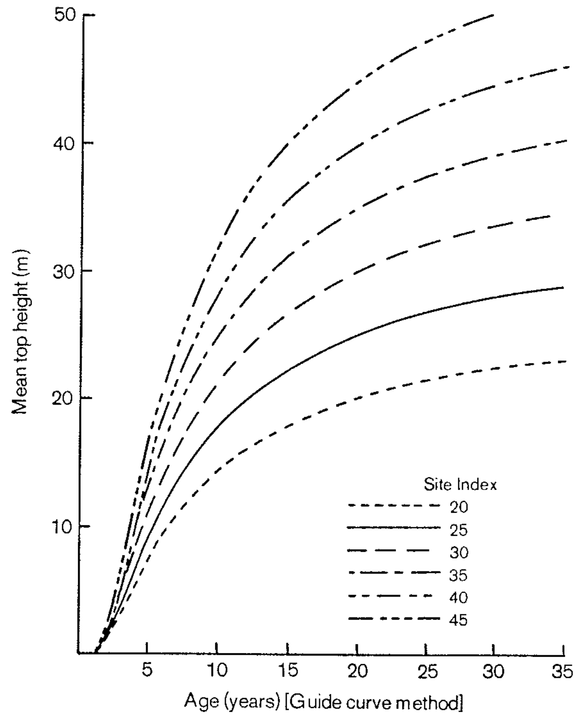
APPENDIX 1

Appendix 1 – Site index curves for E. saligna
(Schumacher model)



Site index curves for E. saligna
(Bertalanffy-Rich. Model)