PREDICTION OF DIAMETER AND HEIGHT STARTING VALUES FOR THE EARLY GROWTH MODEL

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Report No. 8 **November 1994**

FOREST & FARM PLANTATION MANAGEMENT COOPERATIVE

EXECUTIVE SUMMARY

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The EARLY growth model uses a DBH/Ht ratio to estimate starting values at the beginning of a simulation.

Analysis of data from several forests in New Zealand has indicated that DBH/Ht ratios varied with basal area increment level, tree age, and stocking.

New predictive functions for DBH/Ht ratios have been developed which will provide starting values over a wider range of ages (from age 3 to 9 years) with improved accuracy.

A look-up table of DBH/Ht values is provided for users to indicate, from field measurements, the appropriate basal area increment level in EARLY.

PREDICTION OF DIAMETER AND HEIGHT STARTING VALUES FOR THE EARLY GROWTH MODEL

Introduction

The effect of pruning and a early thinning on the growth of radiata pine is currently predicted using the EARLY growth model (West *et al,* 1982) within the STANDPAK modelling system (Whiteside, 1990). The EARLY growth model is used in conjunction with a "later" growth model (the switch between models is usually made at mean crop height 18m or later) to provide growth rates and yield tables for a range of silvicultural regimes. The EARLY growth models is also used extensively to schedule pruning and thinning operations to the nearest month (West and Wisnieski, 1992).
Initial starting values are needed to begin a growth simulation using the EARLY growth model in STANDPAK. If a STANDPAK user has no starting values (from plot measurement or inventory) to begin a prediction, these are currently provided within EARLY from age 4 to 7 . These are particularly useful for theoretical studies where the relativity between starting values need to be uniform across a range of site indices (West *et al,* 1987).
The pathways for the derivation of starting values is given in figure 1.
They are:

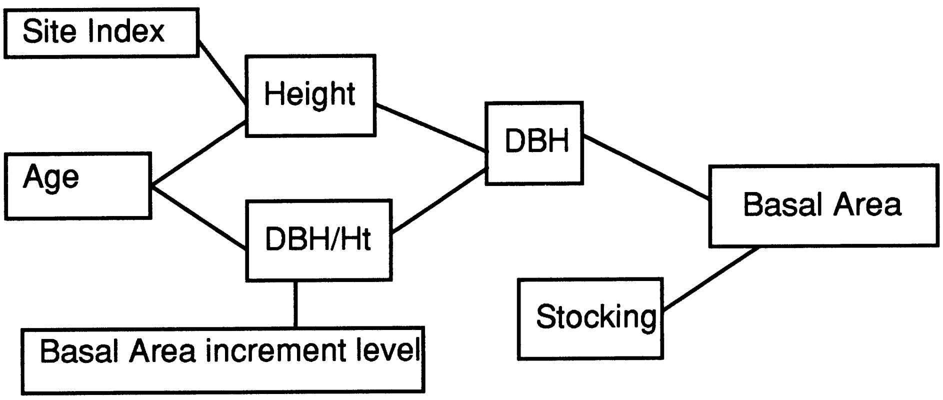
1. Using a given site index, height can be predicted from stand age ie from a height/age curve.

2. From basal area increment level and age the ratio of DBH/Ht can be predicted.

3. From height and the DBH/Ht ratio, DBH can be predicted.

4. From DBH and stocking basal area can be calculated.

Figure 1: Pathway for derivation of starting values



The current DBH/Ht ratios used in the EARLY growth model (West *et al*, 1987) are given in Table 1. These ratios were derived from the EARLY growth model data set and represent "smoothed mean values for four age classes " at three levels of basal area increment. Clearly these ratios provide approximate values which do not account for the influence of establishment practices and silvicultural treatment.

Table 1: Current DBH/Ht ratios in EARLY

Basal Area increment level	Age			
	4	5	6	7
High	1.9	2.1	2.3	2.2
Medium	1.4	1.6	1.8	1.7
Low	1.2	1.4	1.6	1.5

Basal area growth in EARLY is predicted using a choice of three functions - High, Medium, or Low, these generally represent - farm sites, unimproved forest sites, and nutrient deficient sites, respectively. Adjustment (by +- 20%) of each basal area increment levels has also been allowed for in the EARLY growth model. This flexible approach to basal area growth modelling requires the user to calibrate the model to their sites by using local plot growth data in a validation process. Where DBH and height data have been collected from stands (eg pre-assessment data) a DBH/Ht ratio can be calculated and when compared with the values in table 1 will give an indication of the current basal area increment level. eg a stand measured at age 5 that has a DBH/Ht ratio of 2.1 indicates it is growing on the high basal area increment level .

This study will examine factors that influence initial stand DBH/Ht ratios and will attempt to provide a model to predict improved starting values in EARLY. By providing a look-up table of these values users of the EARLY growth model should gain better precision to estimates of basal area increment level.

Methods

A validation study of the EARLY growth model by West *et al* (1987) tested PSP data from a range of trials and determined the appropriate basal area level for a number of forests. This was achieved by running the model for each PSP and observing which level gave the smallest average error.

Data sets for this study were selected from forests where the basal area level had already been determined by the above procedure. These data sets could then be used to derive relationships about their starting values. Table 2 gives the source of trial data used for this study.

One data set chosen, NN525 had not been through this validation process. This trial is part of a national series examining final crop stocking and include an essential range of stockings needed by this study. All plots from this trial except the 50 and 100 stems/ha plots, were tested against EARLY and found to be growing (on average) at the Low basal area increment level.

Table 2: Source of data

Basal Area level	Forest	Experiment No.	Number of plots
High	Tikitere	RO382/1	60
High	Lismore	WN301	12
Medium	Kaingaroa	RO1891	12
Medium	Kaingaroa	RO590	11
Medium	Kaingaroa	RO1083	8
Low	Golden Downs	NN310	15
Low	Golden Downs	NN371	8
Low	Golden Downs	NN525	10

Data for these trials were extracted from the PSP system and manipulated in EXCEL spreadsheets. A description of the data is given in appendix 1. Data for this study was limited to stand age 3 - 9 years. Providing estimates of DBH/Ht outside this range was thought to have little practical application. It is also expected to be more accurate to use the model to grow the stand forward to these extended ages, rather than provide them as starting value, eg ages 10 - 14 years.

Height Measurement

The measurement of height used in DBH/Ht is Mean Crop Height (MCH). MCH best represents the crop trees that are to be pruned and is often the height measurement taken at pre-assessment. However MCH is not summarised by the PSP system, instead Mean Height is calculated . Mean height is derived from a Ht/DBH relationship (Petterson Curve) formed from a sample of approximately 12 trees measured for height and DBH.

MCH can be predicted with reasonable accuracy if PMH and stocking are known (West *et al*, 1987). Using data from RO1891 Mean height and MCH estimates were compared. The difference between the two height measures was found to be very small (approximately 0.2m). It was therefore decided to continue to use MCH and predict this height from PMH. Where PMH had not been measured, Mean Height derived by the PSP system would be used in this analysis.

Results

Tree age

Exploratory data analysis indicated a number variables could be influencing DBH/Ht ratios.

As found previously DBH/Ht ratios were markedly different for each of the basal area increment levels eg at age 5 with 800 stems/ha, High basal area sites have a DBH/Ht ratio of 2.0, medium 1.8 and low 1.5. Tree age was also found to be clearly influencing DBH/Ht ratios with a general trend of DBH/Ht ratios increasing to age 5-6 and then declining.

Stocking

Tree stocking, for the year prior to measurement, was found to be major influence with DBH/Ht ratios decreasing with increasing stand density. This is probably because at higher stockings individual tree diameter growth is slowed by competition whereas height growth generally increases.

Pruning

The effect of pruning severity could only be examined in a limited number of trials. DBH/Ht of pruned and unpruned plots where examined using data from two Kaingaroa trials (RO590 and RO1083) that provided a wide range of pruning treatments: . Where treatments of no pruning versus severe pruning could be contrasted some slight effect was evident but this did not become substantial until after age 9 - the limit of this study.

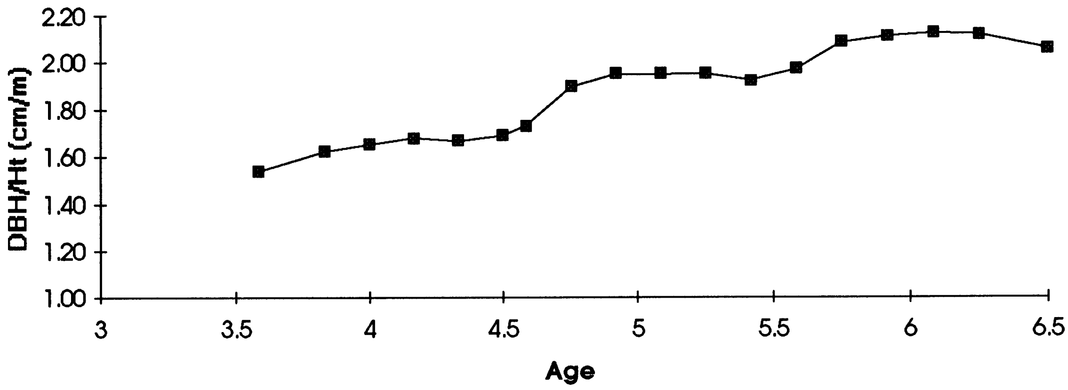
Site Index

Site index could be expected to influence DBH/Ht. However examination of data from identical trials with two different site indices (RO1083/1 central Kaingaroa Site index 30m and RO1083/2 southern Kaingaroa site index 26m) indicated no significant differences in DBH/Ht . As a surrogate for site index , MTH/age was calculated for each plot and tested in the multiple regressions given below.

Seasonal effects

As maximum diameter increment occurs mainly over the summer months and maximum height increment occurs in spring, seasonal patterns in growth are likely to influence DBH/Ht ratios. Using the monthly growth distributions within STANDPAK an estimate of this effect can be predicted. Figure 2 gives the results of using the monthly growth distribution function derived by Jackson *et al*, (1976)(number 3 in STANDPAK).

Figure 2: Seasonal variation in DBH/Ht predicted by STANDPAK



Multiple effects

Regression techniques were used to combine the effects discussed above. A number of variables and functional forms were tested to derive a predictive equation for each basal area level. The two variables found to significantly influence DBH/Ht ratios were stocking (ie the stocking for the year prior to the measurement) and age at the time of measurement. Using SAS routines, the following models were fitted to each basal area level data set.

High basal area level

$DBH/Ht = -477.21 + 475.75 * \exp(1/sph + 415.7) + age/ (.8503+.03066 * age^2)$

n = 660 Residual Mean Square = 0.0440

Medium basal area level

$DBH/Ht = -2593.81 + 2592.60 * \exp(1/sph + 3063.2) + age/ (1.2657+.03592 * age^2)$

n = 239 Residual Mean Square = 0.0148

Low basal area level

$DBH/Ht = -100.237+ 100.513 * \exp(1/sph + 319.3) + age/ (2.9431 + .06767 * age^2)$

n = 124 Residual Mean Square = 0.0088

Figures 3 to 5 give a graphical representation of the above functions

Discussion

Clearly research into the fundamental site factors that effect tree basal area growth would help to understand what has been approached with an empirical and pragmatic method. A current project by a University of Canterbury under-graduate supported by NZ FRI examines this issue and may provide some answers (Wells, 1994 in prep)

A method of accounting for the substantial effects of establishment operations such as cultivation, weed control, and fertiliser would also help with estimating basal area growth rates. This issue has been substantially examined by Mason (1992) for the Central North Island and has resulted in the development of the INITIAL growth model predicting stand growth from age 0 to 5. However until this model includes all sites in NZ, predicting starting values in EARLY will continue to rely on DBH/Ht values.

Conclusions

This study has developed predictive functions for DBH/Ht ratios which will improve the starting values provided in the EARLY growth model. Starting values are provided over a wider range of ages and will now be sensitive to stocking.
A look-up table of DBH/Ht values is provided in appendix 2 for a range of ages and tree stockings.

Acknowledgments

The data provided for this study by the forest industry and NZ FRI staff and the statistical assistance from M. Middlemiss and M. Kimberley is gratefully acknowledged

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Appendix 1: Description of data used

Basal Area level	**Forest**	**Expt No.**	**Age Min**	**Age Max**	**Stocking Min**	**Stocking Max**
High	Tikitere	RO382/1	3	9	45	1000
High	Lismore	WN301	3.8	9.2	150	1967
Medium	Kaingaroa	RO1891	3.5	9.0	93	1130
Medium	Kaingaroa	RO590	3.9	9.0	117	2000
Medium	Kaingaroa	RO1083	5.3	9.2	375	3150
Low	Golden Downs	NN310	5.6	9.0	250	1500
Low	Golden Downs	NN371	6.0	9.2	217	1932
Low	Golden Downs	NN525	4.0	9.0	50	800

Appendix 2: DBH/Ht by basal area level, age, and stocking

		Stems/ha						
Basal area level	Age	100	200	400	600	800	1000	1500
High	3	2.13	1.98	1.79	1.67	1.60	1.54	1.45
	4	2.45	2.30	2.11	1.99	1.91	1.86	1.77
	5	2.56	2.41	2.22	2.10	2.02	1.97	1.88
	6	2.53	2.38	2.19	2.08	2.00	1.95	1.86
	7	2.44	2.29	2.10	1.98	1.91	1.85	1.76
	8	2.31	2.16	1.97	1.85	1.78	1.72	1.63
	9	2.16	2.01	1.82	1.71	1.63	1.58	1.49
Medium	3	1.50	1.47	1.43	1.39	1.35	1.32	1.25
	4	1.78	1.76	1.71	1.67	1.64	1.60	1.53
	5	1.92	1.90	1.85	1.81	1.77	1.74	1.67
	6	1.96	1.93	1.89	1.84	1.81	1.77	1.70
	7	1.92	1.90	1.85	1.81	1.78	1.74	1.67
	8	1.86	1.83	1.78	1.74	1.71	1.67	1.60
	9	1.77	1.74	1.70	1.65	1.62	1.59	1.52
Low	3	1.36	1.31	1.26	1.23	1.21	1.20	1.18
	4	1.51	1.46	1.41	1.38	1.36	1.35	1.33
	5	1.60	1.55	1.50	1.46	1.45	1.43	1.41
	6	1.63	1.59	1.53	1.50	1.48	1.47	1.45
	7	1.64	1.59	1.54	1.50	1.48	1.47	1.45
	8	1.62	1.57	1.52	1.49	1.47	1.45	1.43
	9	1.59	1.54	1.49	1.45	1.43	1.42	1.40