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TITLE:	MONTHLY BASAL AREA GROWTH DISTRIBUTION OF DOUGLAS-FIR IN NEW ZEALAND
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ABSTRACT*

A basal area growth distribution table has been developed for Douglas-fir in New Zealand. This is a method of distributing growth within any one year, which is used as a sub-component of growth models and also for silviculture scheduling. A growth adjustment was derived for each month so that measurements can be adjusted back to a standard period.

Data was used from an earlier study conducted by J. Woodman and G. Holden. The data was collected for the 1975/76 growing season from 5 sites throughout New Zealand, with two plots located at each site. Growth started in September and continued until late April.

A brief comparison was made of the Douglas-fir growth distribution with distributions developed for radiata pine. The growing season is shorter for Douglas-fir which has no growth occurring during the winter.

Note: This material is unpublished and must not be cited as a literature reference

MONTHLY BASAL AREA GROWTH DISTRIBUTION OF DOUGLAS-FIR IN NEW ZEALAND

OBJECTIVE

To develop a growth distribution that will show basal area growth per month as a proportion of the entire year's growth. This will also include growth adjustments for correcting growth measurements taken at any time back to a standard reference point.

INTRODUCTION

The measurement of tree and stand growth is an important part of forest management. Knowing the size of a tree and how fast it is growing is crucial for scheduling silvicultural operations such as thinning and pruning. It is impractical to be continually measuring trees so they are measured periodically. The timing of silviculture is therefore estimated, but if this estimate is out by a matter of months, it can lead to an unsatisfactory result, eg a large defect core at pruning. A monthly growth distribution will help to predict growth, and therefore assist with scheduling operations between annual measurements.

Modelling is another area which requires the use of monthly growth increments. Sample plots are measured at regular intervals so that models can be developed to predict the growth of trees and stands. The increment periods are not always exact years so need to be corrected before they can be used for growth modelling (Garcia 1979).

Growth has been investigated on an intra-annual basis for radiata pine in New Zealand on previous occasions (Jackson *et al.* 1976, Tennent 1986). It has also been examined for *Eucalyptus regnans* (Poole 1986). The standard method of distributing growth within a year is to apply monthly adjustments. An example of this is the "EARLY" growth model developed by West *et al.* (1982).

One of the main applications of a set of Douglas-fir growth adjustments is to adjust sample plot data so that it can be used in the development of a model similar to "EARLY" for Douglas-fir. All measurements will be able to be adjusted to a single date which will act as the standard reference point.

METHOD

The data used in this work was collected by Dr J. Woodman of Weyerhaeuser Company and G. Holden of FRI during 1975/76 as part of a study on the growth of Douglas-fir. The original aim of the study was to relate diameter growth to factors of the environment. The study had involved taking weekly measurements of a sample of trees at a number of sites. The diameter measurements were used in this analysis. Height increments were not measured so it has not been possible to develop a growth distribution for height.

A series of provenance trials established in 1959 by the FRI were selected as study sites. This trial series was established on five sites throughout New Zealand to provide national coverage. One of the better performing provenances was FRI 56/642 from Berteleda, California. Two plots of this provenance were selected in each of the five provenance trials. One of the two plots at each site was thinned to 750 stems/ha, while the other plot remained unthinned.

Dendrometer bands were placed at breast height (1.4m above ground level) on a sample of 13-20 trees per plot and used to measure the weekly diameter growth. The trees were selected to represent the range of diameters present and were free of malformation. A number of climatic factors were also measured but these were not used in this analysis.

The plots at the Kaingaroa site were measured by FRI staff. The other sample plots were established by FRI staff and measured weekly by local Forest Service staff.

Table 1 summarises the location of the plots and the number of sample trees at each site.

Table 1. Plot Location and Sample Size.

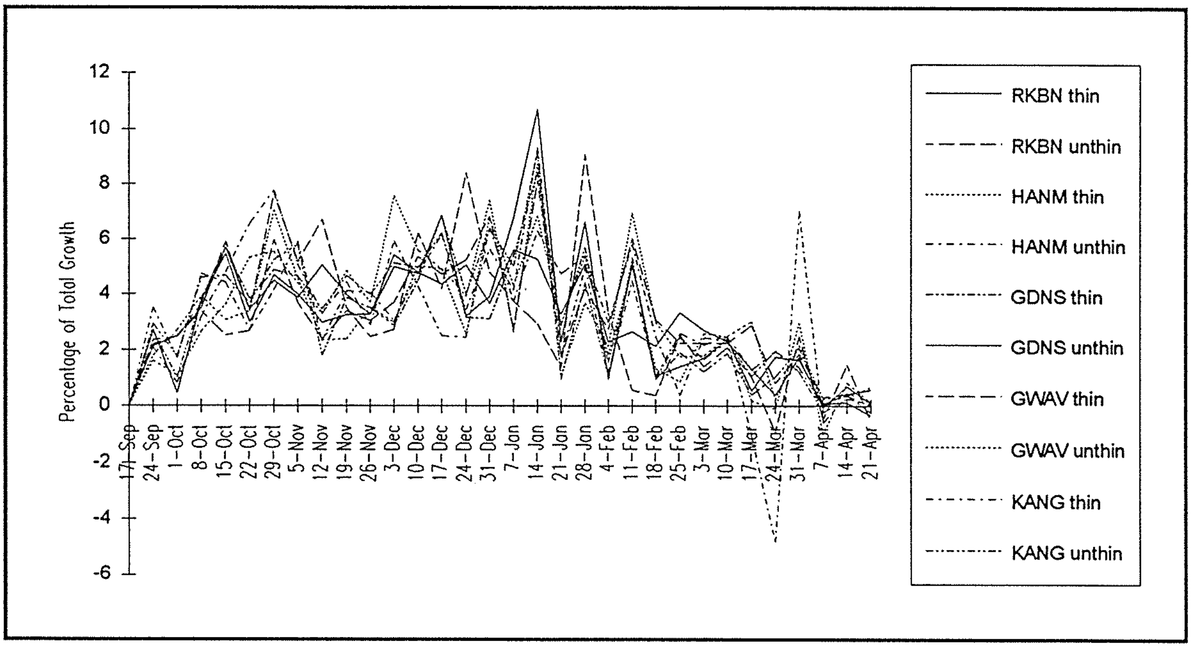
Forest	Number of Sample Trees	
	Thinned Plot	Unthinned Plot
Kaingaroa	17	18
Gwavas	18	19
Golden Downs	16	15
Hanmer	13	14
Rankleburn	16	20

The measurements were taken from August 1975 to April 1976. The measurements were stopped when growth had ceased for the season.

ANALYSIS

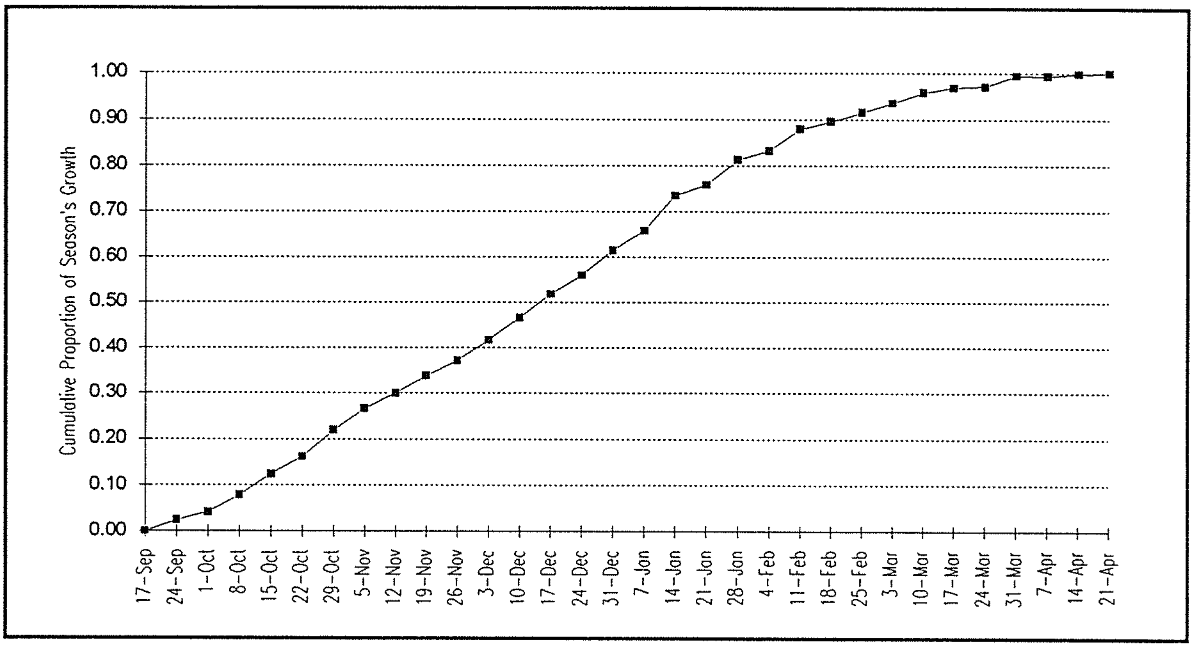
The diameter growth was measured in increments of 0.081 of a millimetre. These were converted to basal area and averaged across the plot. This data was then adjusted to give the value as a percentage of the total season's growth. The mean for each of the plots is shown in Figure 1. As can be seen, all plots show a similar pattern of growth throughout the season. When under high water stress, cells will shrink (Jackson *et al.* 1976), and hence the diameter will decrease, and may even result in a negative value.

Figure 1. Weekly Basal Area Growth as a Percentage of Total Season's Growth.



Weekly basal area growth was averaged for all plots and plotted as a cumulative growth curve for the season. This is shown in Figure 2. The graph is only for the period in which growth occurred, rather than of the whole year. No growth occurred before September 17, 1975, or after April 21, 1976.

Figure 2. Cumulative Basal Area Growth for 1975/76 Season



From this, the proportion of growth occurring in each month could be derived. The growth represented by a "month" is the growth occurring up to the 15th of any given month. This is a standard convention that has been adopted by growth modellers in New Zealand (A. Gordon, pers. comm.). A growth adjustment was calculated so that all measurements could be standardised to a set date.

RESULTS

Table 2 shows the cumulative proportion of growth occurring in each month. It also gives the mid-monthly adjustments that can be applied to allow for seasonal growth to any age. September is regarded as the first month in the year as annual growth is assumed to start on the 1st of September (based on the growth data used in this study).

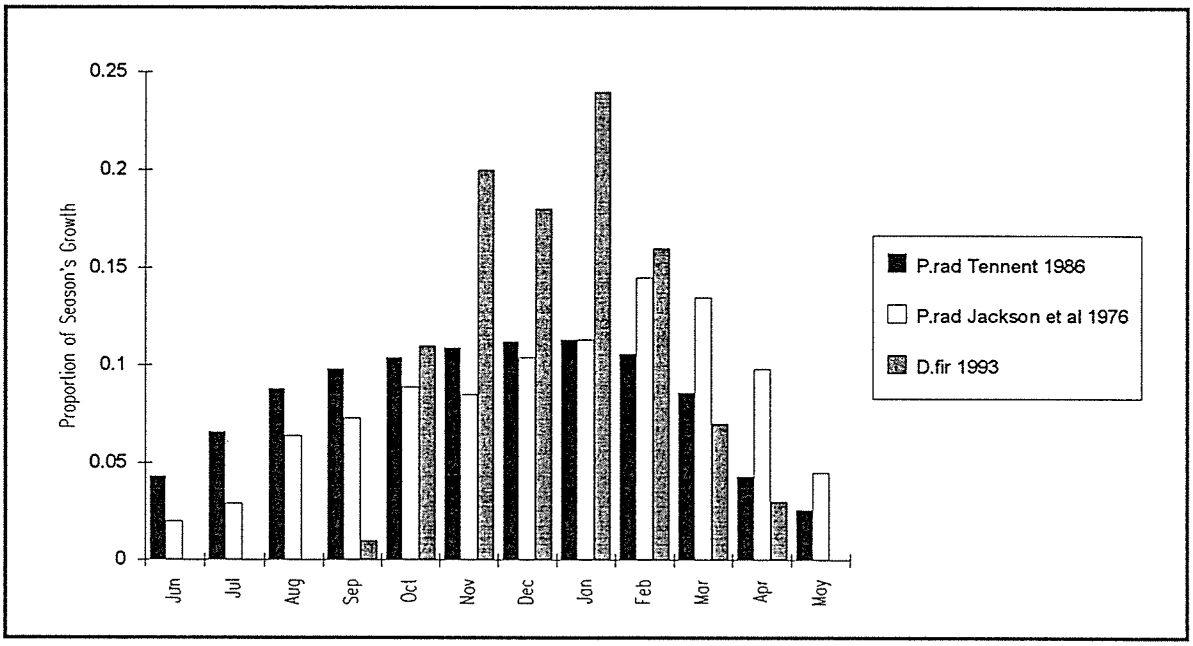
Table 2. Monthly Basal Area Growth and Adjustment Factors.

Month	Cumulative BA Growth (%)	Growth Adjustment (%)
September	0.01	0.01
October	0.12	0.12
November	0.32	0.32
December	0.50	0.50
January	0.74	-0.26
February	0.90	-0.10
March	0.97	-0.03
April	1.00	0.00
May	1.00	0.00
June	1.00	0.00
July	1.00	0.00
August	1.00	0.00

The existing growth distributions for radiata pine in New Zealand were compared with the distribution for Douglas-fir developed here. The radiata pine distributions were developed by Tennent (1986) and Jackson *et al.* (1976). Tennent's distribution was based on growth of 5 year old stands on 4 sites throughout New Zealand. Measurements were carried out over 2 to 4 years. Jackson's work was with 2 year old material grown in individual evapotranspirometer units as part of an experiment on the effect of drought.

All three distributions were plotted on the same graph (see Figure 3). For radiata pine, it is assumed that the growing season starts on the 1st of June (this is the month after the month with the least growth[1]). The graph shows that radiata pine continues to grow throughout the year, albeit by small amounts during the winter, whereas Douglas-fir stops completely. The period of maximum growth tends to peak later for Douglas-fir than for radiata pine.

Figure 3. Proportional Basal Area Growth of Radiata Pine and Douglas-fir.



DISCUSSION

Although the data for this study was obtained from ten samples on five different sites, it was all collected in the same growing season. As was seen in Figure 1, all sites showed similar patterns throughout the season. Part of this pattern would have been a result of the weather conditions. Different climatic patterns from year to year will lead to some variation in the distribution of the year's growth. Data was collected weekly and converted to a monthly total so this will counteract some of the short term variation. The main

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[1]In most uses, the height adjustment is the driving one as height-age-site are usually related. The convention used by modellers is that the first month that shows an increase in the percentage of growth increment is the month in which growth starts. However some of the older tables had other conventions.

difference is if an atypical growth season occurs, in which case the distribution will be different from the actual growth in that year.

The sampled trees were all from one provenance, ie from Berteleda in California. Although this will have given a more consistent result, as the only variation will have been a result of site, it may also cause limitations in the growth distribution. Different provenances will come from regions with slightly different climates. Their growth patterns may be different, ie some will flush earlier than others or have a longer growing season. This could cause errors if other provenances have distinctly different growth patterns.

Basal area growth was not measured on an area basis but derived from the average growth of individual trees. As these trees were selected across the diameter distribution, it is unlikely that competition effects would alter the pattern of seasonal growth.

Although there is some variation shown between sites (see Figure 1), this is not considered sufficiently different to justify the development of regional growth distributions. This national distribution will form a basis for growth modellers to work from, although it will require validation.

It would be useful to have further measurements of weekly or monthly growth in the future. These would be to validate the basal area distribution developed here, and if necessary, to improve it. The new samples could also be measured for height so that a height distribution can be derived.

REFERENCES

Garcia, O. 1979. Modelling stand development with stochastic differential equations. *In* Elliot, D.A. (Ed.) Mensuration for Management Planning of Exotic Forest Plantations. **NZFS, FRI Symposium No 20.** pp 315-33.

Jackson, D.S., Gifford, H.H., Chittenden, J., 1976. Environmental variables influencing the increment of *Pinus radiata*: (2) Effects of seasonal drought on height and diameter increment. **NZ Journal of Forestry Science 5:** 265-86.

Poole, D.J., 1986. Diameter growth of 4-7 year old *Eucalyptus regnans*. **NZ Forestry 31 (1)**, pp 23-24.

Tennent, R.B. 1986. Intra-annual growth of young *Pinus radiata* in New Zealand. **NZ Journal of Forestry Science 16(2):** pp 165-75.

West, G.G., Knowles, R.L., Koehler, A.R. 1982. Model to predict the effects of pruning and early thinning on the growth of radiata pine. **NZFS, FRI Bulletin No. 5.**