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Eucalyptus regnans Pruning Trial Interim Report: Branch Size, DOS, and Effect of Pruning on Growth

H. McKenzie

NZFRI

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EXECUTIVE SUMMARY

A pruning trial was established in 1992 at Pouturu Forest in 5 and 6-year old stands of *E. regnans* to assess the effect of pruning on: defect core size, risk of fungal infection via large branch stubs, stand growth in the following years and the extent of infection caused by pruning wounds by destructive sampling several years after the operation.
Interim results are presented and future plans for the trial outlined.
In the younger of the two study stands, volume was highly significantly different 2 years after the first pruning, and one year after the second pruning lift. At age 9 years, volume was significantly different being 12 % less in the pruned plots. Volume increment was highly significantly different in the two years after pruning but not in the following two years. In the older stand volume was not affected by pruning 3 years after treatment.
In both stands there were a large number of branches over 2.5 cm in diameter which increases the chance of infection. The diameter over stubs was 21 and 24 cm diameter in the two stands. Branch stubs are likely to be contained in the low-grade wood core. The next stage in the study will be to sectionally sample trees in both stands to assess the incidence and severity of stem decay.

EUCALYPTUS REGNANS PRUNING TRIAL
INTERIM REPORT: BRANCH SIZE, DOS AND EFFECT OF PRUNING ON GROWTH.

Heather McKenzie

INTRODUCTION

When the Management of Eucalypts Cooperative was formed in 1986 several members were interested in pruning *E. regnans*. The effect of pruning on growth and the incidence of internal decay were identified as requiring further investigation in a trial established in 1992. In this report, the initial stages of the pruning trial are described, results to date relating to pruning and growth are summarised and future plans for the trial outlined.

BACKGROUND

Sawlog production from eucalypts has been the subject of a small on-going programme at the New Zealand Forest Research Institute Ltd. for over 20 years. The research was initiated in parallel with the N.Z. Forest Service Policy of growing hardwoods for high quality timber. *Eucalyptus regnans* was considered to be a species suitable for the production high quality furniture and joinery. Pruning was considered necessary as branches would degrade timber for high quality end uses. During this period 550 ha of eucalypts, including a small area of *E. regnans*, were pruned by the Forest Service and Tasman Forestry Ltd. (Deadman and Caulderon, 1988).

Previous studies

A *E. regnans* regime trial was planted at Kaingaroa Forest in 1978 and incorporated treatments with no pruning, pruning in two lifts and pruning in three lifts. From the data collected at the time of pruning, diameter over stubs (DOS) equations were derived. Growth data collected at the time of pruning and one year later were also analysed (Deadman and Caulderon, 1988). The main conclusion from the DOS study was that because DOS was so much smaller in *E. regnans* than for *P. radiata* at a similar height, pruning could be left until the eucalypts are taller than the pine to achieve a similar DOS.

Growth rate data from this study showed that at a MTH of 12.8 m, a first lift to 2.5 m (removing 1 m of green crown) had no effect on growth, while a lift to 4 m (removing 2.5 m of green crown) caused a 6% loss in volume after one year. The maximum branch stub size was greater than 2.5 cm in a fifth of trees in the 4 m lift. When the 2nd (2.5-4 m) lift was applied to the three lift treatment a year later, a third of trees had a maximum branch stub of greater than 2.5 cm. An analysis of the effect of different levels of pruning on growth rate over more than one year could not be carried out because subsequent thinning of each treatment was to different stockings, and this may have interacted with the effect of pruning.

Decay

Decay commonly enters the stem of eucalypt trees via dead branch stubs. Pruned branches can also be a source of entry by decay agents especially *Chondrostereum purpureum*, a serious disease causing dieback (Gadgil and Bawden, 1981). The FRI (1982) recommended that pruning be timed to achieve pruned stub diameters of less than 2.5 cm diameter as one measure to reduce infection levels.

The spread of decay and its importance in the defect core zone of *E. regnans* was considered by Glass and McKenzie (1989). During a thinning operation in the Kaingaroa regime trial at age 8 years, 15 trees were examined by cross-sectioning at 12.5 cm intervals along the stem. In 12 trees, decay had spread beyond the pruning wounds in a longitudinal direction along the stem without spreading into wood laid down after pruning. Smaller branch stubs were less likely to be an entry points for decay than large branch stubs. This research supported the recommendation to prune branches when they are less than 2.5 cm.

The study of the defect cores indicated that brittle heart, which is related to growth stress, is likely to have more impact on the extent of the defect core zone than decay or branches.

Wood properties

The wood properties of *E. regnans* are not ideal for solid wood purposes, being difficult to dry successfully, (Haslett, 1988). There is a high level of collapse and internal checking following drying. Collapse can be recovered by reconditioning but internal checking is a permanent defect that down-grades timber for further processing. A recent sawing and drying study of a 22-year-old pruned *E. regnans* trees confirmed that drying degrade is a serious problem. The degree of internal checking in the dried sawn timber was related to the tree that the timber came from, but whether this tree variation was genetic or related to site influences is not known.

Kino, another defect that can be found in eucalypts, was so extensive in one of the 15 sample trees that it was replaced in the study.

Current status of eucalypt pruning

Interest in pruning eucalypts has declined since the trial was established. Forestry Tasmania is the only Cooperative member planting and managing significant areas for solid wood production but has now switched to *E. nitens*. In New Zealand two companies are planting eucalypts for pulpwood in the central North Island, a region where *E. regnans* was previously the preferred species. However both companies are planting *E. nitens* as their main species, with smaller areas planted in *E. fastigata*. The change to *E. nitens* has been due to reduced leaf defoliation by *Paropsis charybdis* following the introduction of a predator. *Eucalyptus regnans* has fallen out of favour because of health concerns - particularly leaf spot fungi and the development of some unhealthy stands. The author is not aware of any *E. regnans* being planted at present.

TRIAL OBJECTIVE

The objective of the Pouturu Forest trial was to:

- measure the effectiveness of pruning by assessing DOS;
- measure the impact of green crown removal on stand growth by measuring stand growth for several years;
- assess the impact of pruning on branch stub size;
- assess the degree of infection via pruning wounds by sectionally sampling trees at age 10 years or more (prior to stand clearfell).

METHOD

Two stands planted in 1986 and 1987 at Pouturu Forest were made available by the managers, P.F. Olsen and Co. Ltd., who also provided extensive assistance by measuring and pruning trees. The older stand (6 years old) was pruned in one lift to 6m and the younger stand (5 years old) was pruned in two lifts leaving 4 m of green crown on each occasion. The older stand was on a north-west slope and the younger in a valley bottom.

The original trial design was for six 80 x 40m blocks at each site, half of each block to be pruned and the other half left unpruned. The measurement plot was 20 x 20 m with a 10 metre surround. However, following plot establishment the stocking was found to be variable, requiring modification of the trial design. The new design was paired plots on the basis of stocking - one of each pair to be pruned. The instructions as to which plots were to be pruned were misunderstood and different plots were treated. This resulted in the treatments being considered as randomly assigned to plots and analysis undertaken on this basis.

ASSESSMENT

The following tree parameters were measured at time of pruning in all the 0.04 ha measurement plots:

1. dbh
2. total tree height
3. green crown: height above ground of the bottom of the green crown

and for all pruned trees:

1. height of lowest green branch
2. pruned height
3. DOS: largest diameter over stub(s)
4. DOS height: height at which DOS measured
5. maximum branch stub diameter at DOS
6. count of branches larger than 2.5 cm
7. maximum branch stub diameter over entire lift

Subsequent measurements were dbh of all trees and a sample of tree heights. The timing of assessments and pruning is shown in Table 1.

Table 1: Dates for assessments and pruning

Date	Block 1 Age(years)	Block 2 Age(years)	Operation
March 1992	5	6	Layout plots, mark height for pruning, prune trees, complete tree measurements
June 1993	6	7	Block 1 & 2 measured
November 1993		7.5	Block 2 measured
June 1994	7		Second pruning and measurement of block 1
August 1995	8	9	Block 1 & 2 measured
September 1996	9	10	Block 1& 2 (dbh) measured

Inconsistencies in the 1993 measurements meant that they were excluded from analysis.

RESULTS

Mean stand parameters for block 1, pruned and unpruned plots are shown in Tables 2 and 3.

Table 2: Block 1 pruned plots: stocking, mean tree size and stand volume.

Age (years)	Live stocking (stems/ha)	Dead (s/ha)	Crown Ht (m)	Mean dbh (cm)	Mean Ht (m)	Volume (m^3/ha)
5	508	0	1.1	15.2	11.4	41.7
7	504	4	7.7	19.5	14.3	84.7
8	492	13		21.3	16.4	112.5
9	458	33		22.6	17.7	125.7

Table 3: Block 1 unpruned plots: stocking, mean tree size and stand volume.

Age (years)	Live stocking (stems/ha)	Dead (s/ha)	Windblown (s/ha)	Crown Ht (m)	Mean dbh (cm)	Mean Ht (m)	Volume (m^3/ha)
5	563	0	0	1.4	15.7	11.8	51.6
7	558	5	0		21.8	14.9	120.9
8	525	25	8		23.8	17.1	153.9
9	483	42	0		25.0	18.3	167.3

Mean stand parameters for block 2, pruned and unpruned plots are shown in Tables 4 and 5.

Table 4: Block 2 pruned plots: stocking, mean tree size and stand volume.

Age (years)	Live Stocking(s/ha)	Dead (s/ha)	Crown Ht (m)	Mean dbh (cm)	Mean Ht (m)	Volume (m^3/ha)
6	513	0	2.0	19.0	16.5	99.9
9	509	4*		26.4	22.6	253.3
10	501	8		27.5		

*felled tree in one plot.

Table 5: Block 2 unpruned plots: stocking, mean tree size and stand volume.

Age (years)	Live Stocking(s/ha)	Dead (s/ha)	Crown Ht (m)	Mean dbh (cm)	Mean Ht (m)	Volume (m³/ha)
6	475	0	1.7	17.9	14.7	69.0
9	463	12		26.4	20.6	200.8
10	458	5		27.5		

Pruning related data collected in block 1 at time of 1st and 2nd pruning lifts and block 2 when it was pruned, are shown in Table 6.

Table 6: Data collected at time of pruning

Block/lift:	1/1	1/2	2/1
Pruned trees (stems/ha)	504	488	471
Pruned height (m)	5.6	6.4	6.3
Lowest green branch height (m)	0.6		1.0
Crown height (m)	1.1	7.7	2.1
Mean tree height (m)	11.4	14.3	16.5
Mean dbh (cm)	15.2	19.5	19.0
DOS (cm)	20.6	17.6	23.7
DOS Ht (m)	0.6		0.5
DOS Branch Diameter (cm)	6.5		7.4
Diameter largest branch in lift (cm)	8.1		9.2
Number of branches>2.5 cm	8.2	1.7	7.1

ANALYSIS

Tree data was summarised at a plot level to provide mean tree and per hectare values as appropriate. The data is shown in Appendix 1. An analysis of covariance, with the covariate being initial values and stocking, was undertaken to determine if growth was affected by pruning. The analysis is shown in Tables 7 and 8.

Table 7: Analysis of covariance block 1

Variable	Actual		Adjusted for initial size & stocking		P Value
	Unpruned	Pruned	Unpruned	Pruned	
Stocking (s/ha)	563	508			
dbh age 5 (cm)	15.7	15.2			
dbh age 7 (cm)	21.8	19.5	21.7	19.7	0.0002
dbh age 8 (cm)	23.8	21.3	23.7	21.5	0.005
dbh age 5 (cm)	25.0	22.6	24.8	22.8	0.008
dbh inc 5-7 yrs (cm)	6.1	4.3	6.2	4.2	0.0001
dbh inc 7-8 yrs (cm)	2.0	1.8	2.1	1.7	0.34
dbh inc 8-9 yrs (cm)	1.2	1.3	1.2	1.3	0.80
Height age 5 years (m)	11.8	11.4			
Height age 7 years (m)	14.9	14.3	14.7	14.5	0.29
Height age 8 years (m)	17.1	16.4	17.0	16.5	0.01
Height age 9 years (m)	18.3	17.7	18.2	17.8	0.049
Height inc 5-7 yrs (m)	3.1	2.9	3.1	2.9	0.32
Height inc 7-8 yrs (m)	2.3	2.1	2.3	2.1	0.39
Height inc 8-9 yrs (m)	1.2	1.3	1.2	1.3	0.65
Volume age 5 (m^3/ha)	51.6	41.7			
Volume age 5 (m^3/ha)	120.9	84.8	112.5	93.1	0.0007
Volume age 8 (m^3/ha)	154.1	112.5	143.9	122.7	0.001
Volume age 9 (m^3/ha)	167.3	125.7	156.2	136.9	0.026
Volume inc 5-7 yrs (m^3/ha)	69.3	43.0	66.8	45.5	0.0003
Volume inc 7-8 yrs (m^3/ha)	33.3	27.7	31.5	29.5	0.33
Volume inc 8-9 yrs (m^3/ha)	13.4	13.3	12.8	13.9	0.75

Table 8: Analysis of covariance Block 2

Variable	Actual		Adjusted for initial size & stocking		P Value
	Unpruned	Pruned	Unpruned	Pruned	
Stocking (s/ha)	475	513			
dbh age 6 (cm)	17.9	19.0			
dbh age 9 (cm)	26.3	26.4	26.8	26.0	0.061
dbh age 10 (cm)	27.5	27.5	27.8	27.2	0.31
dbh inc 6-9 yrs (cm)	8.5	7.4	8.4	7.5	0.036
dbh inc 9-10 yrs (cm)	1.2	1.1	1.1	1.1	0.99
Height age 6 years (m)	14.7	16.5			
Height age 9 years (m)	20.6	22.6	21.5	21.6	0.75
Height inc 6-9 yrs (m)	5.9	6.1	5.9	6.1	0.46
Volume age 6 (m^3/ha)	69.0	100.3			
Volume age 9 (m^3/ha)	200.8	253.4	229.1	225.1	0.76
Volume inc 6-9 yrs (m^3/ha)	131.7	153.1	136.1	148.7	0.47

In block 1 the mean diameter at all ages was highly significantly different between the pruned and unpruned treatments. Diameter *increment* in the two year period between the first and second pruning lifts (age 5 -7 years) was also highly significantly different but there was no significant difference in diameter *increments* in the following two years. Height was not significantly different 2 years after the first pruning lift but there were differences in the following two years. Height *increments* were not significantly different at any time. Volume was highly significantly different 2 years after the first pruning, and one year after the second pruning lift. At age 9 years it was significantly different being 12 % less. Volume *increment* was highly significantly different in the two years after pruning but not in the following two years.

In block 2 diameter increment was significantly different in the 3 year period after pruning however the mean diameter at age 9 and 10 was not significantly different. Height and volume were not affected by pruning 3 years after treatment.

FUTURE ASSESSMENT

It is proposed to fell 12 trees per treatment in both blocks, and cut cross-sections at 25 cm intervals. If any decay systems are discovered, thin sections will be cut in a similar fashion to the Glass and Mckenzie (1989) study to identify the source of infection. The longitudinal and radial extent of decay systems will also be measured.

CONCLUSION

The two blocks were located in stands on different site types; block 2 had remained healthier with few dead stems whilst block 1 has had quite high mortality and appears less healthy. The unadjusted stand volume in the unpruned treatment in block 1 at age 9 is 167 m^3/ha compared with 201 m^3/ha in block 2, which has fewer stems per hectare. Although the pruning at an earlier stage in block 1 (mean height about 11.5 m compared with about 15 m in block 2) led to a reduction in growth for at least 2 years after pruning, further testing would be required to determine if the response was associated with the stand height or if there was an interaction with the particular site. The mortality is similar in pruned and unpruned treatments suggesting that pruning has not contributed to the poor health.

In both stands, there were a large number of branches over 2.5 cm in diameter, on average 7 branches in the older stand pruned in one lift, and 10 branches in the combined lifts in the younger stand. Pruning the younger stand did not reduce the frequency of branches over 2.5 cm. This may be related to site differences. The largest branches were very large with a mean for both blocks of over 7 cm.

The diameter over stubs was 21 and 24 cm diameter for blocks 1 and 2 respectively. This indicates branch stubs would be contained within the low-grade core zone and hence would not be a constraint in sawn timber yield.

The next crucial stage in the study will be to sectionally sample trees in both stands to assess the incidence and severity of stem decay which will be undertaken shortly when the stands are to be clearfelled.

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Appendix 1: Plot data for Blocks 1 and 2 in the pruning trial.

Block 1 pruned plots growth data

plot	Age (years)	Live stocking (stems/ha)	dead stems/ha	Crown Height (m)	Mean dbh (cm)	Mean Height (m)	Volume (m^3/ha)
1	4.9	300		0.6	14.3	9.8	18.5
	7	300		6.7	18.7	12.6	39.9
	8.1	250	50		20.6	14.9	47.5
	9.2	200	50		21.9	16.1	46.8
4	4.9	450		1	15.1	11.3	35.2
	7	450		7.4	19.6	14.2	73.3
	8.1	450			21.1	16.5	99.6
	9.2	450			22	17.4	114.9
6	4.9	450		1.1	16.2	12	43.7
	7	450		7.9	20.5	15	86.9
	8.1	425	25		23.1	16.5	115.6
	9.2	350	75		25.6	18.5	128.4
7	4.9	625		1.2	15.4	11.2	51.1
	7	625		7.9	19.9	14.5	109.8
	8.1	625			21.2	16.5	142.1
	9.2	625			22	17.6	163.4
9	4.9	600		1.1	14.9	11.6	47.1
	7	575	25	7.8	19	14.4	90.7
	8.1	575			20.8	16.8	126.3
	9.2	525	50		22.2	17.9	139.6
11	4.9	625		1.3	15.3	12.3	54.7
	7	625		8.6	19.4	15	107.9
	8.1	625			21.1	17	143.8
	9.2	600	25		21.9	18.4	161.3

Block 1 unpruned plots growth data

plot	Age (years)	Live stocking (stems/ha)	dead stems/ ha	windblown stems/ha	Crown Height (m)	Mean dbh (cm)	Mean Height (m)	Volume (m^3/ha)
2	4.9	550			1.1	15.3	11.4	44.7
	7	550				21.6	14.8	115
	8.1	500	25	25		23.3	17	147.1
	9.2	475	25			24.4	17.9	154.4
3	4.9	350			1	15.6	10.4	27.6
	7	350				23	13.7	78.8
	8.1	275	50	25		26.9	16.6	101.6
	9.2	275				27.9	17.8	119.6
5	4.9	500			1	14.7	11.2	37.1
	7	475	25			21.5	15	99.5
	8.1	475				23.1	16.8	127.3
	9.2	450	25			24	17.9	140.1
8	4.9	675			1.6	16.8	12.7	73.1
	7	675				22.2	15.7	157.2
	8.1	650	25			23.6	17.7	194.8
	9.2	600	50			24.7	19	212.3
10	4.9	675			1.6	16.3	12.7	70.6
	7	675	0			22	15.6	156.4
	8.1	650	25			23.9	17.4	197.1
	9.2	575	75			25.2	19	212.4
13	4.9	625			1.8	15.5	12.2	56.2
	7	625				20.6	14.5	118.2
	8.1	600	25			21.9	17.3	155.5
	9.2	525	75			23.6	18.4	165.1

Block 2: pruned plots growth data

plot	Age (years)	Live Stocking (s/ha)	Dead Stems/ ha	Crown Ht (m)	Mean dbh (cm)	Mean Height (m)	Volume (m^3/ha)
1	5.9	550		0	16.1	15.8	67.8
	9.1	550			23.3	22.3	203.4
	10.2	525	25		24.8		
5	5.9	475		1.8	18.4	16.2	74.8
	9.1	450	25*		27.1	22.4	229.3
	10.2	425	25		29.4		
6	5.9	350		1.2	15.5	14.2	36.2
	9.1	350			24.2	20.3	128.4
	10.2	350			25.4		
7	5.9	575		2.2	20.9	18.2	138.4
	9.1	575			27.9	24.2	329.3
	10.2	575			28.5		
8	5.9	675		2.9	22.2	17.7	177.2
	9.1	675			28.3	23.8	387.1
	10.2	675			28.3		
9	5.9	475		1.9	20.8	16.7	104.7
	9.1	475			27.6	22.3	242.6
	10.2	475			28.5		

*felled tree

Block 2 unpruned plots growth data

plot	Age (years)	Live Stocking (s/ha)	Dead Stems/ha	Crown Ht (m)	Mean dbh (cm)	Mean Height (m)	Volume (m^3/ha)
2	5.9	600		2.5	18.2	15.3	91.3
	9.1	600			26.6	21.6	279.8
	10.2	600			27.8		
3	5.9	500		1.8	18.1	16.3	81.7
	9.1	500			26.7	22.3	240.7
	10.2	475	25		28.5		
4	5.9	250		1.8	18.6	14	37.1
	9.1	250			28.6	20	123.9
	10.2	250			30		
10	5.9	475		1.8	21	15.3	97.5
	9.1	450	25		29	20.9	243
	10.2	450			29.8		
11	5.9	400		0.9	15.8	13.4	42.4
	9.1	400			24.5	19.9	147.3
	10.2	400			25.6		
12	5.9	625		1.3	15.5	13.8	64.2
	9.1	575	50		22.7	18.7	169.9
	10.2	575			23.4		

Pruning related data block 1 in the first lift at age 5 and the second lift at age 7 years

plot	lift	Crown Height (m)	Mean dbh (cm)	Mean height (m)	Pruned stem/ha	Pruned height (m)	DOS (cm)	DOS height (m)	Branch diameter(cm)	height lowest green branch (m)	maximum branch diameter(cm)	Number of branches >2.5 cm
1	1	0.6	14.3	9.8	275	5	21.1	0.6	7.7	0.4	8.2	11.9
	2	6.7	18.7	12.6	225	6	17.4					2.5
4	1	1	15.1	11.3	450	5.8	20.3	0.5	5.3	0.5	7.7	8.5
	2	7.4	19.6	14.2	450	6.7	18.9					1.8
6	1	1.1	16.2	12	450	6.2	21.7	0.5	6.2	0.7	7.9	5.6
	2	7.9	20.5	15	450	6.4	18.7					0.8
7	1	1.2	15.4	11.2	625	5.3	20.5	0.7	6.7	0.7	8.3	7.8
	2	7.9	19.9	14.5	625	6.4	16.4					2.2
9	1	1.1	14.9	11.6	600	5.6	19.4	0.8	6.3	0.5	7.8	7.4
	2	7.8	19	14.4	550	6.6	17.4					1.7
11	1	1.3	15.3	12.3	625	5.4	20.3	0.6	7	0.6	8.6	7.8
	2	8.6	19.4	15	625	6.1	16.9					0.9

Pruning related data collected at age 5.9 years Block 2

plot	Crown Height (m)	Mean dbh (cm)	Mean height (m)	Pruned stem/ha	Pruned height (m)	DOS (cm)	DOS height (m)	Branch diameter(cm)	height lowest green branch (m)	maximum branch diameter(cm)	Number of branches >2.5 cm
1	2.8	16.1	15.8	550	6.3	20.6	0.4	6.5	1.5	7.2	5
5	1.8	18.4	16.2	475	6.2	23.2	0.4	7.3	0.7	9	8.2
6	1.2	15.5	14.2	300	6	22.7	0.6	10.2	0.5	10	7.9
7	2.2	20.9	18.2	575	6.5	24.8	0.4	5.9	0.9	9.7	6.2
8	2.9	22.2	17.7	675	6.5	25.5	0.8	7.7	1.8	10.3	7
9	1.9	20.8	16.7	250	6.5	25.5	0.5	6.7	0.8	8.8	8.5