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Analysis of Douglas-fir Regime Trials

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EXECUTIVE SUMMARY

The Douglas-fir regime trials were set up to enable different regimes to be modelled across a range of sites. Most of the data has been used to build growth models for incorporation into the Douglas-fir calculator. This analysis aims to show clearly how growth rates were affected by different regimes and whether the differences were considered to be significant.

Early plantings of Douglas-fir received no silviculture and took a long time to reach sufficient size for harvest. Work done on radiata pine plantations showed that properly treated stands were healthier and could be harvested much sooner.

Foresters of the New Zealand Forest Service set up thinning trials in Douglas-fir stands to test a range of stockings and found that the stands responded well to choosing the best trees and releasing them from competition. These early trials left some unanswered questions, so shortly after the Douglas-fir research co-operative was formed it commissioned two thinning and pruning trials and five trials to test the timing of thinning as well as a range of stockings.

The seven trials required a lot of time to record the response of the trees to thinning and pruning. The two pruning trials were thinned to 250, 500 and 750 stems per hectare (spha) in 1993, so have had eighteen years of subsequent growth. The aggressive pruning treatments were completed early but the treatment to leave eight metres of green crown pruning took some time. The planned treatment to prune to twelve metres was abandoned and replaced by pruning to six, eight and ten metres.

Pruning does cost growth rate. A decision to prune only 250 spha complicated the growth of the pruned trees, with competition from unpruned “follower” trees. The trees in the 250 spha unpruned plots were always bigger than those in the pruned plots, although this was caused by a small initial drop in growth followed by the same rate of growth for pruned or unpruned. Aggressive pruning to a four-metre green crown caused the most growth loss, but these trees caught up with the other pruned treatments later on. At Kaingaroa the followers remained sub-dominant, but at Ribbonwood they had caught up and passed the pruned trees.

At age thirty, the highest stockings have the greatest volume, but the short green crowns and the beginning of mortality predict that lower stockings would be better in the long run. The lowest stockings have the best diameter growth but were losing out badly in volume growth. The 500 spha stocking produces diameter and volume growth in the middle of the range to age thirty.

Early thinning resulted in the best growth rates, as competition had started to shrink the green crown by the time of the later thinning treatments. The drop-off in the rate of growth with the later thinning treatments might have been caused by damage to the green crowns of the remaining trees.

These trials were set up with options to do production thins, but these are not due yet. Without production thinning, these trials suggest thinning to 500 spha at a height of eight metres was optimal. If a premium price for pruned logs could compensate for a small loss of volume and the cost of pruning, then pruning to a four-metre green crown would be most effective. This aggressive pruning cost initial growth rate over pruning to a six- or eight-metre green crown, but the trees caught up before age thirty.

INTRODUCTION

There are more than 500 permanent sample plots (PSP) in New Zealand Douglas-fir stands. As the stocking of these stands has been changed by thinning, some ideas of the correct stockings for a given age have emerged and been incorporated into growth models. However, the response to thinning is confounded by microsite effects and by the arrival of Swiss needlecast (*Phaeocryptopus guaemannii*) on many sites in the 1960s and 1970s.

Some of the foresters employed by the Forest Service set up thinning trials, which provided better data than having different treatments in different stands. However, these tended to be a single block for each treatment (unreplicated), hence any predictions were prone to large errors. These trials are NN399, RO698, RO775, RO776 and RO906.

The Douglas-fir research co-operative was formed in 1993 and new trials were established. There were two thinning and pruning trials;

- FR191 in a stand in Kaingaroa compartment 96 planted in 1982. FR191 is the only planting featuring the faster growing Fort Bragg provenance from California.
- FR206 in a stand in Ribbonwood station planted in 1981, near Omarama. It started life as a stocking trial with trees planted at 830, 1200 and 2000 stems per hectare (spha), and there are untreated blocks at these original stockings.

A response surface thinning trial was also marked out on five sites where reasonably homogeneous stands had been planted at stockings from 1600-2000 spha. The design had the greatest number of plots for the most likely stocking of 500 spha, with the fewest plots for extremes of 150 spha and no thinning.
Trials are:

- FR212 (Kaingaroa) has been set up with six extra plots at 500 and 750 spha to allow for a “production thin” at age 30 (2013)
- FR213 (Blue Mountains),
- FR245 (Hanmer),
- FR246 (Berwick) and
- FR277 (Castle Downs).

This Project quantifies the effects of various levels of pruning severity, in conjunction with likely thinning treatments on tree growth. If the effects of these treatments on growth are shown to be significantly different, they should be fitted to the growth model.

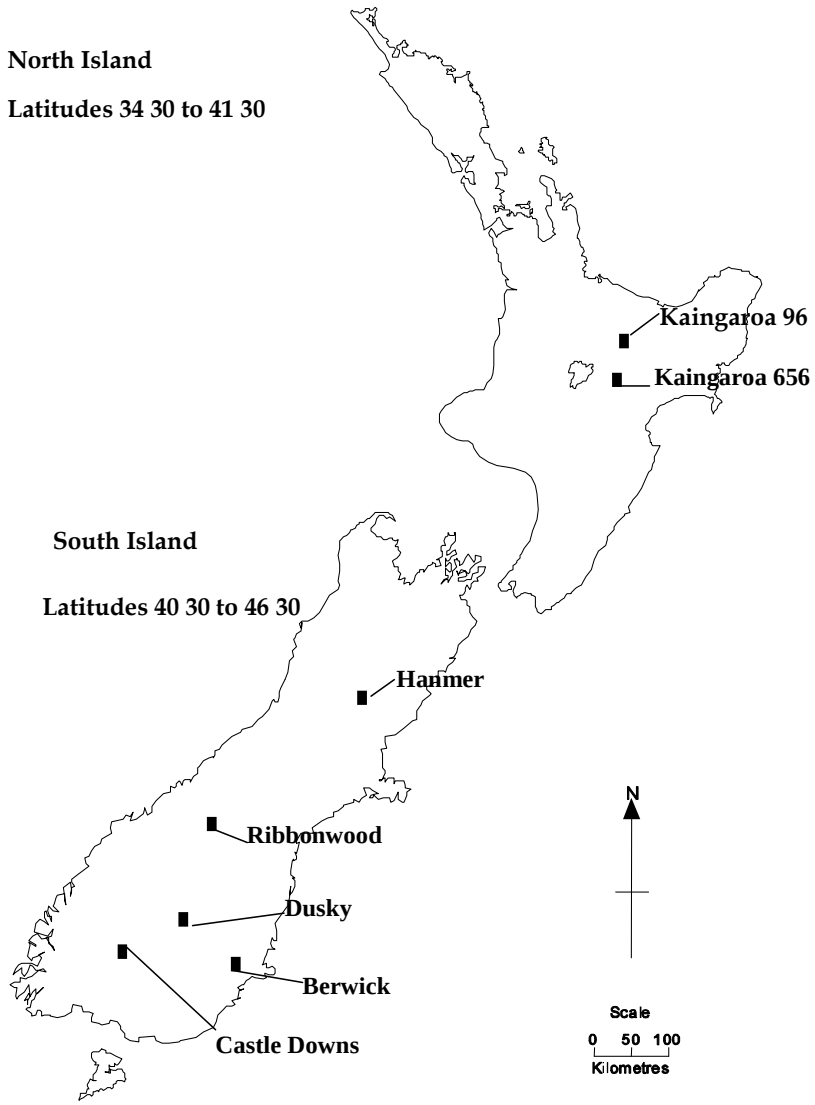
METHODS: OVERVIEW OF DOUGLAS-FIR REGIME TRIALS

New Zealand Douglas-fir regime trials analysed are in Table 1 and their locations are in Figure 1.

Table 1. Details of Douglas-fir regime trials

Plot	Forest	Cpt	Altitude	Planted	Trial	Seedlot	Remarks
FR191	Kaingaroa	96	420	1982	1993	Ft Bragg	Thinning and pruning
FR206	Ribbonwood		650	1983	1993	Ashley	Thinning and pruning
FR212	Kaingaroa	656	780	1983	1994	Ashley	Thinning only
FR245	Hanmer	30	520	1984	1995	Ashley	Thinning only, microsite effects
FR213	Dusky	101	300	1984	1996	Beaumont	Thinning only
FR246	Berwick	320	530	1981	1995	unknown	Thinning only
FR277	Castle Downs	853	500	1985	1996	Beaumont	Thinning only

Figure 1. Location of the Douglas-fir regime trials across New Zealand.



Kaingaroa Cpt. 96

The allocation of treatments to plots in trial FR191, compartment 96 Kaingaroa, was very complicated. There were supposed to be three pruning heights of 0, 6 & 12 metres where the green crown after pruning was at 4, 6 or 8 metres. Apparently the pruning to 12 metres was deemed too difficult and the plots nominated for this pruning were pruned to 6, 8 or 10 metres.

The pruning treatments were fitted to what were supposed to be two stockings of 250 stems per hectare (spha) and 500 spha. However, many plots were destined to be thinned to 250 spha, but also had a further 250 or 500 spha of unpruned trees, known as followers. Therefore the trial has three stockings of 250, 500 and 750 spha, with unpruned followers complicating plot mean diameters and crown lengths in pruned plots at higher stockings.

Fortunately there was a group of four plots that were thinned to 500 spha and had all trees pruned. This group was supposed to anchor the other treatments around the conventional “best practice” treatment. Details of plots and treatments can be found in Table 2.

Table 2. Treatments for plots in Compartment 96, Kaingaroa

Plot No.	Replicate	Pruning height	Crown length	Final crop stocking	Number of followers	Treatment name
12	1	0	0	250	0	NP250
22	2	0	0	250	0	NP250
25	1	0	0	250	0	NP250
34	2	0	0	250	0	NP250
3	1	0	0	250	250	NP500
18	2	0	0	250	250	NP500
43	2	0	0	250	250	NP500
48	1	0	0	250	250	NP500
11	1	0	0	250	500	NP750
28	2	0	0	250	500	NP750
37	1	0	0	250	500	NP750
42	2	0	0	250	500	NP750
5	1	10	4	250	0	P10_25_4
29	2	10	4	250	0	P10_25_4
8	2	10	4	250	250	P10_50_4
31	2	10	4	250	250	P10_50_4
13	1	10	4	250	500	P10_75_4
39	2	10	4	250	500	P10_75_4
10	2	9	6	250	500	P10_75_6
32	2	9	6	250	500	P10_75_6
14	1	6	4	250	0	P6_25_4
41	2	6	4	250	0	P6_25_4
4	1	6	6	250	0	P6_25_6
7	2	6	6	250	0	P6_25_6
35	1	7	6	250	0	P6_25_6
27	1	6	8	250	0	P6_25_8
38	2	6	8	250	0	P6_25_8

Plot No.	Replicate	Pruning height	Crown length	Final crop stocking	Number of followers	Treatment name
47	1	6	8	250	0	P6_25_8
49	2	6	8	250	0	P6_25_8
6	1	6	6	500	0	P6_50_0
16	2	6	6	500	0	P6_50_0
26	3	6	6	500	0	P6_50_0
52	4	6	6	500	0	P6_50_0
17	1	6	4	250	250	P6_50_4
30	2	6	4	250	250	P6_50_4
36	1	6	6	250	250	P6_50_6
44	2	6	6	250	250	P6_50_6
21	2	6	8	250	250	P6_50_8
24	2	6	8	250	250	P6_50_8
45	1	6	8	250	250	P6_50_8
51	1	7	8	250	250	P6_50_8
19	2	6	4	250	500	P6_75_4
50	1	6	4	250	500	P6_75_4
1	1	6	6	250	500	P6_75_6
9	2	6	6	250	500	P6_75_6
23	1	6	6	250	500	P6_75_6
20	2	6	8	250	500	P6_75_8
33	1	6	8	250	500	P6_75_8
46	2	7	8	250	500	P6_75_8
15	2	8	6	250	0	P8_25_6
40	2	8	6	250	250	P8_50_6
2	1	8	8	250	250	P8_50_8

Kaingaroa Cpt. 96 Results

The pruning and thinning trial (FR191) in Kaingaroa compartment 96 has the most comprehensive range of treatments, so will be described first. Growth of this Fort Bragg seedlot is extremely good, with the PSP system calculating site indices for each plot that vary from 38 metres (at 40 years of age) to 41 metres.

Most treatments were replicated with at least three plots, so these were averaged to graph growth over time. All comparisons contain the plots that were thinned to 500 spha and all trees pruned to 6 metres. There were 22 treatments, so it was decided to look at them in groups of unpruned plots, plots thinned to 250 spha, plots thinned to 750 spha and plots pruned higher than six metres. Stocking rates were fixed by thinning at the start of the trial and there was very little mortality.

An analysis of variance was run on the individual tree data using the Tukey multiple range test to estimate the least significant differences (LSD) for diameter and height. Height did not differ much between treatments. Diameters were significantly different for treatments with an LSD of 1.2 cm on mean diameters by treatment that ranged from 14 to 18 cm at age 11. This showed that there was some microsite variation not overcome by replication.

The LSD increased slightly for each assessment, reaching 4 cm at age 29 when treatment mean diameters ranged between 29 and 45 cm. By this age the differences made sense, with all of the stocking treatments grouped together quite tightly and large differences between stockings.

The first set of graphs compares the unpruned treatments to get an unbiased evaluation of different stocking rates. This is straightforward, with the low stocking of 250 spha giving greatest diameter growth (Figure 2) and the highest stocking of 750 having much less. The unpruned 500 spha stocked plots were in the middle, with the both pruned and unpruned plots very close.

Volume growth (Figure 3) is the complete opposite with the 750 spha plot continuing to pull away out to age 29 years, where it had about 80% more volume than the 250 spha plot.

Height growth (Figure 4) was not affected to anywhere near the same extent, but changes in the length of the green crown (Figure 5) were marked by age 29. The lower stockings retained greater lengths of green crown, which will give them an advantage in the near future.

Figure 2. Douglas-fir diameter growth (mm) for unpruned plots at Kaingaroa Cpt. 96.

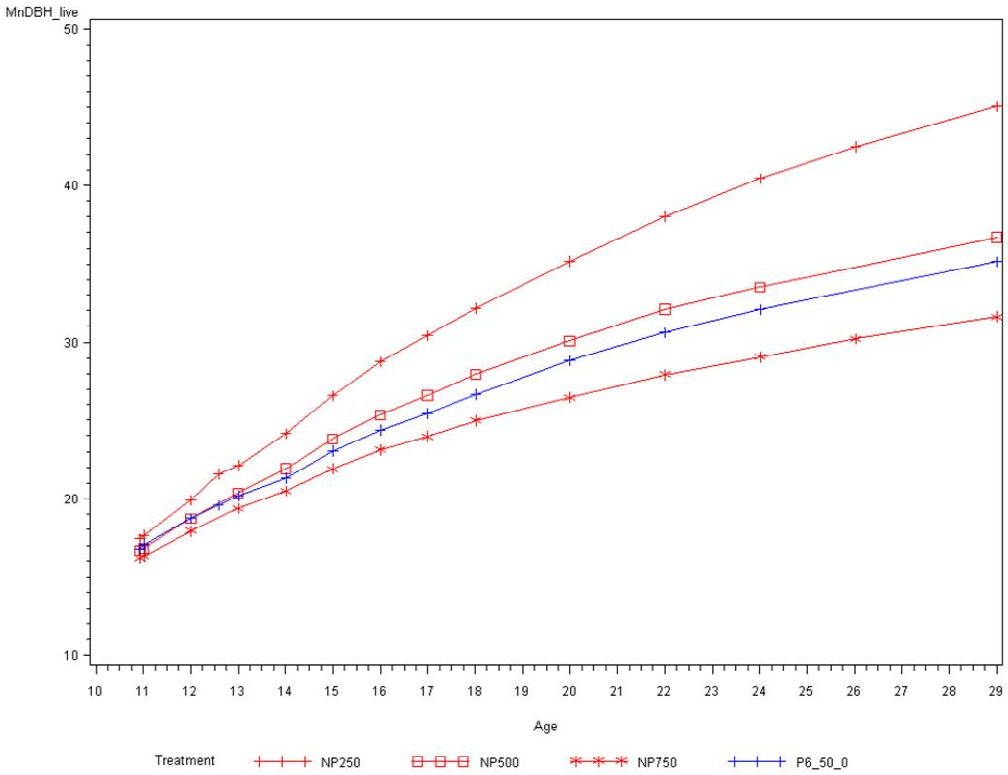


Figure 3. Douglas-fir volume growth m^3 / hectare by age for unpruned plots at Kaingaroa Cpt 96.

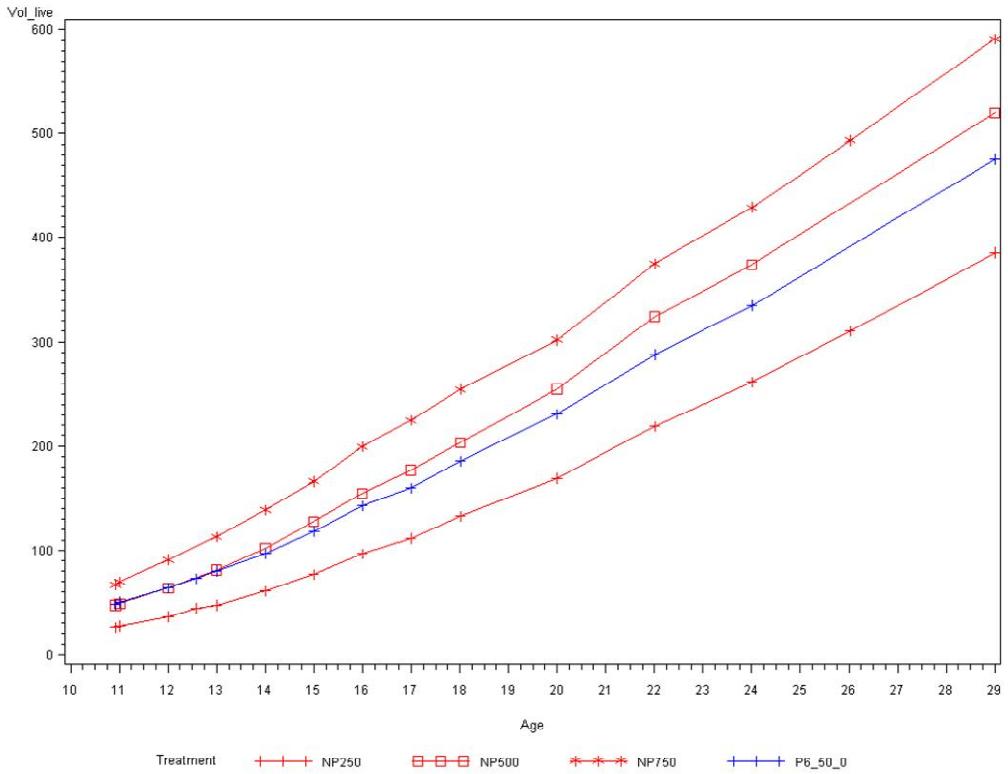


Figure 4. Douglas-fir height growth (metres) for unpruned plots at Kaingaroa Cpt 96.

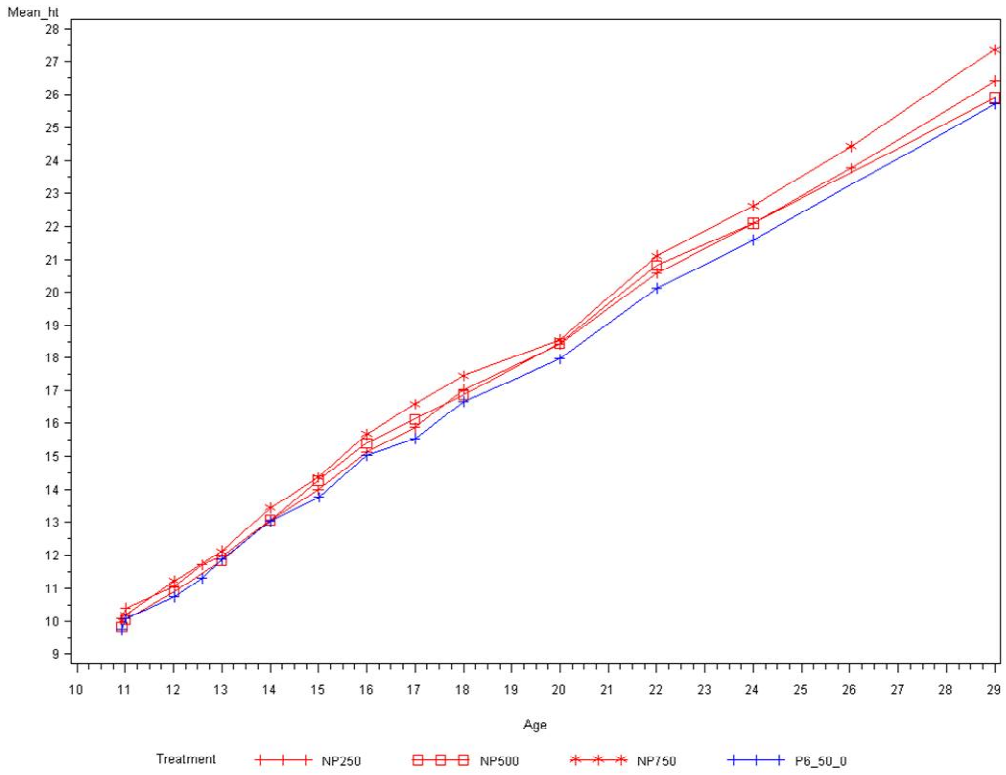
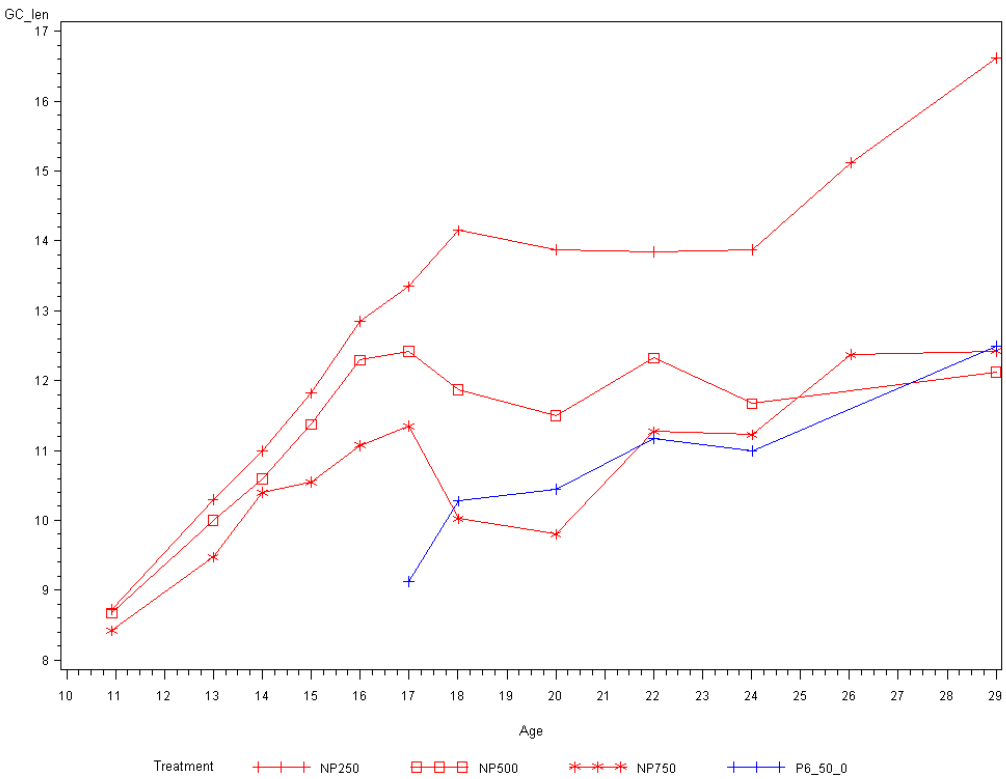


Figure 5. Douglas-fir green crown growth (metres) for unpruned plots at Kaingaroa Cpt 96.



The next sets of comparisons involved pruning at constant stocking rates to leave four, six or eight metre lengths of green crown as well as unpruned plots. The pruning started relatively late as the ten-year-old trees were around 10 metres tall. Pruning in radiata pine or cypress stands usually starts at a height of six metres, when the trees may be only four years old.

Practically all of the six-metre lift was achieved in the first lift to leave a four-metre green crown. A second lift, two years later completed the pruning on this, the hardest schedule. The pruning to a six-metre green crown had a third lift at age 14 and the pruning to an eight- or ten-metre green crown had a fourth lift at age 16 in some plots.

The 250 spha stocking had all trees pruned, so growth is not complicated by unpruned followers. The pruning to a four-metre green crown definitely slows both diameter and volume growth (Figures 6 & 7) immediately after the first lift. However, the trees appear to be catching up to the milder pruning treatments by age 29, so overall growth has not been lost against milder treatments. The unpruned treatment enjoys a small diameter advantage of about 4 cm over the pruned treatments at age 29, so the difference is marginally significant. The 500 spha pruned treatment has opened up a wide margin for volume, however.

The diameter and volume growth of the 500 spha plots (Figures 8 & 9) are so close that the differences are not significant. The growth disadvantage from the most aggressive pruning was considered to be within the error of estimation, as the numbers of trees involved in each treatment were small. The treatment where all 500 trees were pruned is very similar to treatments with 250 spha pruned.

The diameter and volume growth (Figures 10 & 11) of the 750 spha plots are also grouped quite closely together. The larger diameter yet smaller volume of the 500 spha pruned treatment shows the extent of the significant tradeoff between the larger volume of small logs versus the smaller volume of large logs.

The diameter growth (Figure 12) of the plots thinned to 250 spha and pruned to 8 and 10 metres, showed that the aggressive pruning to a 4-metre green crown slowed diameter growth to below that of the 500 spha treatments. However, the trees had recovered the lost diameter by age 29. The graph of volume growth (Figure 13) showed that the combination of low stocking and hard pruning cost a lot of valuable volume.

The 500 and 750 spha treatments have only 250 spha pruned, so unpruned followers remain. The PSP system has tagged which trees were pruned, so the pruned and unpruned trees could be separated and analysed as separate treatments. This was done, and it showed that the mean diameters (Figure 14) of the followers started smaller than the better trees that were selected for pruning. Interestingly, the difference remained fairly constant, although the diameter of both pruned and follower trees lagged behind that of the unpruned 250 spha trees.

Figure 6. Douglas-fir diameter growth (mm) for pruned 250 spha at Kaingaroa Cpt 96.

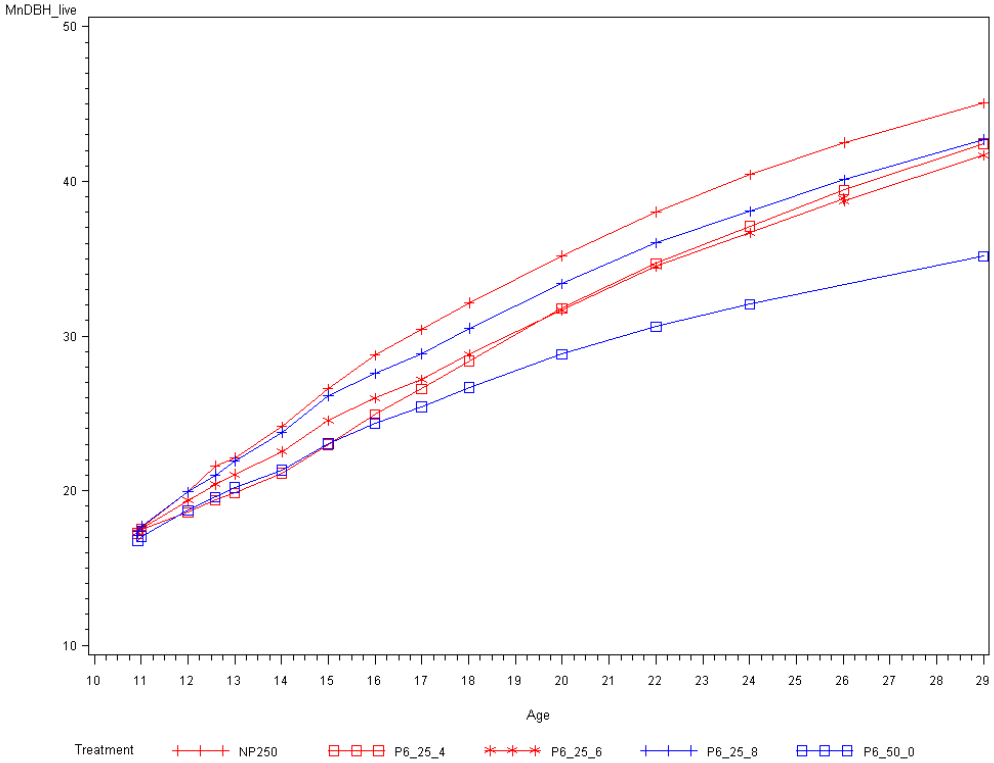


Figure 7. Douglas-fir volume growth (m^3 / hectare) by age for pruned 250 spha at Kaingaroa Cpt 96.

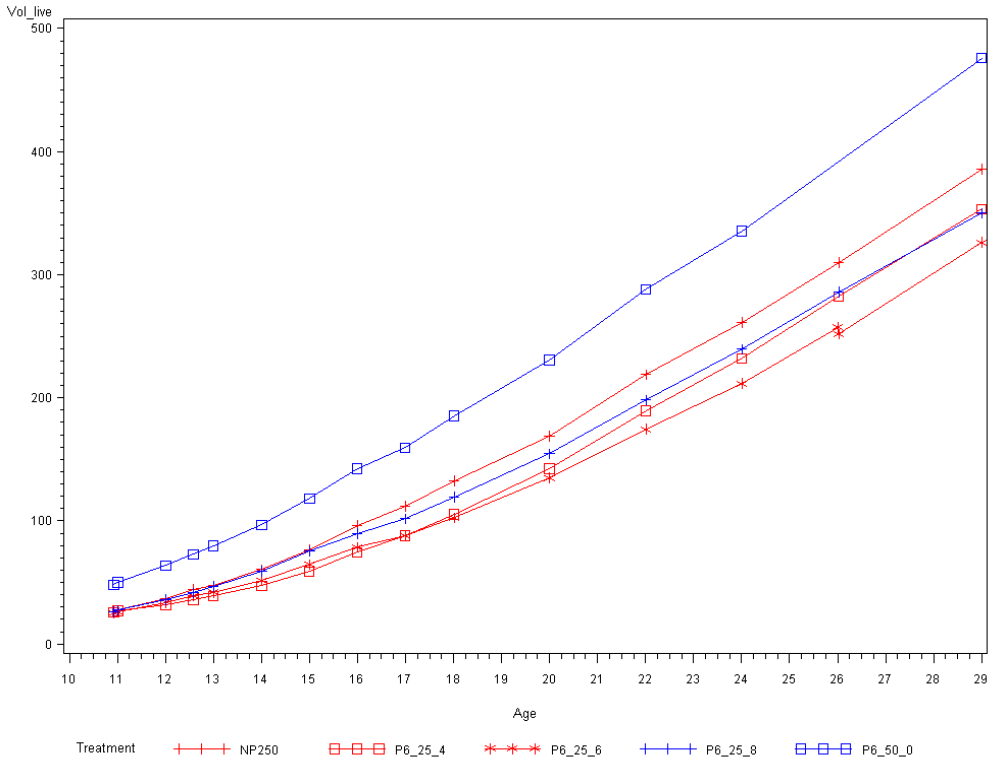


Figure 8. Douglas-fir diameter growth (mm) for pruned 500 spha at Kaingaroa Cpt 96

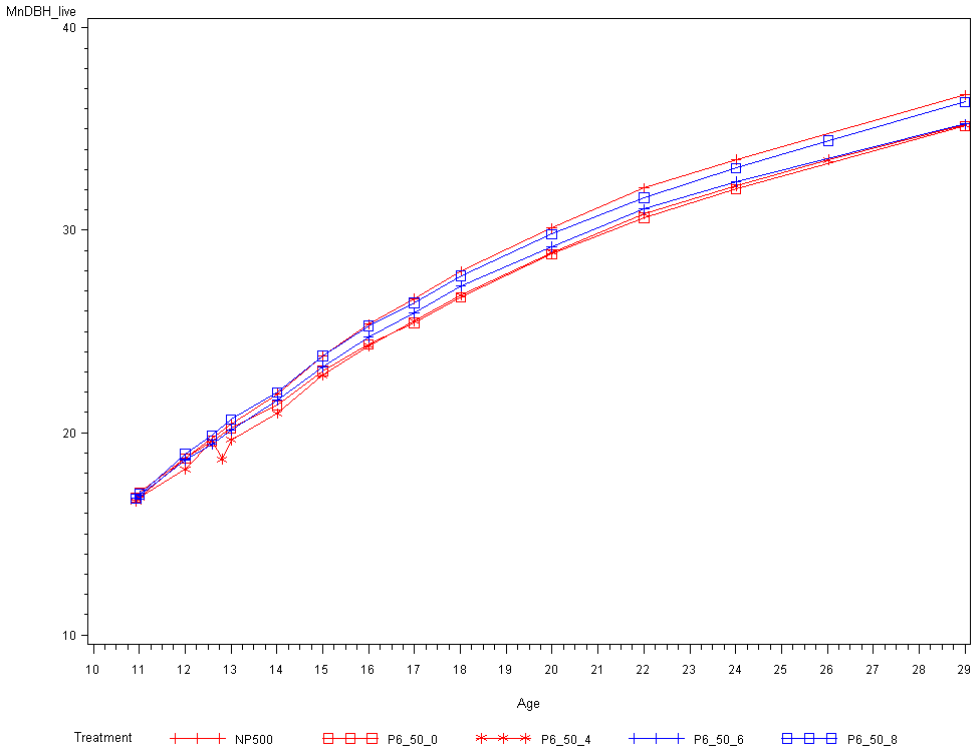


Figure 9. Douglas-fir volume growth (m^3 / hectare) by age for pruned 500 spha at Kaingaroa Cpt 96.

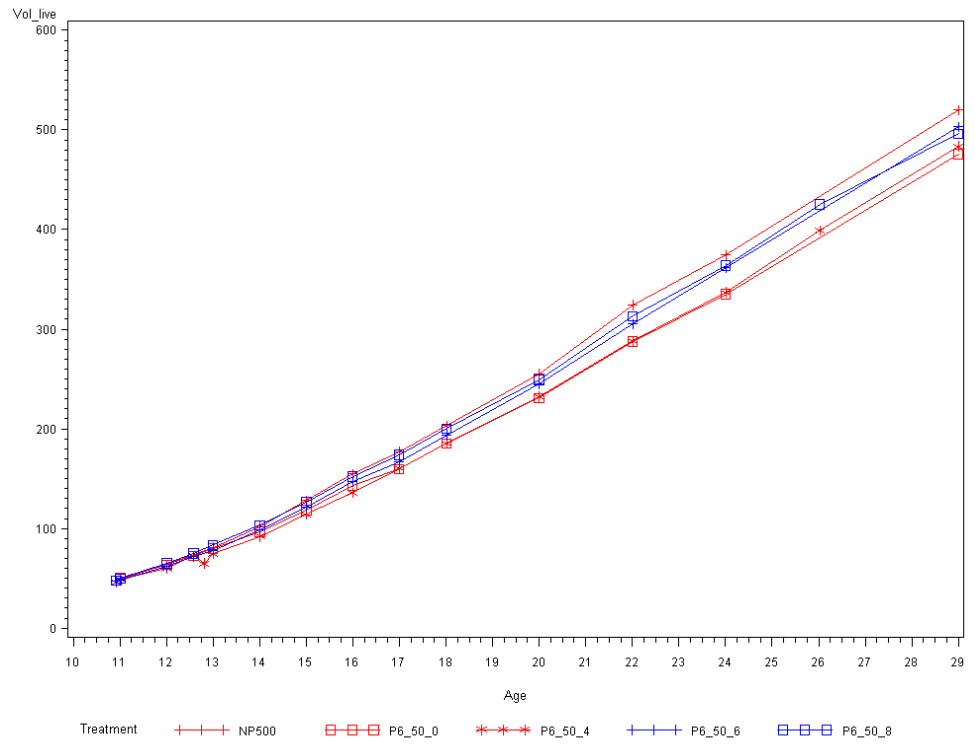


Figure 10. Douglas-fir diameter growth (mm) for pruned 750 spha at Kaingaroa Cpt 96.

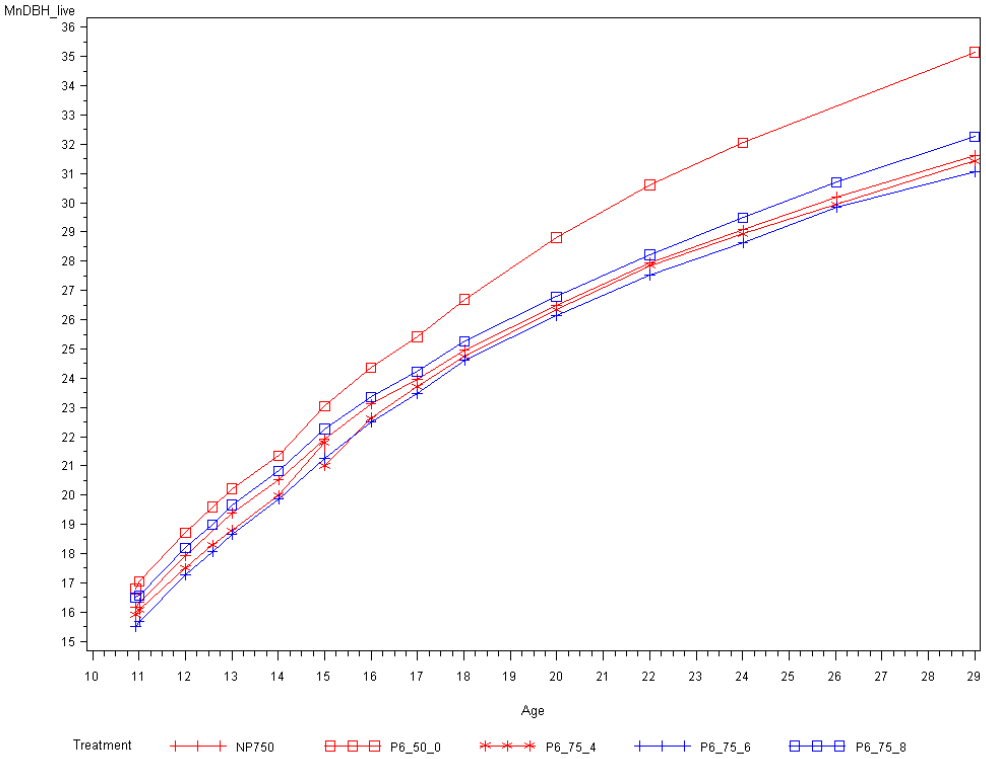


Figure 11. Douglas-fir volume growth (m^3 / hectare) by age for pruned 750 spha at Kaingaroa Cpt 96.

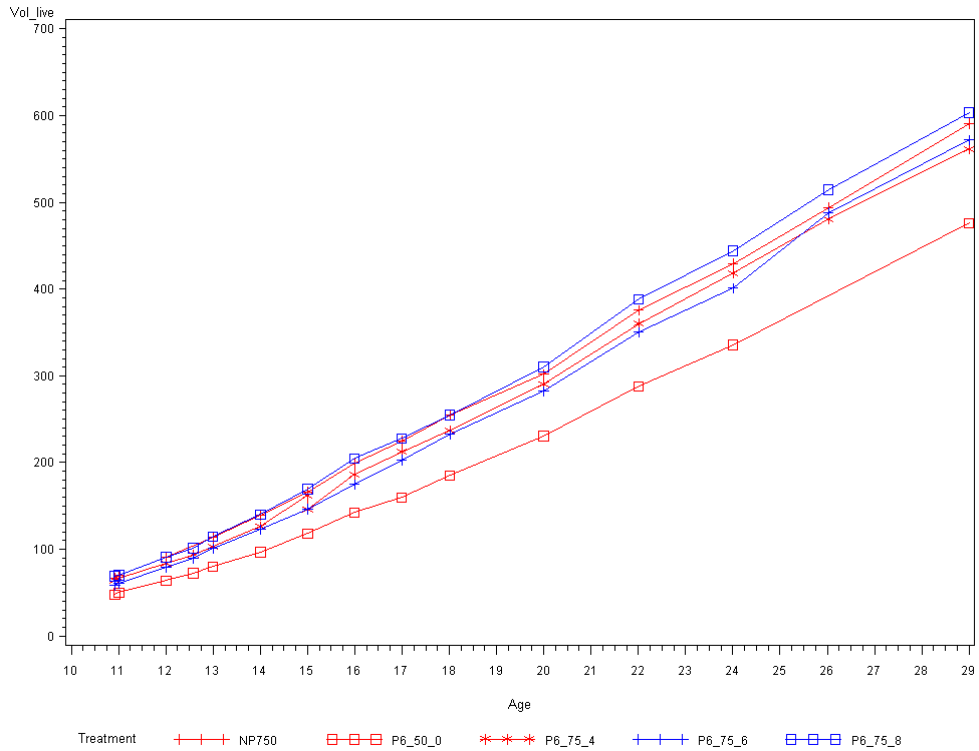


Figure 12. Douglas-fir diameter growth (mm) for high-pruned trees at Kaingaroa Cpt 96.

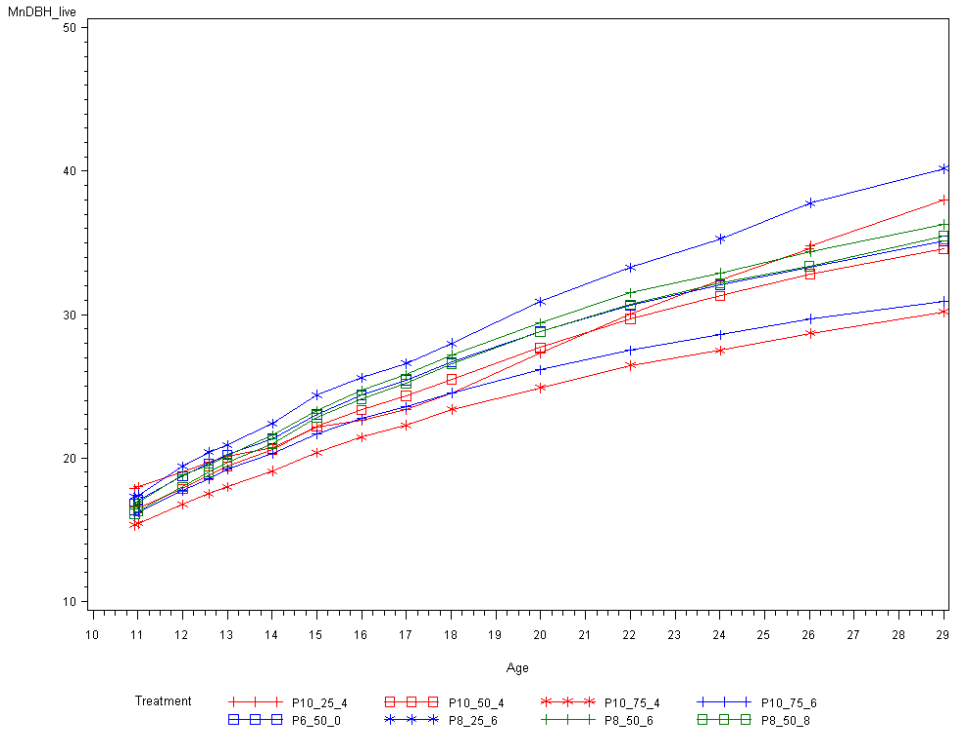


Figure 13. Douglas-fir volume growth (m^3 / hectare) by age for high-pruned trees at Kaingaroa Cpt 96.

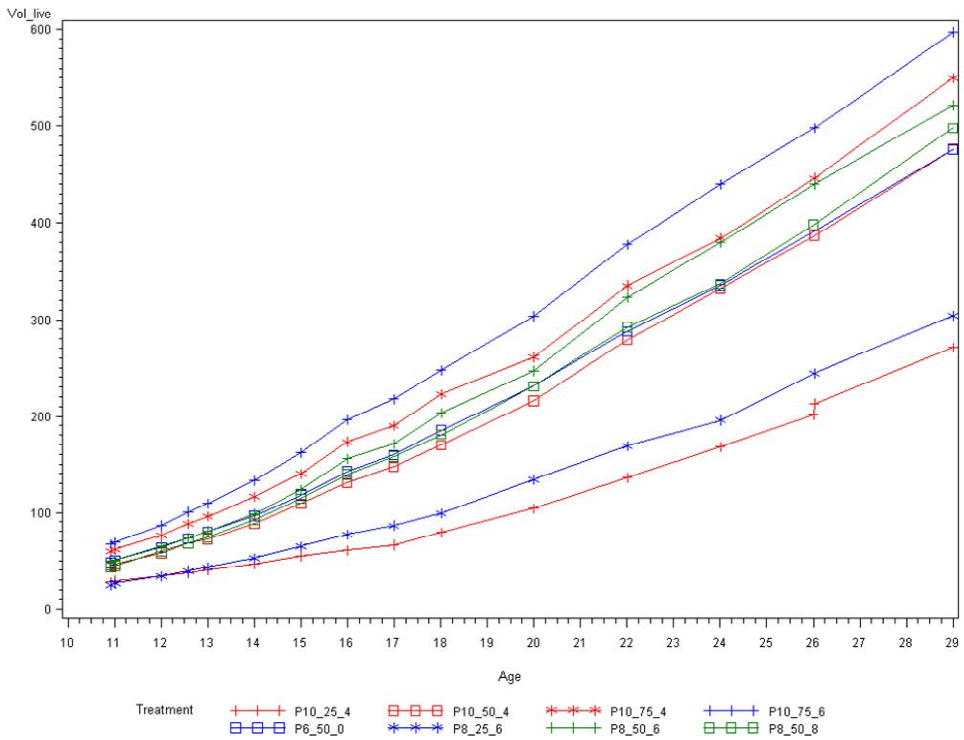
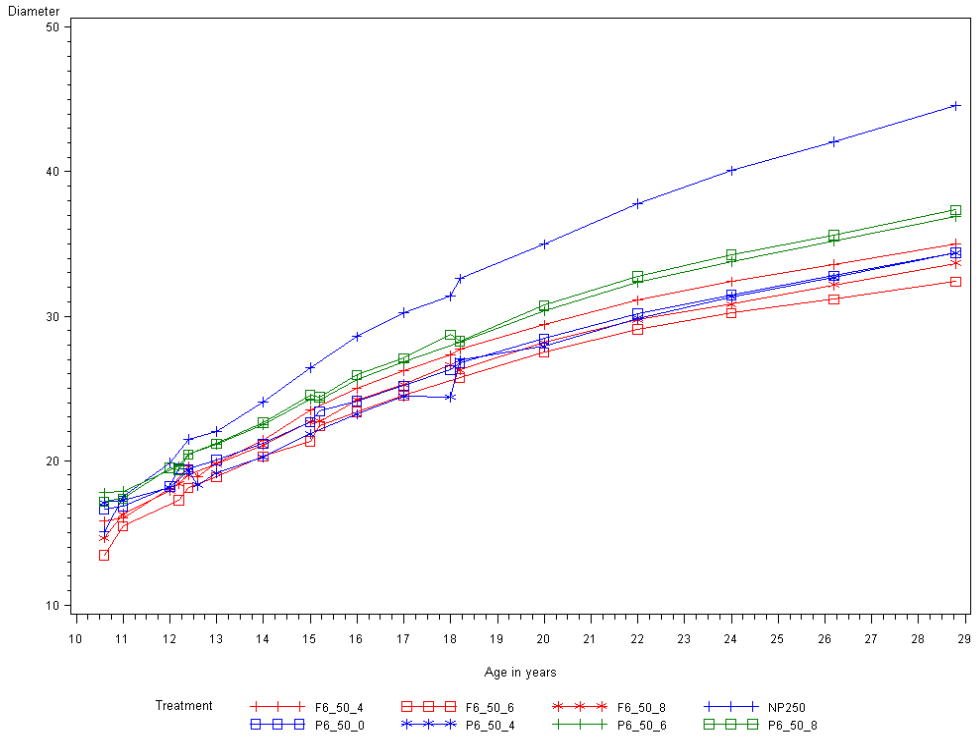


Figure 14. Douglas-fir diameter (mm) for pruned and follower plots at Kaingaroa Cpt 96. (Follower trees have an F instead of P in the treatment name).



Ribbonwood

The pruning and thinning trial FR206 at Ribbonwood station was established into an existing stocking and establishment methods trial. The stocking trial comprised three blocks of two and a half hectares at stockings of 800, 1330 and 2000 spha. The establishment methods trial comprised a four hectare block planted at 1250 spha. No difference was observed between establishment methods, so it was assumed that it could be treated as two very similar replicates in the regime trial.

The site is quite unusual as it is located in a part of the country normally described as dry, but the site is at the foot of the Hawkdun range. Consequently, the trees can access groundwater from melting snow percolating down through shingle from high above. The combination of dry air, high sunshine and a lot of available water provide better than expected growth rates for Douglas-fir in New Zealand.

The original stockings have been designated as replicates with Rep1 at 833, Rep 2 at 1333, Rep 3 at 2000 and Reps 4 and 5 at 1250 spha. The trial comprised 59 plots with nine thinning and pruning treatment combinations and several unthinned and unpruned plots in each of the 830, 1330 and 2000 spha stockings (Table 3). Unthinned plots 5, 22 and 26 were not measured.

Table 3. Treatments in the Ribbonwood Douglas-fir regime trial

Plot	Replicate	Pruning height	Crown height	Final crop stocking	Number of followers	Treatment code	Treatment name
11	1	0	0	250	0	A	NP250
21	2	0	0	250	0	A	NP250
31	3	0	0	250	0	A	NP250
42	4	0	0	250	0	A	NP250
56	5	0	0	250	0	A	NP250
8	1	6	4	250	0	B	P6_25_4
16	2	6	4	250	0	B	P6_25_4
39	3	6	4	250	0	B	P6_25_4
48	4	6	4	250	0	B	P6_25_4
54	5	6	4	250	0	B	P6_25_4
4	1	6	6	250	0	C	P6_25_6
27	2	6	6	250	0	C	P6_25_6
32	3	6	6	250	0	C	P6_25_6
44	4	6	6	250	0	C	P6_25_6
50	5	6	6	250	0	C	P6_25_6
7	1	0	0	250	250	D	NP500
23	2	0	0	250	250	D	NP500
30	3	0	0	250	250	D	NP500
47	4	0	0	250	250	D	NP500
49	5	0	0	250	250	D	NP500
13	1	6	4	250	250	E	P6_50_4
17	2	6	4	250	250	E	P6_50_4
35	3	6	4	250	250	E	P6_50_4
43	4	6	4	250	250	E	P6_50_4

Plot	Replicate	Pruning height	Crown height	Final crop stocking	Number of followers	Treatment code	Treatment name
55	5	6	4	250	250	E	P6_50_4
1	1	6	6	250	250	F	P6_50_6
18	2	6	6	250	250	F	P6_50_6
40	3	6	6	250	250	F	P6_50_6
53	5	6	6	250	250	F	P6_50_6
59	5	6	6	250	250	F	P6_50_6
10	1	0	0	250	500	G	NP750
15	2	0	0	250	500	G	NP750
37	3	0	0	250	500	G	NP750
45	4	0	0	250	500	G	NP750
57	5	0	0	250	500	G	NP750
6	1	6	4	250	500	H	P6_75_4
24	2	6	4	250	500	H	P6_75_4
29	3	6	4	250	500	H	P6_75_4
51	5	6	4	250	500	H	P6_75_4
58	5	6	4	250	500	H	P6_75_4
3	1	6	6	250	500	I	P6_75_6
19	2	6	6	250	500	I	P6_75_6
36	3	6	6	250	500	I	P6_75_6
46	4	6	6	250	500	I	P6_75_6
52	5	6	6	250	500	I	P6_75_6
2	1	0	0	830	0	Z	NP830
5	1	0	0	830	0	Z	NP830
9	1	0	0	830	0	Z	NP830
12	1	0	0	830	0	Z	NP830
14	2	0	0	1330	0	Z	NP1330
20	2	0	0	1330	0	Z	NP1330
22	2	0	0	1330	0	Z	NP1330
25	2	0	0	1330	0	Z	NP1330
26	2	0	0	1330	0	Z	NP1330
28	3	0	0	2000	0	Z	NP2000
33	3	0	0	2000	0	Z	NP2000
34	3	0	0	2000	0	Z	NP2000
38	3	0	0	2000	0	Z	NP2000
41	3	0	0	2000	0	Z	NP2000

Ribbonwood Results

The PSP system rates the site index for the Ribbonwood trial much lower (site index 31) than the trial in compartment 96, Kaingaroa. This is mainly due to growth rate differences between the Fort Bragg seedlot used to grow the trees for Kaingaroa and the Ashley seed stand seed used to grow the trees for Ribbonwood. However, diameter growth is rather better at Ribbonwood.

There were nine different thinning and pruning treatments at Ribbonwood and a further three sets of unthinned and unpruned plots, so several attempts at groupings were tried before the final set. There was only one thinning event, and even the very high stockings remained constant throughout the time of the assessments. It proved possible to simply group them as unpruned treatments and pruned treatments.

An analysis of variance was run on the data leaving out the untouched treatments at 830, 1330 and 200 spha. The LSD values were very small, which means that relatively small differences are statistically significant. The LSD started at 0.73 cm with treatment mean diameters ranging from 12 to 13 and only increasing to 1.5 cm, with diameters ranging from 34 to 46 at age 27.

Diameter growth for unpruned plots (Figure 15) showed huge differences conferred by stocking. Volume growth (Figure 16) had the very high stocking of 2000 spha (actually around 1800 spha) at almost 700 cubic metres by age 27. The treatment that was thinned to 750 probably showed the benefit of tree selection as its volume kept up with the 830 and 1330 unthinned treatments, while the treatment thinned to 250 spha really lost out.

Height growth (Figure 17) seemed fairly unaffected by stocking changes. Green crown length (Figure 18) was dramatically affected by stocking with the 250 and 500 spha stockings having got much longer green crowns by age 22.

Figure 15. Douglas-fir diameter growth (mm) for unpruned plots at Ribbonwood.

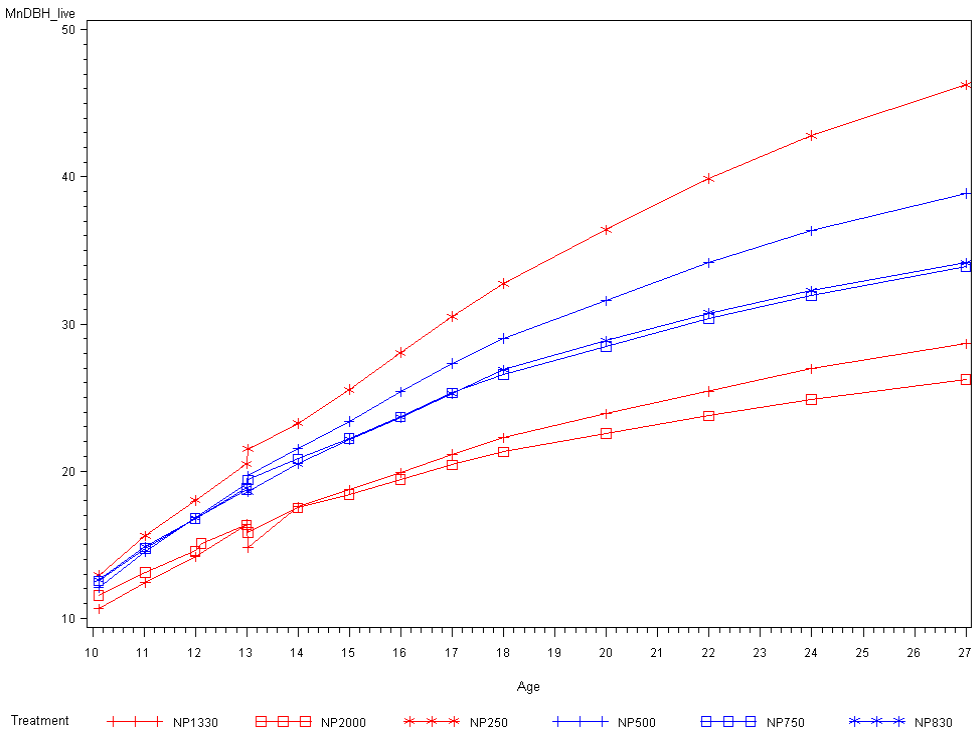


Figure 16. Douglas-fir volume growth m^3 / hectare by age for unpruned plots at Ribbonwood.

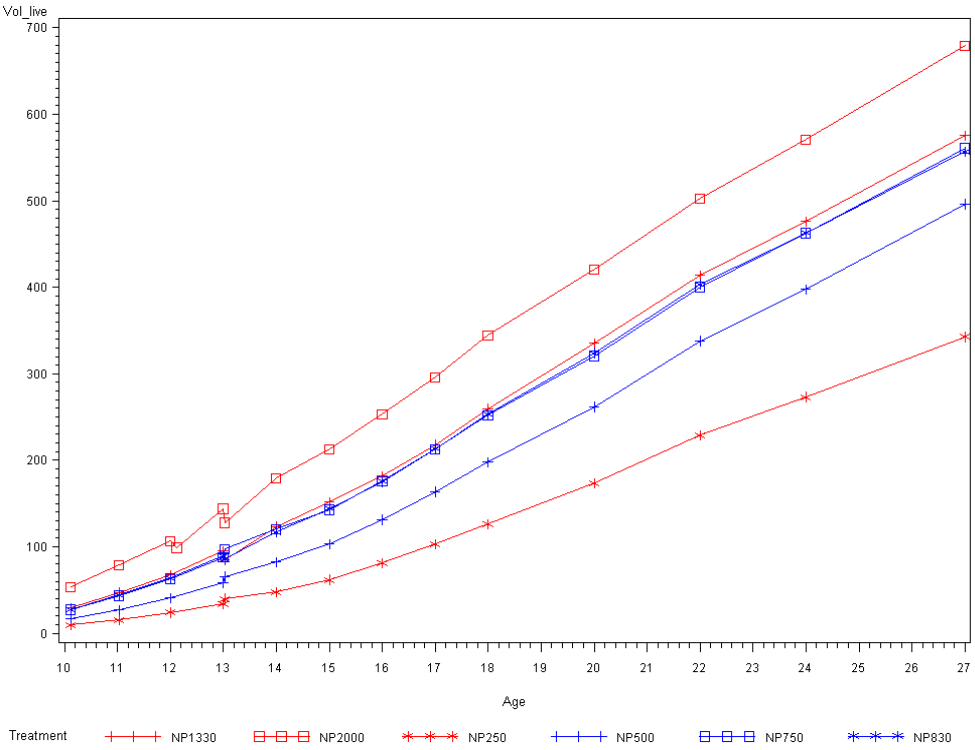


Figure 17. Douglas-fir height growth (metres) for unpruned plots at Ribbonwood.

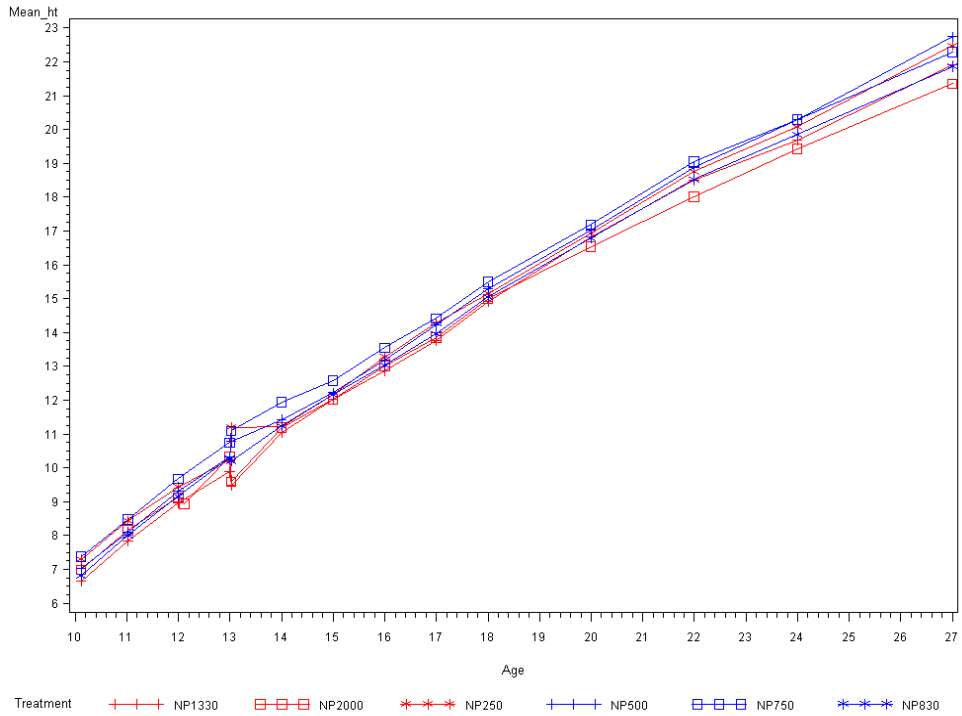
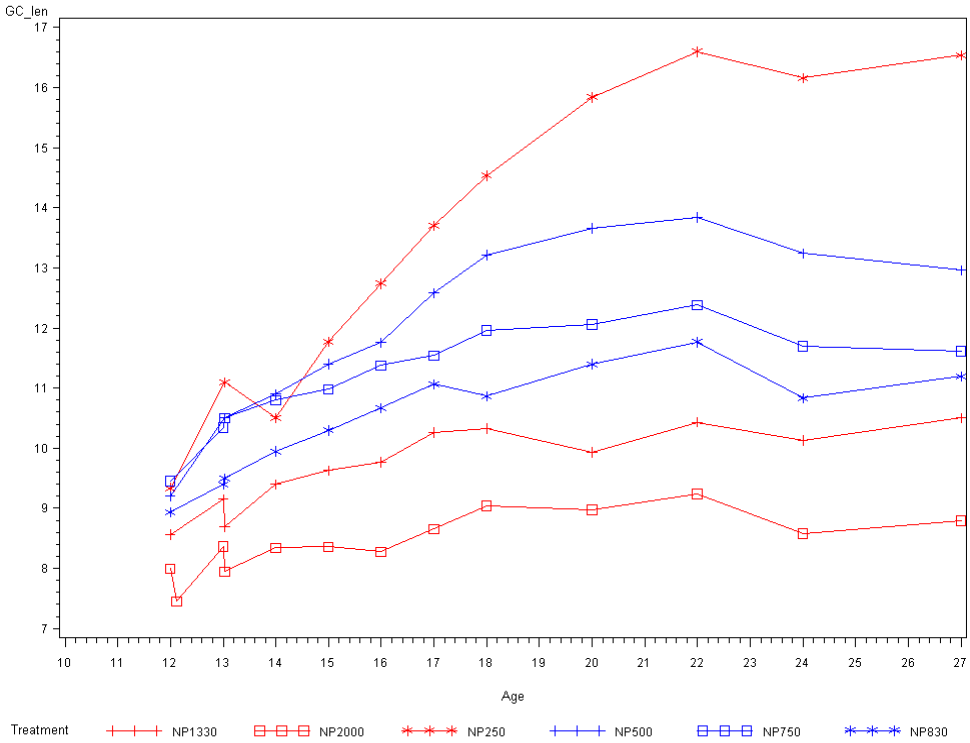


Figure 18. Douglas-fir green crown growth (metres) by age for unpruned plots at Ribbonwood.



The treatment that was thinned to 500 spha but unpruned was included with the pruned plots to link their performance to the other unpruned treatments. Significant differences in diameter growth (Figure 19) are just beginning to show up at age 18 and have increased by age 27, with the trees in the 750 spha stockings evidently suffering from competition.

Volume growth (Figure 20) showed a similar effect to the Kaingaroa trial where the pruning treatments within each stocking treatment had relatively little effect compared to the large effect of stocking. The 250 spha stocking appeared to be a real loser on this highly productive site.

Height growth (Figure 21) was constant across all treatments, just as it was for the unpruned plots. Green crown length (Figure 22) was compromised by the presence of followers in the pruned treatments within the 500 and 750 spha treatments. The average green crown length for the pruned 500 spha treatments was very similar to that of the unpruned 500 spha treatment.

The individual tree data was divided into pruned trees and followers (Figure 23). The followers started off as smaller trees but their development was quite different from that at Kaingaroa. They managed to overhaul the pruned trees shortly after pruning even with the pruning to a six-metre green crown. The pruned trees in the treatment to a four-metre green crown were particularly disadvantaged, so this treatment did not work out on this site.

The height to the base of the green crown (Figure 24) explained part of the problem. The pruned trees lost six metres of green branches against the followers, which managed to maintain living foliage on those low branches for a long time. It took ten years before the base of the green crown on the followers receded to match that of the pruned trees. The likely cause is the outstanding foliage health of this stand in the continental climate, while Douglas-fir in Kaingaroa has to cope with relatively high levels of needlecast.

Figure 19. Douglas-fir diameter growth (mm) for pruned treatments at Ribbonwood.

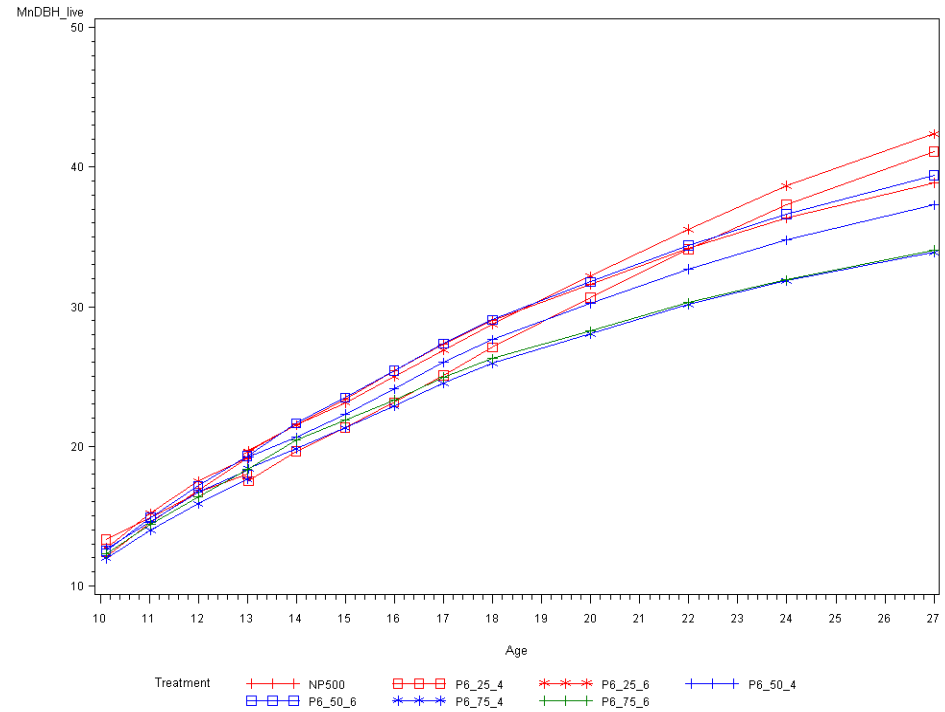


Figure 20. Douglas-fir volume growth (m^3 / hectare) by age for pruned treatments at Ribbonwood.

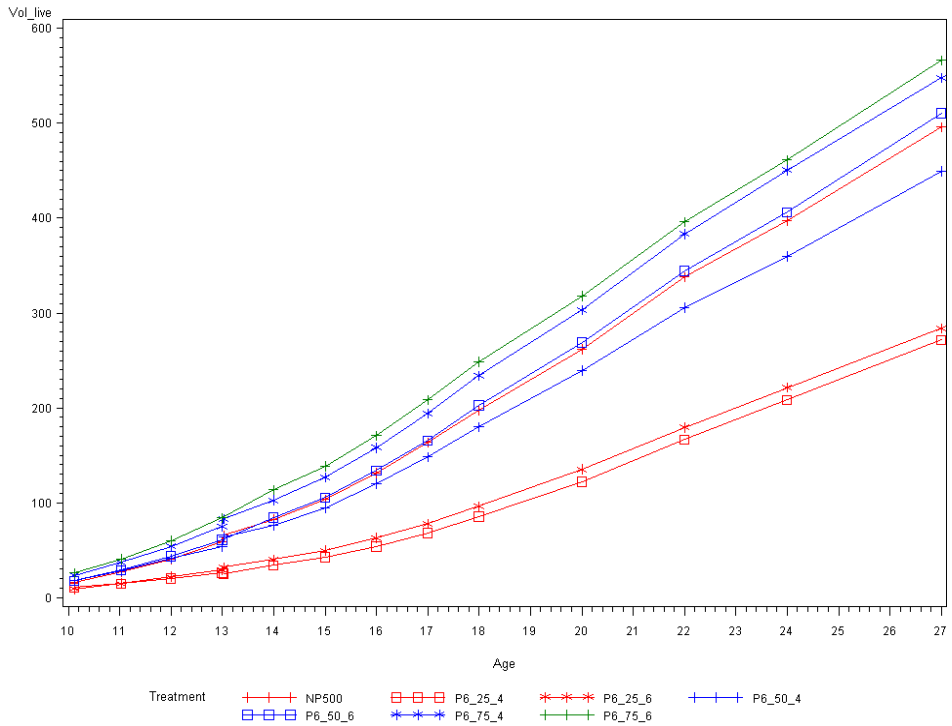


Figure 21 Height growth (metres) by age for pruned plots at Ribbonwood

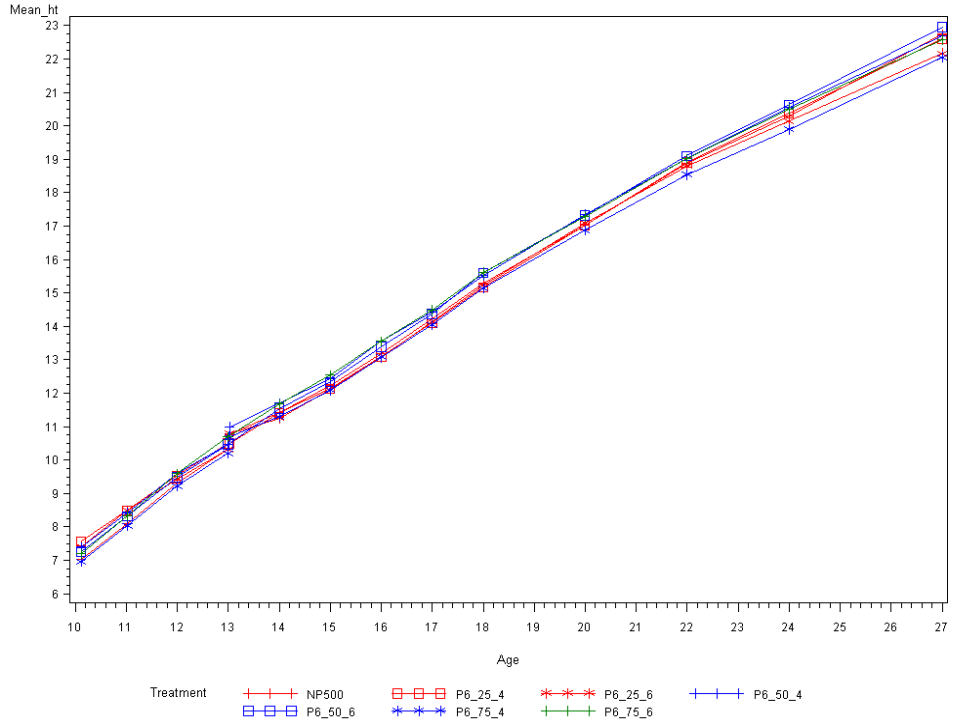


Figure 22. Douglas-fir green crown growth by age for pruned treatments at Ribbonwood.

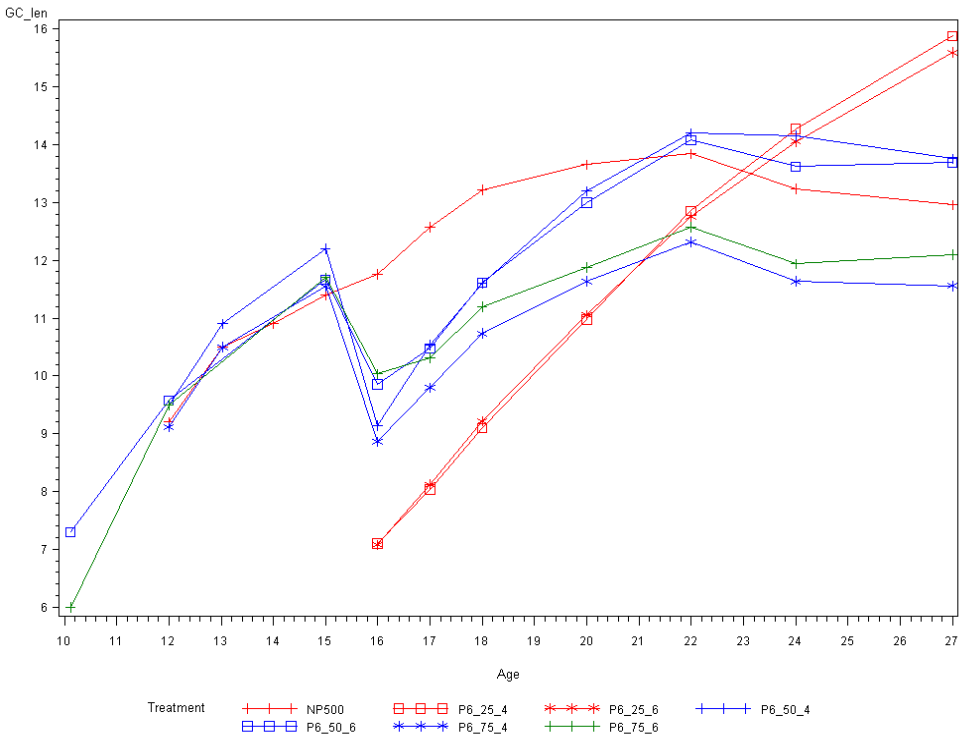


Figure 23. Douglas-fir diameter growth (mm) for pruned and follower plots at Ribbonwood. (Follower trees have an F instead of P in the treatment name).

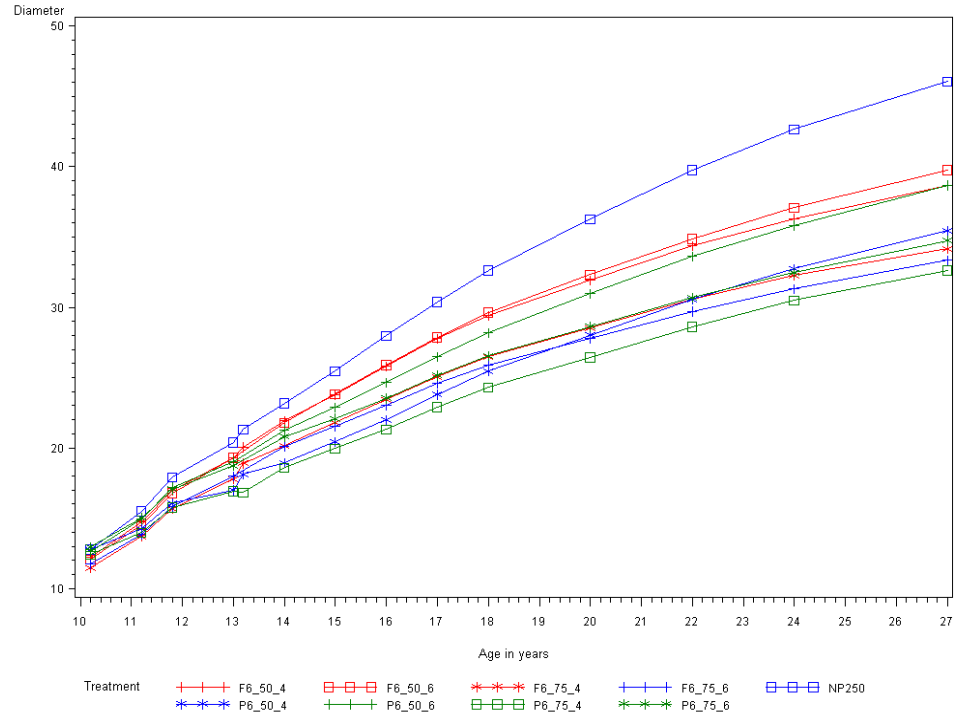
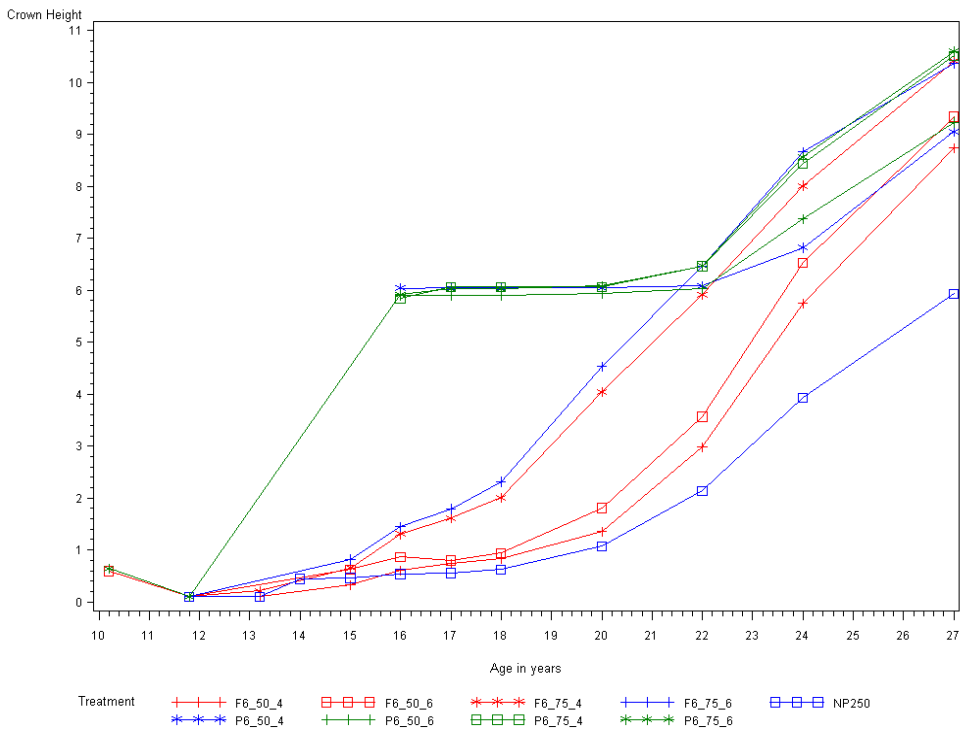


Figure 24. Douglas-fir crown height (metres) for pruned and follower plots at Ribbonwood. (Follower trees have an F instead of P in the treatment name).



Later Thinning Trials

The later series of thinning trials evaluated nine thinning treatments against unthinned control blocks (Table 4) at what had been the original stocking. There were no pruning treatments. The trial in compartment 656 Kaingaroa had six extra blocks to permit a production thin at the age of thirty years. The treatments were thinning to 500 spha at a stand average height of 14 metres, and thinning to 750 spha at the same stand height.

All of the trial sites were harder and less fertile sites than the two thinning and pruning trial sites. Since the treatments were intended to be applied at average stand heights of between 8.4 and 19.6 metres on these relatively slow-growing sites, the treatments at 18 and 19.6 metres would have been thinned very recently. Therefore the full effects of these late treatments cannot be evaluated yet.

Table 4. Treatments in the 1994-1996 thinning trials

No. of Plots	Height at treatment	Final stocking	Treatment name
3	0	1250-2000	Nothin
1	8.4	500	500_8
1	10	250	250_10
1	10	750	750_10
2	14	150	150_14
5	14	500	500_14
1	14	850	850_14
1	18	250	250_18
1	18	750	750_18
1	19.6	500	500_20

Later Douglas-fir Cooperative Thinning Trials

Southern Kaingaroa Results

The trial in Southern Kaingaroa (FR212) is on a colder and harder site than the pruning trial in compartment 96. It was planted with seedlings raised from a seedlot of Ashley origin, so would be expected to be less vigorous, but the site indices assigned by the PSP system were quite good at 33 to 35 metres of height at age 40. There are two main components to this series of trials. One is the number of stems and the other is the timing of thinning, based on the height of the trees.

Diameter growth (Figure 25) responded very well to thinning, with the trees at low stockings putting on twice the growth of unthinned plots. The trees also responded well for the later thinning treatments where there was an initial diameter jump from taking out smaller trees, then a decisive upwards change in the slope of the graph line.

The highly stocked plots had a definite advantage in volume growth (Figure 26). The early thinning treatments gave better individual tree growth at the cost of a lot of volume growth to age 27. The original stocking (Figure 27) was very high at nearly 2000 spha and even thinning to a conservative 750 spha resulted in large losses of volume growth. It was interesting to note that there was little mortality in the very high stockings

Height growth (Figure 28) had relatively little variation amongst treatments. However, the selection of better trees to be retained after thinning gave a lift to tree height. Green crown length (Figure 29) had developed marked differences in the treatments with very long green crowns for the early thinning to low stockings. However these had not begun to affect relative changes in volume growth rate.

Figure 25. Douglas-fir diameter growth (mm) for treatments at Kaingaroa cpt 656

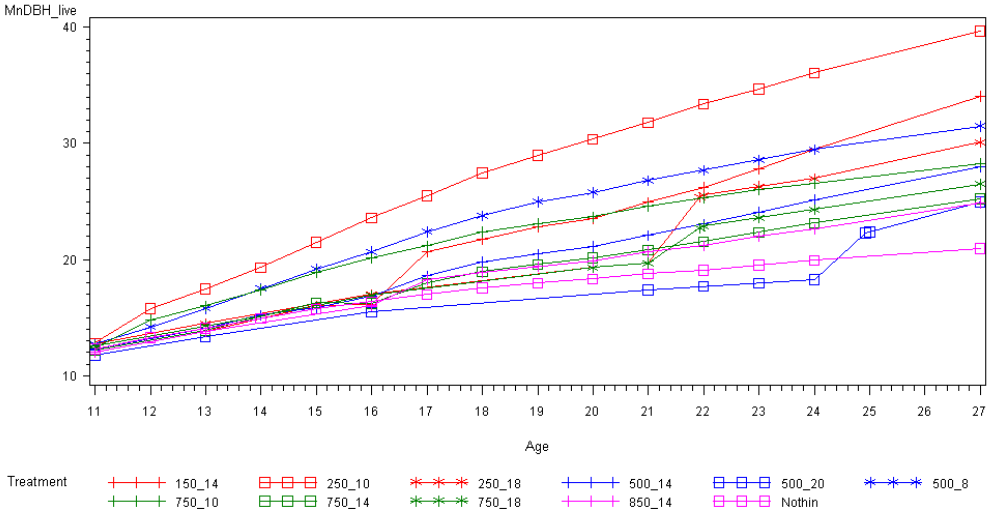


Figure 26. Douglas-fir volume growth (m^3 / hectare) for treatments at Kaingaroa cpt 656

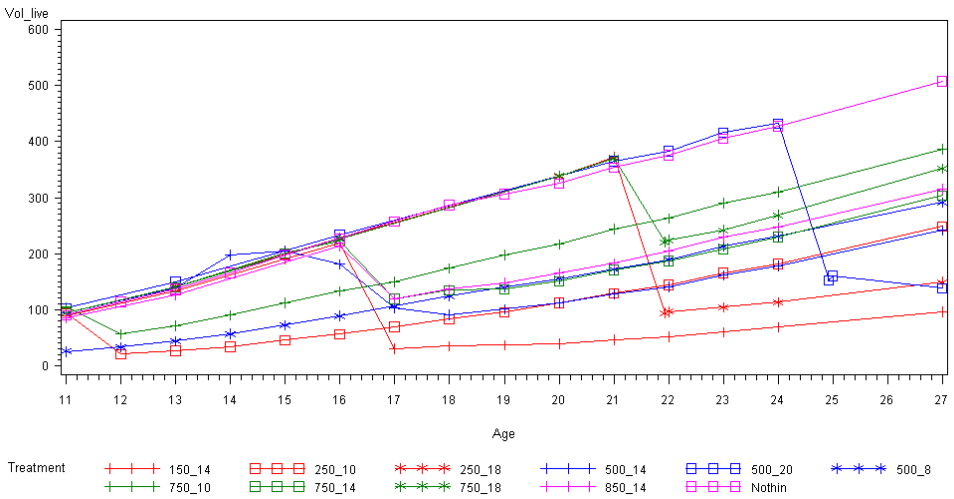


Figure 27. Douglas-fir stocking (spha) by age for treatments at Kaingaroa cpt 656

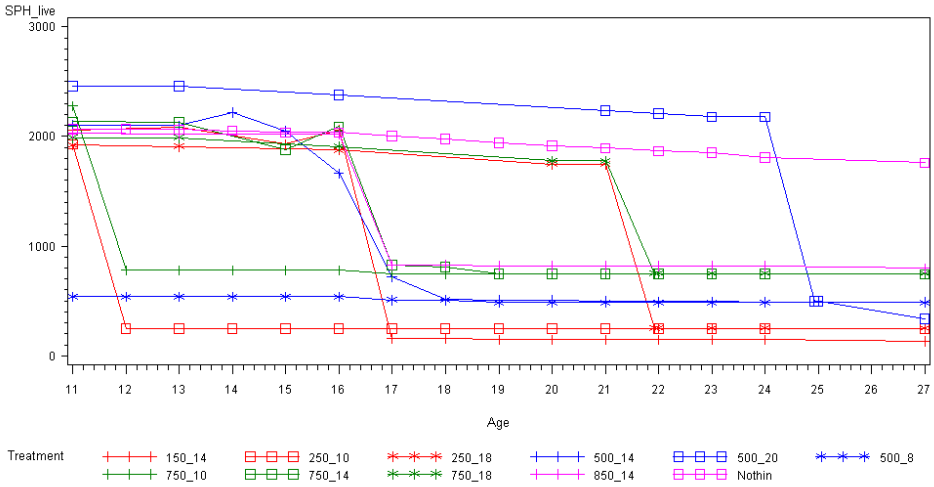


Figure 28. Douglas-fir height growth (metres) by age for treatments at Kaingaroa cpt 656

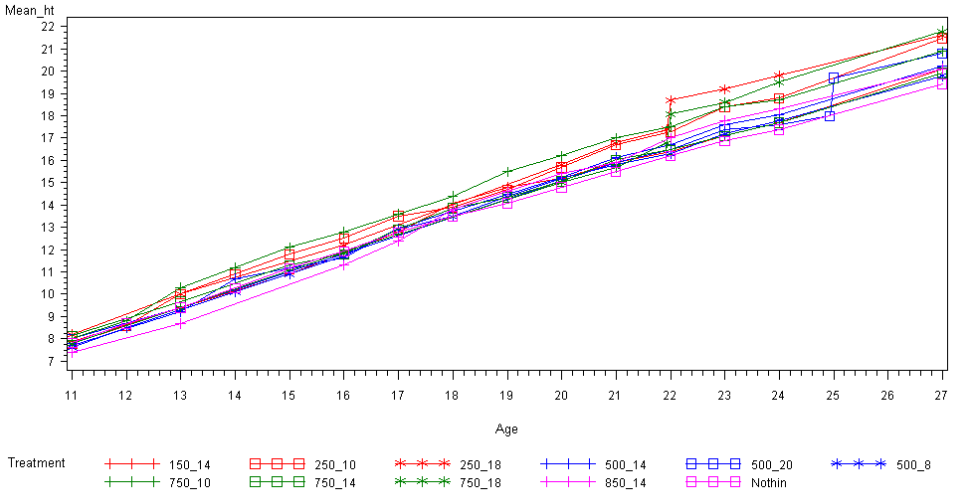
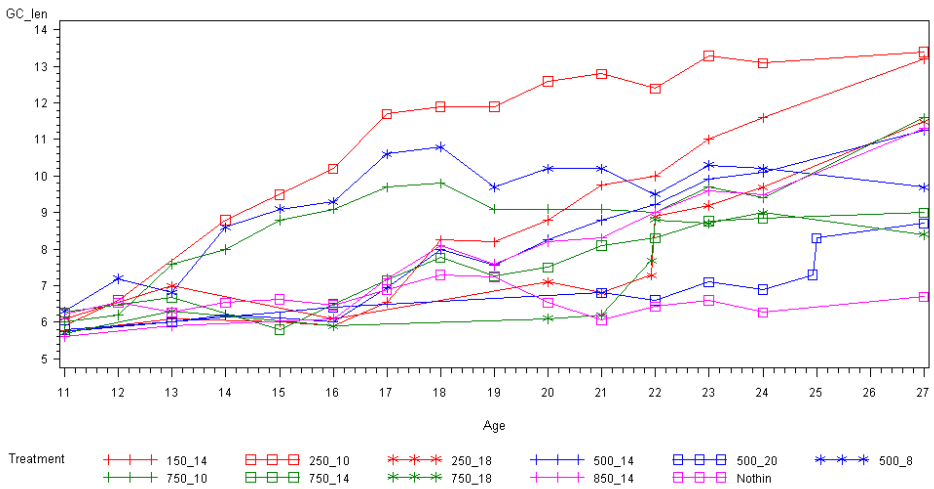


Figure 29. Douglas-fir Green Crown length (metres) by age for treatments at Kaingaroa cpt 656



Hanmer

The two Kaingaroa trials had consistent responses to the thinning treatments. Most Douglas-fir is planted in the South Island, so the four South Island trials may be more meaningful to most Douglas-fir growers. However, the trial at Hanmer had a four-metre difference in height between plots, which translated to site index differences from a poor 26 to an excellent 35.

In spite of the site index differences, diameter growth (Figure 30) followed the same pattern of response to thinning, where lower stockings responded with better growth. Volume growth (figure 31) also followed the pattern established by the other trials, although the treatment of thinning to 750 spha at 10 metres has a smaller than expected volume similar to that of the 500 spha treatments. The PSP data shows a poor site index for the plot which accounts for the poor performance.

The graph of stocking over time (Figure 32) shows that the thinning treatments were done to schedule and that there has been little subsequent mortality. Height growth (Figure 33) showed just how much the 750 spha thinning at 10 metres treatment had suffered, with the likely cause being thin soils over rocky substrates that would dry out quickly during summer. The graph of green crown length (Figure 34) corresponds to the same graph for Kaingaroa, with low stockings able to sustain the longest green crowns

Figure 30. Douglas-fir diameter growth (mm) for treatments at Hanmer

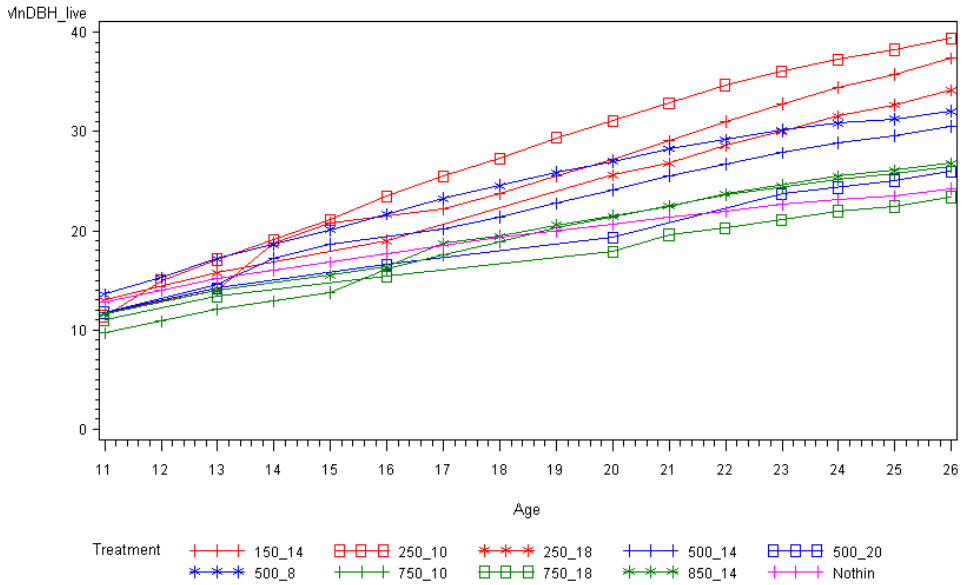


Figure 31. Douglas-fir volume growth m^3 / hectare for treatments at Hanmer

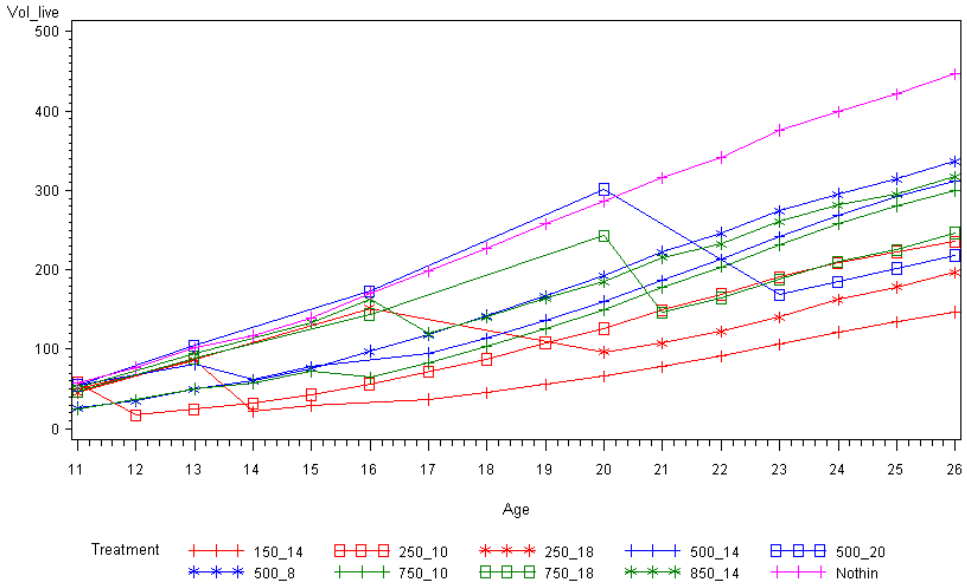


Figure 32. Douglas-fir stocking (spha) by age for treatments at Hanmer

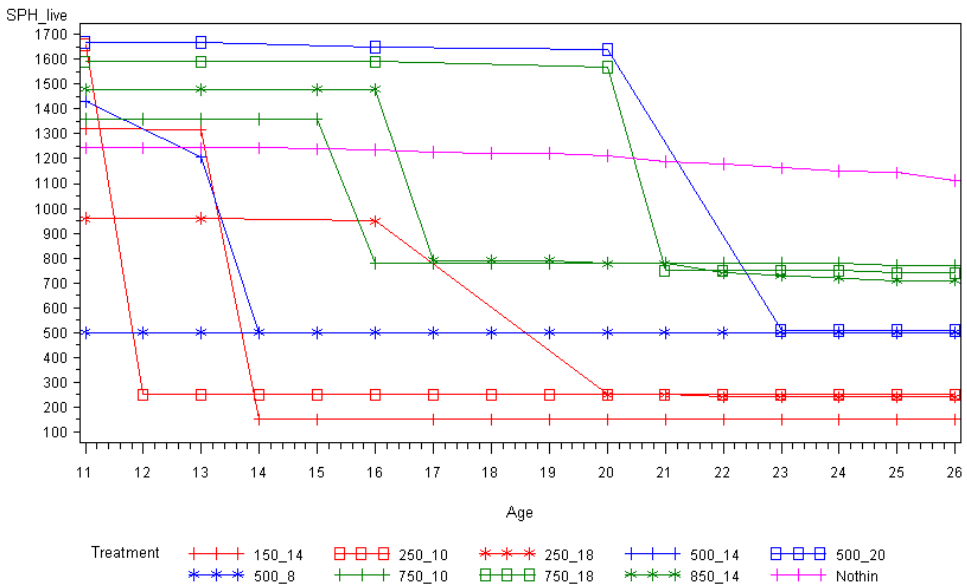


Figure 33. Douglas-fir height growth (metres) by age for treatments at Hanmer

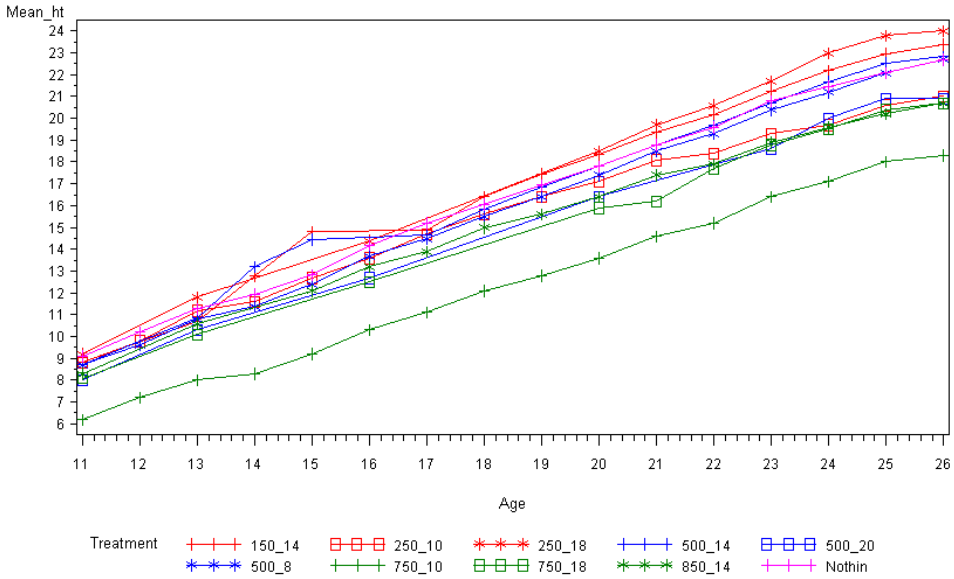
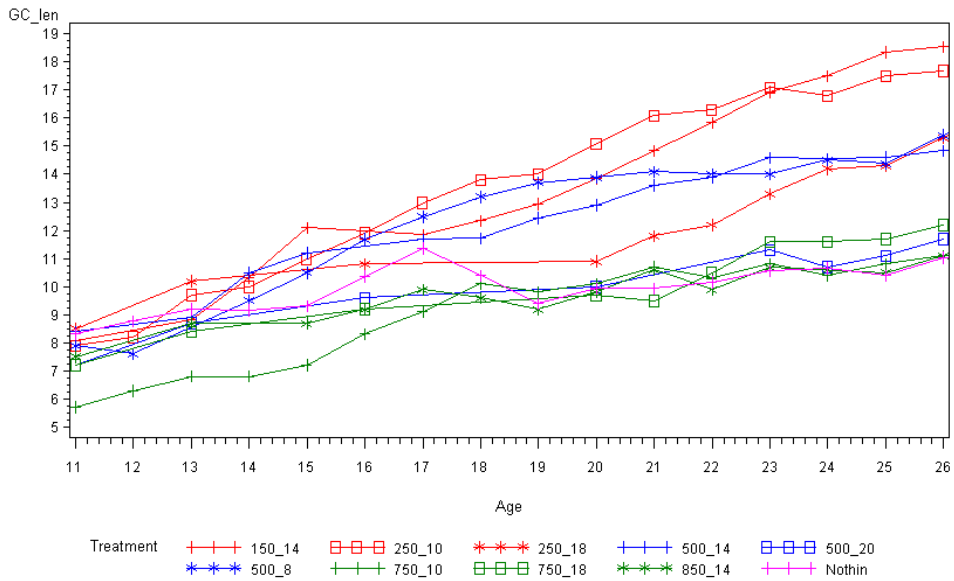


Figure 34. Douglas-fir Green Crown length (metres) by age for treatments at Hanmer



Dusky Forest

The trial at Dusky forest had low site index between 25 and 27. This meant that the thinning treatments would be done at the same height as other sites, but at a much later age. This meant that the early thinning to 500 spha at eight metres height managed to jump out to have better diameter growth (Figure 35) than the lower stockings that traditionally dominate diameter growth. The range of diameters is also more tightly grouped than at other sites.

Volume growth (Figure 36) also shows that the early thinning to 500 spha contributed to very good volume growth. This is an unusual result and may show that early thinning on a low site index site is the best strategy. The late thinning to low stockings also shows that the trees did not respond to the thinning, and in the case of thinning to 250 spha at a height of 18 metres the slope of the volume increase is less than any other treatment. There have been various theories about what may have happened, ranging from crown damage to the residual trees, to a crash in mycorrhizae caused by the drastic reduction in stocking.

The graph of stocking (Figure 37) shows when the treatments were done and correlates with the changes in volume growth. The graph of height growth (Figure 38) is quite similar to the other sites and shows that here is a small lift in mean height when the smaller trees are removed. The graph of changes to green crown length (Figure 39) also reflects the changes to stand stocking.

Figure 35. Douglas-fir diameter growth (mm) for treatments at Dusky

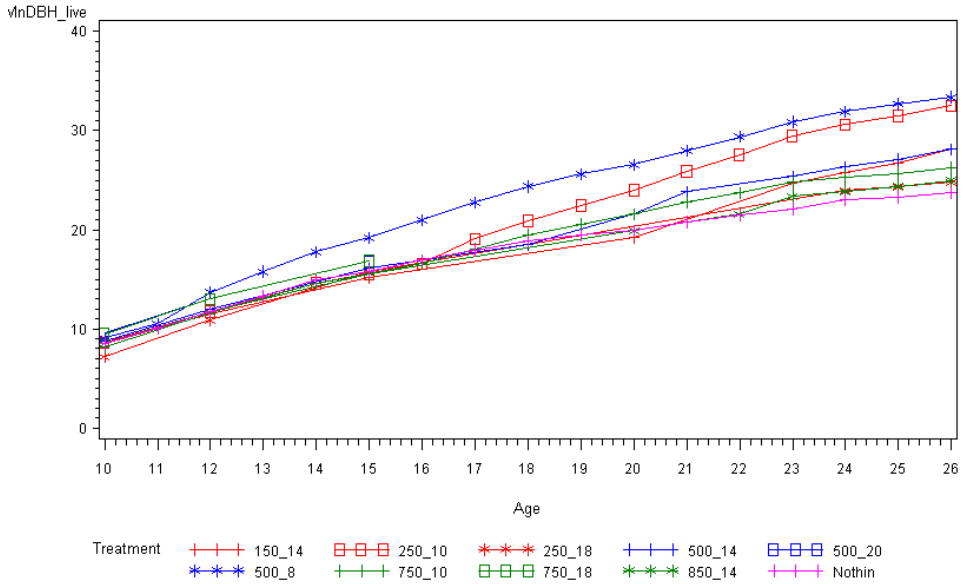


Figure 36. Douglas-fir volume growth (m3 / hectare for treatments at Dusky

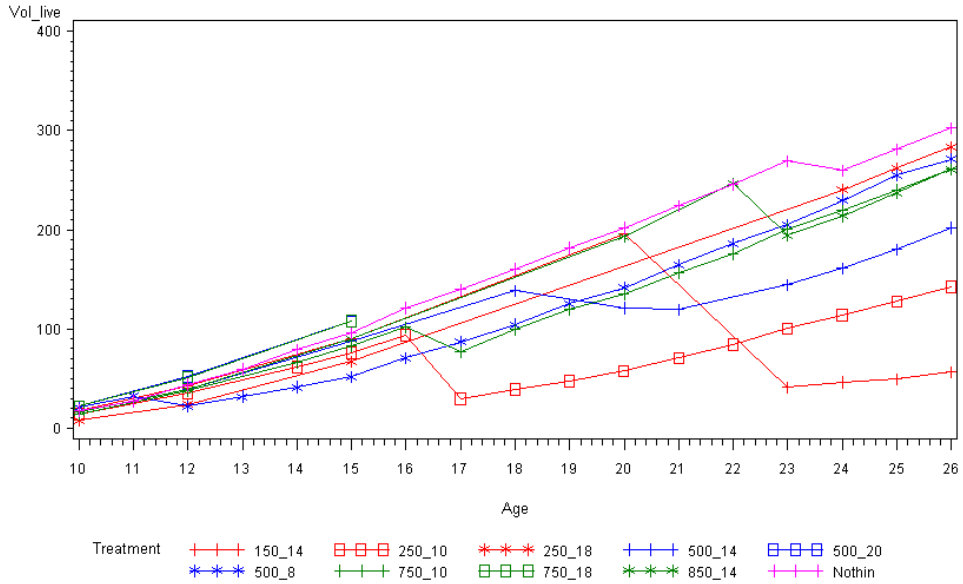


Figure 37. Douglas-fir stocking (spha) by age for treatments at Dusky

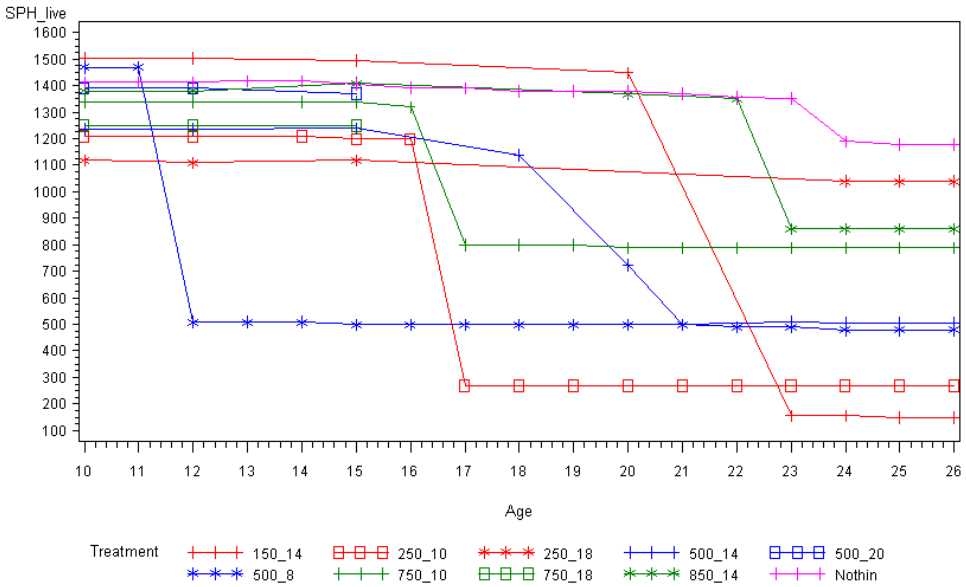


Figure 38. Douglas-fir height growth (metres) by age for treatments at Dusky

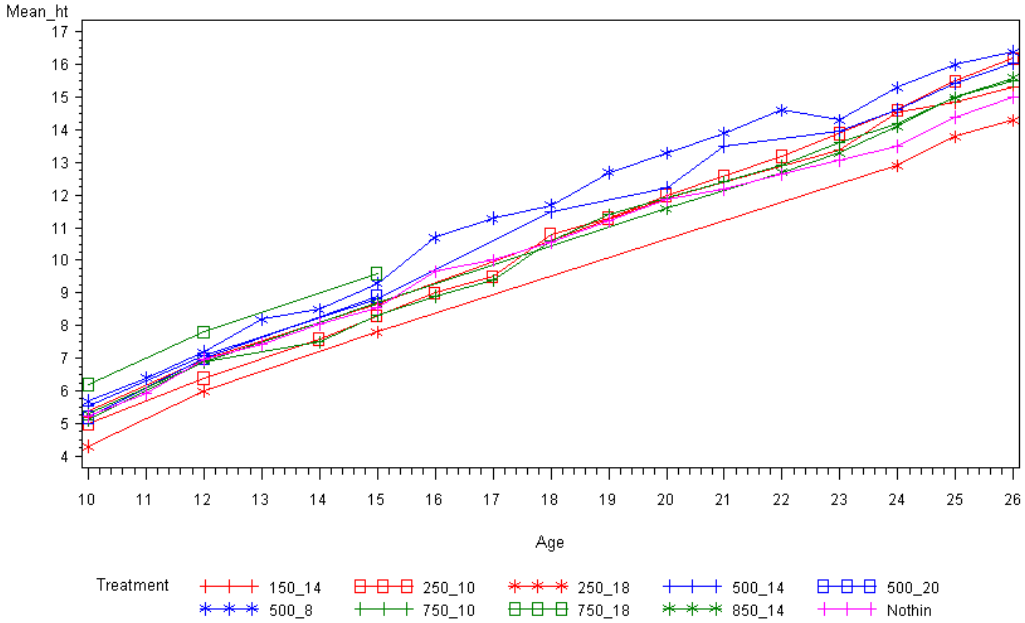
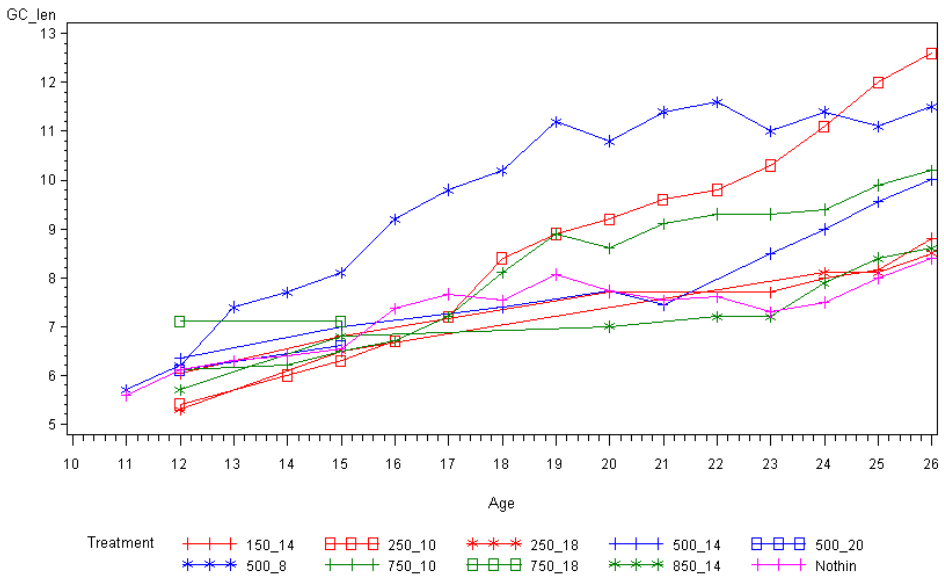


Figure 39. Douglas-fir Green Crown length (metres) by age for treatments at Dusky



The Berwick Trial

The Berwick trial might be the hardest site in this series, with exposure to cold, strong southerly airflows, depleted soils and a fairly low rainfall. However, the site index was slightly better than at Dusky, ranging from 25 to 31. Once again, the slow height growth means that the late thinning treatments have been carried out only recently and the trees have not really had enough time to show the full effects.

Diameter growth (Figure 40) was more predictable than at the Dusky site. Low stockings delivered better volume growth, with the 500 spha treatments more or less in the middle of the range. Like the Dusky site, the spread of diameters is smaller than that seen at sites of higher site index. The graph of stocking (Figure 41) shows when the treatments were carried out and explains the drastic changes in volume with the late thinning.

The graph of height growth (Figure 42) showed a large initial spread for all treatments and that they maintained their position during the course of the trial. The site was not a good one for comparing growth rates, but at least the different treatments are maintaining their respective positions.

The graph of green crown length (Figure 43) indicated that competition was setting in at the time of the first thinning. The treatment that was thinned to 500 spha at eight metres enjoyed the deepest green crown for a number of years – even better than the treatment thinned to 250 spha at a height of ten metres.

Figure 40. Douglas-fir diameter growth (mm) for treatments at Berwick

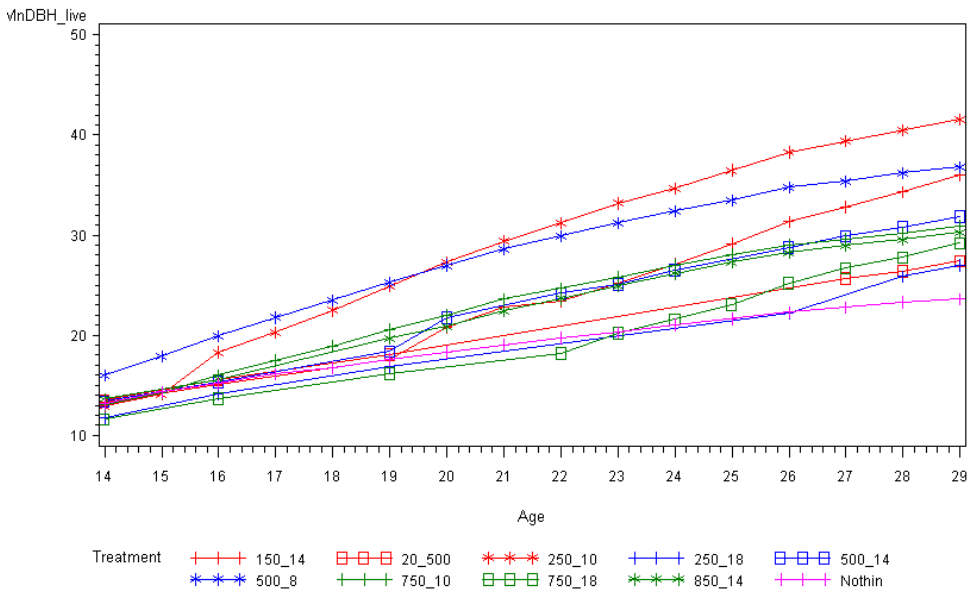


Figure 41. Douglas-fir stocking (spha) by age for treatments at Berwick

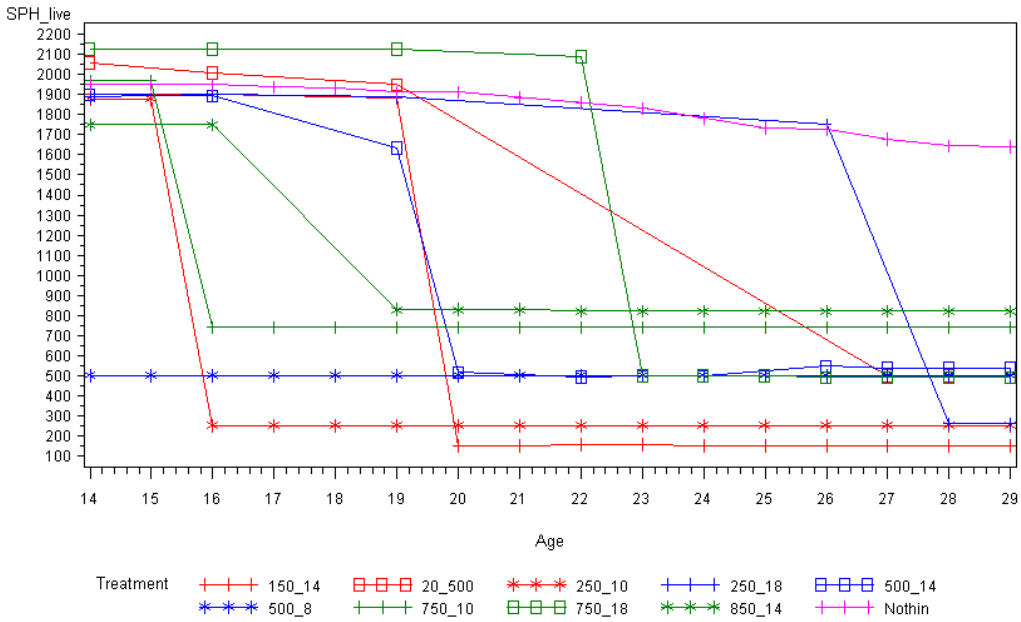


Figure 42. Douglas-fir height growth (metres) by age for treatments at Berwick

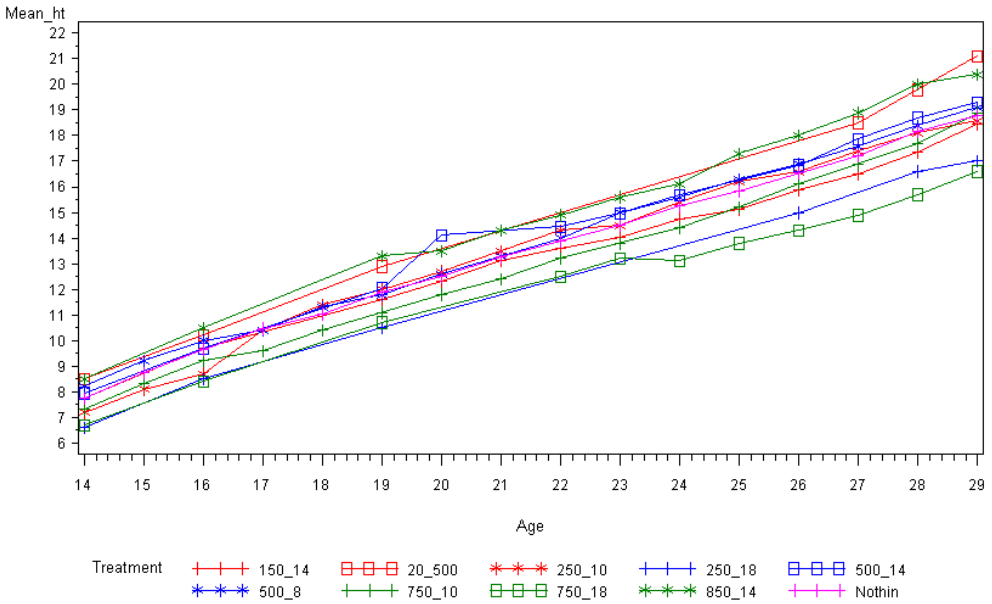
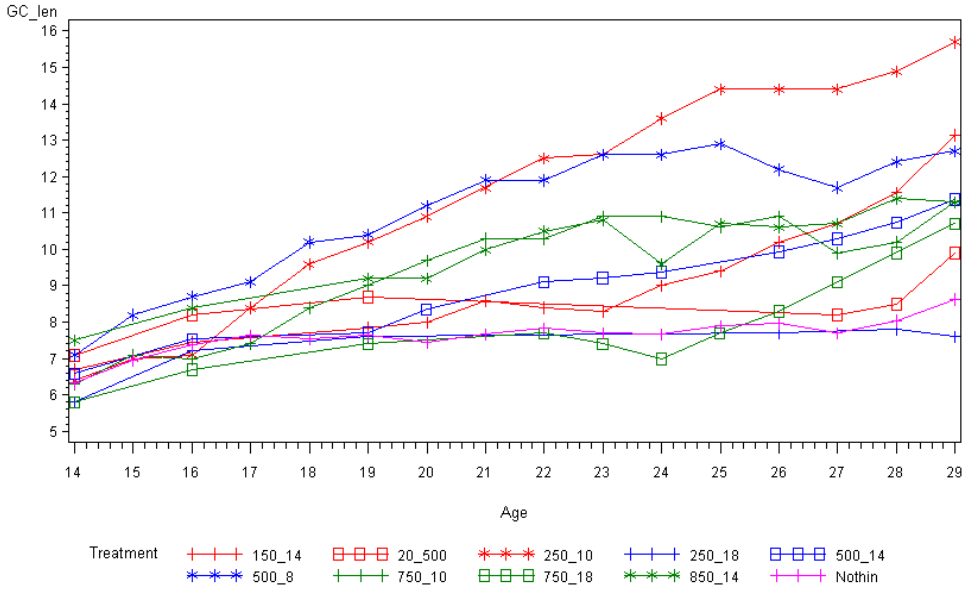


Figure 43. Douglas-fir Green Crown length (metres) by age for treatments at Berwick



Castle Downs

Castle Downs proved to be a good site for growing Douglas-fir, with site index ranging from 29 to 35. Diameter growth (Figure 44) showed the early thinning gave the treatment of 500 spha at a height of eight metres a considerable advantage. The treatment thinned to 250 spha at ten metres did catch up and pass it, but it got a considerable advantage over the 500 spha at height 14 metres treatment.

Volume growth (Figure 45) was by far the best for the high stockings on this site, although the 500 spha at height eight metres was tracking at the same volume as the 750 spha treatments. The late thinning treatments cost a lot of volume and the lack of an immediate response may mean that there was significant damage to the crown.

The graph of stocking (Figure 46) shows when thinning took place and also shows that there was little mortality in even the 2000 spha unthinned treatment. Height growth (Figure 47) showed that the early thinning to 500 spha treatment got an advantage over the other treatments. There was a jump in height growth for other thinning treatments, presumably due to the removal of the shorter trees. Otherwise, the slope of the height growth line was parallel for all treatments.

Once again, the early thinning conferred a massive advantage in green crown length. It is hard to understand how there is such a large advantage over the 250 spha treatment that was thinned only two years later. Perhaps the very high stocking of 2000 spha contributes by inducing competition early, but this trial sent a distinct message that later thinning affects growth rate considerably.

Figure 44. Douglas-fir diameter growth (mm) for treatments at Castle Downs

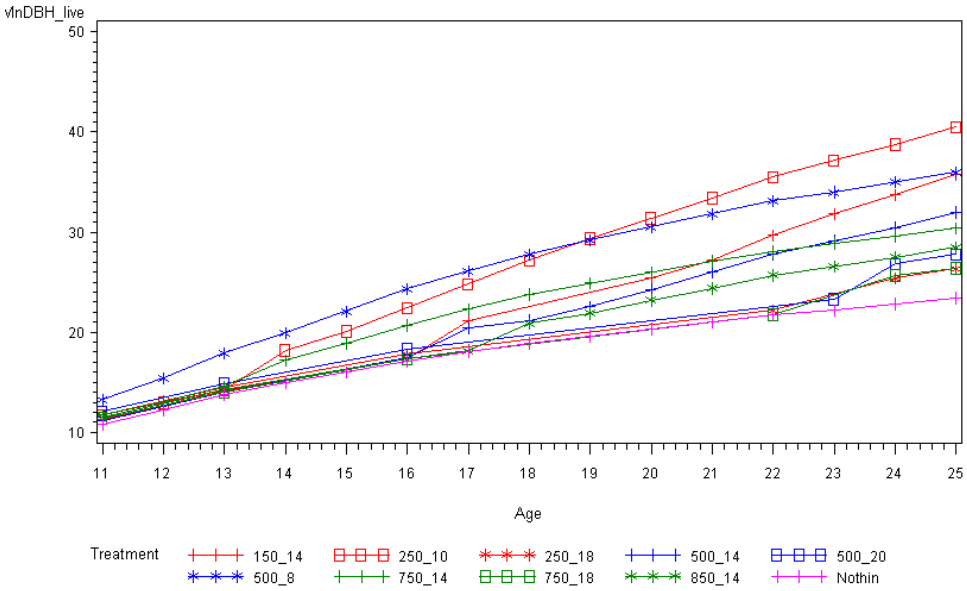


Figure 45. Douglas-fir volume growth (m^3 / hectare) for treatments at Castle Downs

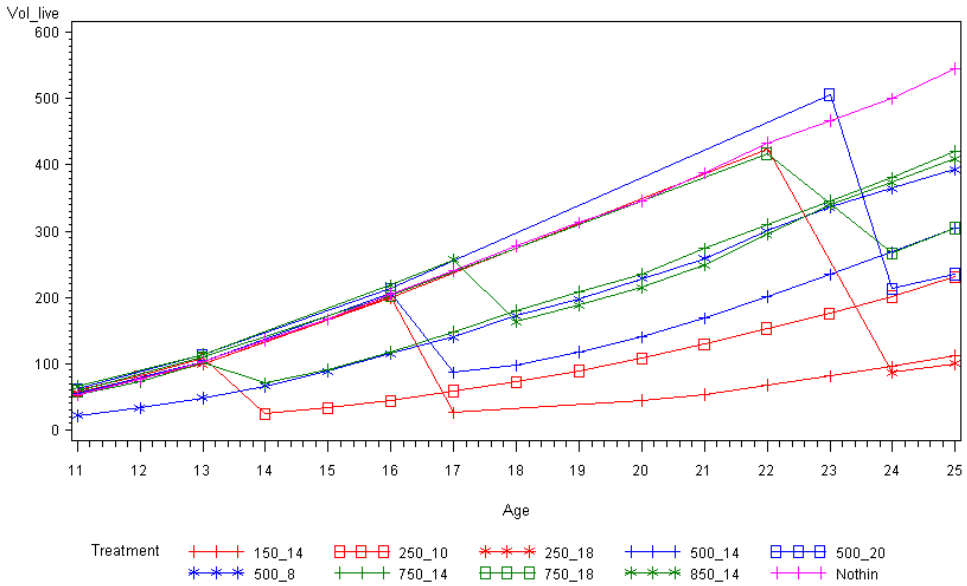


Figure 46. Douglas-fir stocking (spha) by age for treatments at Castle Downs

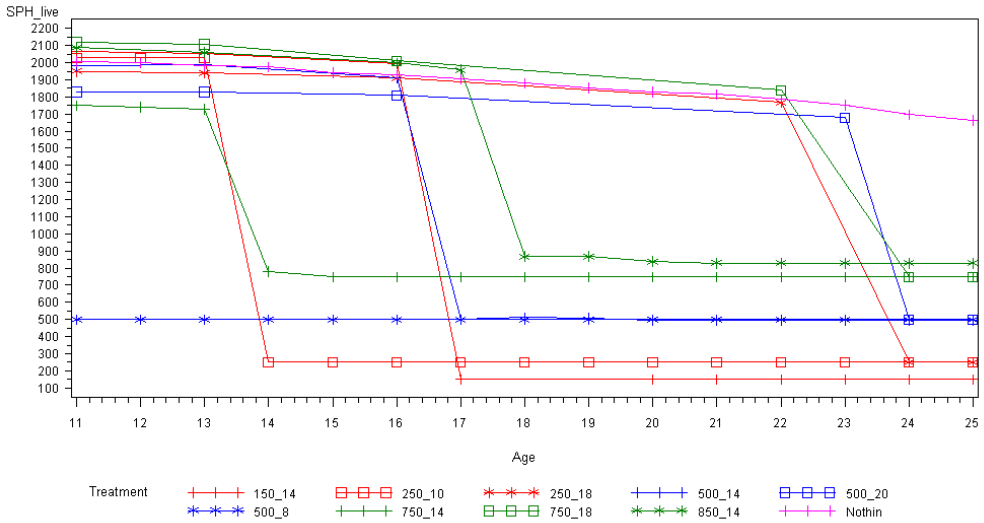


Figure 47. Douglas-fir height growth (metres) by age for treatments at Castle Downs

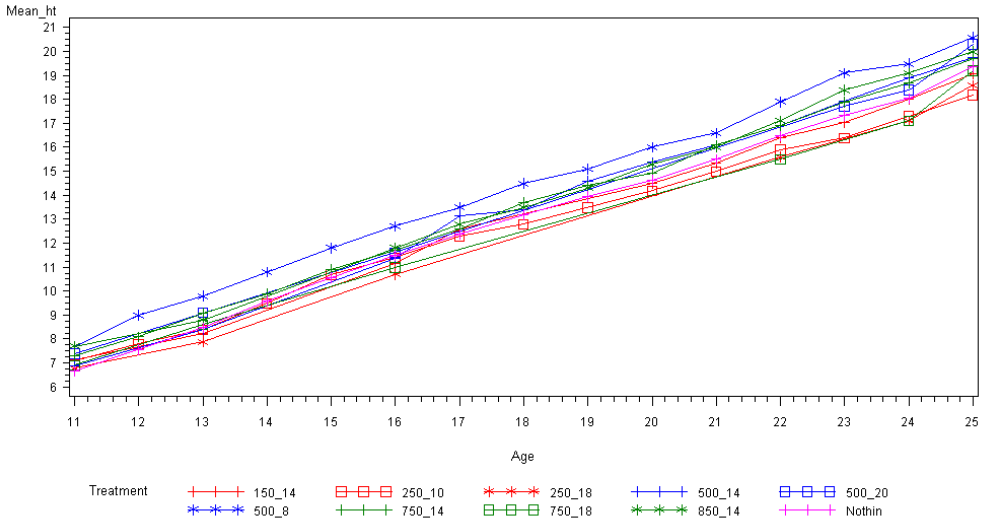
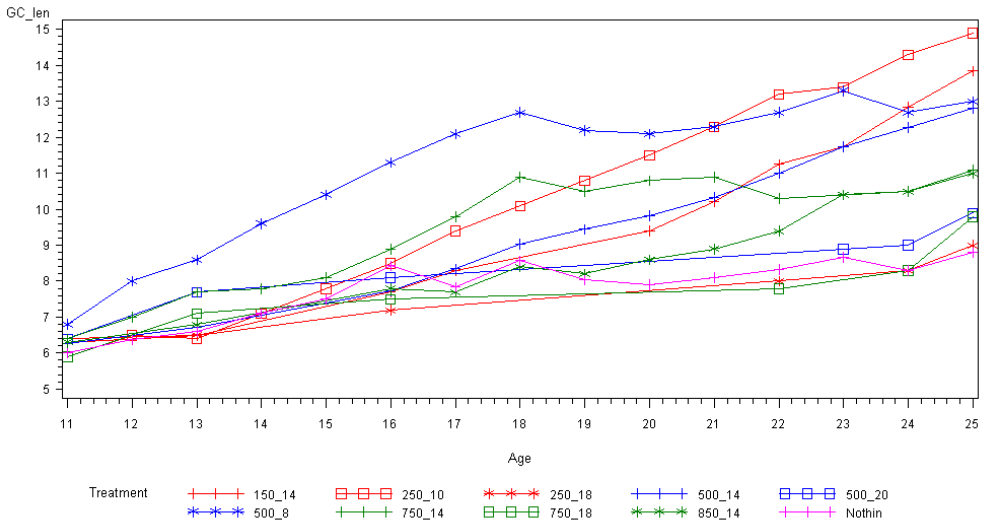


Figure 48. Douglas-fir Green Crown length (metres) by age for treatments at Castle Downs



CONCLUSION

The Douglas-fir regime trials are the culmination of a lot of thinking about Douglas-fir silviculture. It must have been a difficult mission to set them up and then follow through with the treatments from 1993 to 2008. Even the measurements represent a tremendous amount of work.

Thirty years of growth on the trees have answered some of the questions that these trials were designed to answer. The pruning trials were aimed for a final stocking of 250 spha, but that stocking appeared to be far too low for Douglas-fir, with unacceptable losses in volume even though diameter growth increased.

Out to age thirty the unthinned treatments appeared to have the edge for volume production, but mortality was just beginning to take a toll. The next ten years may see the more sensible stockings take over in terms of volume growth. The 750 spha stocking also seemed good for volume growth out to age thirty, with no sign that the 500 spha stocking would catch up.

Early thinning at a height of eight metres was much better for growth rate and ensured deep green crowns. The question of whether this produces unacceptably large branches could be answered by a branch size study in these trials.

Three different pruning intensities were tried, leaving four, six and eight metres of green crown. The treatment leaving four metres of green crown definitely affected growth, but the trees recovered and regained lost growth to be comparable to the milder pruning treatments. The unpruned followers were slightly smaller trees and stayed that way at Kaingaroa, where there might have been moderate needlecast. At Ribbonwood where there was no needlecast, the unpruned followers had caught up with and passed the pruned trees.

Pruning cost some growth rate at both sites, especially comparing the unpruned and pruned treatments at 250 spha. At Kaingaroa the treatment where all 500 stems were pruned also lost ground to the unpruned 500 spha treatment. The presence of unpruned followers in the other 500 and 750 spha treatments masked pruning effects.

The five thinning regime trials compared a range of stockings and the timing of thinning operations. Out to age thirty on the better sites the higher stockings produced the highest volumes, but the shortening of green crowns and the advent of some mortality may foreshadow a decline. At Dusky, the slowest growing site, the 750 spha stocking looked likely to be the best volume producer.

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