New Zealand Forest Site Management Cooperative

INSTALLATION REPORT FOR NZFSMC BORON TRIAL FR358/2, LAKE TAUPO FOREST

BY

S.T. OLYKAN, J.D. GRAHAM, & M.F. SKINNER

Report No. 117 **JUNE 2001**

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EXECUTIVE SUMMARY

This report describes the following aspects of the NZFSMC boron trial FR358/2:

- objectives for the trial series and this trial,
- site selection criteria, location, associated soils information, historical foliage data and recent environmental data,
- trial design including treatments (fertiliser and weed control), plot details and planting stock
- installation issues and procedures including layout of plots in the trial, allocation of blocking and treatments and fertiliser requirements,
- results from the initial measurement,
- data storage and analysis
- a schedule for future measurements and assessments.

In brief, the trial was installed in stand 1 of Cpt. 82 in Lake Taupo Forest and planted in August 1998. There are 4 replicates of the following 11 treatments:

- B added as ulexite (~10% B) at rates of at 0, 4, 8, 16 and 32 kg B/ha, by
- weed control (plus or minus).

plus an additional 'optimum' treatment:

- 1 rate of Nitrophoska Blue TE (added at 50 kg P/ha) plus 16 kg B/ha, with weed control.

The fertiliser was applied in November 1998.

Early results indicated that survival across the trial was high between planting and measurement (approximately 8 weeks). Since establishment, the trial has been measured (winter 2000), foliage sampled (February 2001) and soil sampled (May 2001). This data will be analysed later in 2001.

INTRODUCTION

Background to the FR358 trial series

This was described by Olykan *et al.* (2000) in the installation report for the B trial installed in Balmoral Forest, North Canterbury (FR358/1).

FR358/2 in Lake Taupo Forest

The Lake Taupo Forest trial, FR358/2, was established in 1998 at the same time that the Balmoral Forest Trial, FR358/1, was replanted.

FR358/2 objectives

To test the following hypotheses on a site where the rainfall was high and the total soil B was low:

- B addition significantly improves wood cell characteristics and wood quality in radiata.
- Weed control improves B availability to trees by increasing soil moisture availability and removing competition for B.
- A measure of the rainfall in the spring/summer season prior to foliage sampling in March can assist in the diagnosis of foliar B concentrations.
- Internal retranslocation significantly increases the efficiency of B use and prolongs the effect of added B.
- The soil can act as a reservoir of B for a number of years after B addition.

SITE SELECTION AND SOILS

Site selection

Boron nutrition in the central North Island has been described as marginal with a medium probability of some deficiency (Hunter *et al.* 1991). The search for a 2nd site, in the Boron trial series, focussed on areas which were low in B with high rainfall. A search of the foliar nutrient database, at Forest Research, identified Lake Taupo Forest as a candidate site. A visit to this area was made in March 1998, by Malcolm Skinner, Doug Graham (Forest Research) and Colin Dunstan (NZ Forest Managers), to further assess the potential of Lake Taupo Forest as a location for a trial. The current site was identified and Warrick Foran, MAF Crown Lease Forests, was contacted for approval to install the trial.

Site and soil details

General forest stand information

An area in stand 1 in compartment 82, on the corner of Waitetoko and Ruru Roads (**Figure 1**), was available for planting in the winter of 1998. The trial site is on a gently undulating slope with a northwesterly aspect at an altitude of 400 m asl, and is located at 2764000 E. 6249200 N

The current rotation is the second of radiata pine on this site. When the stand was selected it had already been ripped and mounded at 5m spacings (rows running NW to SE).

Current ownership

Lake Taupo Forest is a collection of blocks originally leased to the Government for 70 years by the Lake Taupo Forest Trust in 1969. The then NZ Forest Service ran the plantation with a percentage of stumpage value (reviewable 5-yearly) going back to the Trust. In March 2000, reflecting the current Government's desire to not be involved in production forestry, the terms of the lease were renegotiated and the Trust took over full control of any second rotation crop. Day to day management is in the hands of NZ Forest Managers.

Historical foliage data

A search of the Forest Research foliage database identified 244 samples that had been taken from Lake Taupo Forest between 1985 and 1998. A summary of this data (**Table 1**) shows that mean foliar B

concentration was 12 µg/g with a range of 4 to 56. Of the foliage samples analysed, 46 had foliar B concentrations less than 8 µg/g.

Table 1: Summary of historical foliage data from Lake Taupo Forest.

	Age years	N	P	K %	Mg	B µg/g	KMg
Number[†]		240	240	240	218	244	218
Mean	**7**	**1.49**	**0.16**	**0.89**	**0.10**	**12**	**9.3**
Maximum	24	2.00	0.26	1.50	0.17	56	17
Minimum	1	1.14	0.08	0.43	0.04	4	4
Number deficient[‡]		6	17	0	13	46	82[+]

[†] Number of samples out of 244 analysed for each nutrient.
[‡] Number of samples with 'deficient' or 'low' concentrations (based on values from Will 1985).
[+] Number of samples with KMg ratios greater than 10.

Figure 1: Stand map of compartment 82, Lake Taupo Forest, and the siting of FR358/2.

Soils

The soils in this area are yellow-brown pumice soils. The soil type is Waipahihi sand derived from water sorted tephra.

Soil boron in Lake Taupo Forest

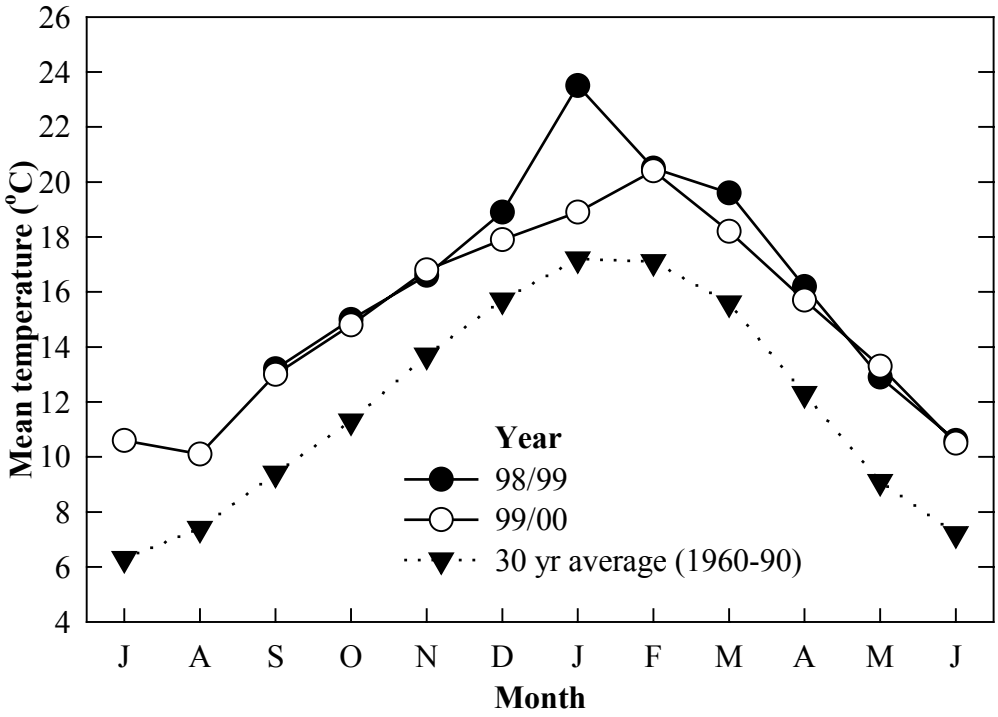
Soil samples were collected from the 8 plots that had not received boron or intensive weed control in October 1999, to confirm the B status of this soil. Eight samples were taken from each plot and bulked, per plot, to give a sample for the 0 to 10 and 10 to 20 cm depths. The 0 – 10 cm samples were analysed for total available soil B using a perchloric acid / nitric acid digest.

Mean total 'available' soil B was 2.9 ppm (range of 2.4 to 3.4) in the 0 to 10 cm depth. The "Total Boron In Topsoils" map (Wells and Crerar 1962) rated this area as medium to low at 10 to 15 ppm. It is not currently known how these values for total 'available' and the actual total boron compare. The samples will be reanalysed for total B.

Environmental conditions

Temperatures from September 1998 to June 2000 were considerably warmer than the 30-year average from 1960 to 1990, especially during the summer of 1998/99 (**Figure 2**).

Figure 2: Mean monthly temperatures from September 1998 to June 2000 at Turangi (south of Lake Taupo). Long term average from 1960 to 1990 included.

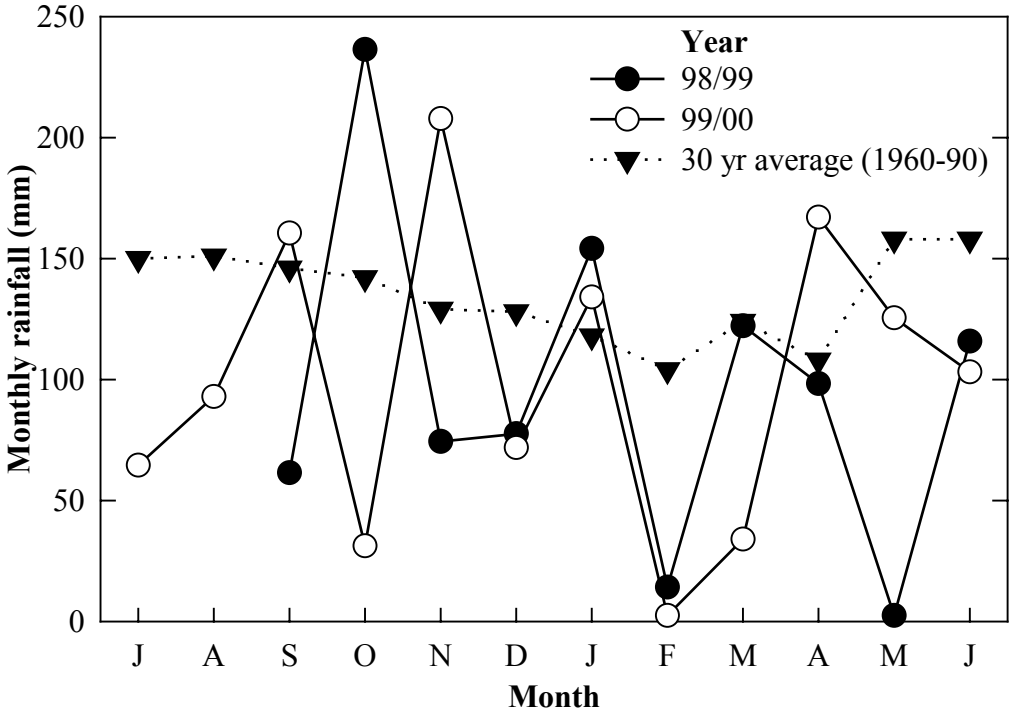


The trial is located in a high rainfall area. The 30-year (1960 to 1990) long-term average annual rainfall for Turangi is 1616 mm (Grant Pearce, *pers. comm.*). Rainfall since the middle of 1998 has been highly variable (**Figure 3**). During 1998/99, September, February, and particularly May, were dry months with rainfalls less than half the long term average (42, 14 and 2% respectively). While there was 236 mm of rain in October 1998 (166% the long term average), the total rainfall from September 1998 to June 1999 was 957 mm which represented only 73% of the long term average for this period.

Four months of the 99/00year had rainfall that less than the half the long-term average – July, October, February and March (43, 22, 2 and 27% respectively). Of key interest was the two dry months of February and March where rainfall was exceptionally low. Instead of the expected 228 mm, only 29 mm was recorded suggesting that this site is not immune from drought. While November and April were much wetter than the long term average (208 and 167 mm versus long-term averages of 129 and

108 mm respectively) the total rainfall during the 1999/00 year was 1195 mm which was 74% of the long-term average.

Figure 3: Monthly rainfall at Turangi (south of Lake Taupo) from September 1998 June 2000. Long term average from 1960 to 1990 included.



TRIAL DESIGN

Treatments

The design for the Boron trial series consists of a factorial of the following treatments:

- rates of B (added as ulexite, ~10% B) at 0, 4, 8, 16 and 32 kg B/ha, by
- weed control (plus or minus).

plus an additional 'optimum' treatment:

- 1 rate of Hydro Green[1] (added at 50 kg P/ha) plus 16 kg B/ha, with weed control.

There are a total of 11 treatments (**Table 2**), which are replicated 4 times to give a total of 44 plots.

Weed control

It is envisaged that chemical and/or manual methods of weed removal will be used. The chemicals and rates of active ingredient used will depend on the weeds present on the site. The method of application will depend on the equipment used by the forest company and the topography.

Plot size

At Lake Taupo Forest, the inner plots are 25 m x 25 m and the outer plots are 45 m x 45 m (0.0625 and 0.2025 ha respectively) covering a total area of 8.9 ha. The plot sizes varied slightly to accommodate variations in the cultivation line spacing, the aim being to include 5 rows in the inner

[1] Hydro Green contains the following elements: 14% Nitrogen (N), 5% Phosphorus (P), 15% Potassium (K), 4% Calcium (Ca), 1% Sulphur (S), 1% Magnesium (Mg).This rate of Hydro Green would add: N at 140 kg/ha, P at 50 kg/ha, K at 150 kg/ha, Ca at 40 kg/ha, Mg at 10 kg/ha, S at 10 kg/ha .

plots and 9 rows across the total plot width. It was envisaged that this plot size would provide sufficient measurement trees during the rotation and allow the periodic biomassing of trees.

Table 2: Treatments added in the FR358 trial series.

	Treatments		
Trtmt no.	**Boron kg/ha**	**Weed control (+/-)**	**Optimum**
1	0	- (No)	-
2	4	- (No)	-
3	8	- (No)	-
4	16	- (No)	-
5	32	- (No)	-
6	0	+ (Yes)	-
7	4	+ (Yes)	-
8	8	+ (Yes)	-
9	16	+ (Yes)	-
10	32	+ (Yes)	-
11	16	+ (Yes)	Yes

Planting stock

The radiata pine planting stock for the B trials was provided by CHH (3 families) and FCF (5 clones) as an inkind contribution. The same genetic material has been and will be used for installing all of the B trials.

Stocking rate

The site at Lake Taupo Forest was lightly V-bladed (slash removal only) then ripped and mounded. The final planting pattern was 5 m (between rows) x 2.25-2.5 m within rows to give a final stocking of 840 sph.

TRIAL INSTALLATION

Installation issues

The plots were installed in late July 1998. Areas with small steep gullies or badly discontinuous cultivation lines were avoided. Wooden pegs 50x25x1200mm were used to mark the corners of the inner and outer plots. The tops of pegs in the inner plots were painted yellow and the outer plot pegs painted blue.

The layout of the plots is shown in **Figure 4**. The plots are then numbered 1 to 44. White aluminium tags with the plot number in orange were attached to all four pegs in each inner plot for future identification.

Preparation and planting of stock

Preparation of the planting stock

Each genotype, to be planted in the inner plot, was labelled with a coloured tag to identify its genetic origins (**Table 3**). The tag was attached to the upper part of the seedling so that it was not buried during planting.

Figure 4: Layout of plots in the Lake Taupo Forest B trial, FR358/2.

Table 3: Genotypes and codes of the planting material planted in the Lake Taupo Forest B trial, FR358/2, in 1998.

No.	Genotype	Tag
1	Clone 111P	Orange
2	Clone 107P	White+red splash
3	Clone 143P	White
4	Family 96-033	White pointed or numbered 33
5	Clone 230P	White+dark blue splash
6	Family 96-035	Yellow or numbered 35
7	Clone 146P	Lime green
8	Family 96-226	Light blue or numbered 226

On receiving the planting material from the companies it was kept in a cool store. Preparation of the stock for planting involved recombining the genotypes for planting and repackaging in the planter boxes. There were insufficient clonal representatives to cover the whole plot uniformly so the bundles of 10 genotypes were assembled in the following manner:

- For each line of the inner plot – one of each of the 8 individuals plus 2 chosen at random (bundles labelled " I ", 5 bundles per inner plot).
- For the buffer areas – one of each individual plus 2 random families (bundles labelled " O ", 12 bundles per outer plot).

Planting

The trial was planted in mid August 1998. MAF provided a group of 7 trained planters including a leading hand. Three people from Forest Research transported the planting stock from the cooler to the field, moved the 'start-stop' lines, helped distribute planting stock to the planters and oversaw the planting process. Planting took 1.5 days.

Blocking and allocation of treatments

Blocking of the plots was based on a combination of slope position and observed soil colour in the cultivated lines. The treatments were then randomly allocated to the plots within each block (**Appendix 1**).

Fertiliser requirements and addition

The total amount of fertiliser required per plot is shown in **Appendix 2**. Boronat (the pelletised form of ulexite used in the experiment) was donated by the fertiliser merchants D R Johnston Ltd while the Hydro Green was purchased through normal channels. The fertiliser was broadcast by hand on 10 November 1998. Nine people took part in the operation, 3 from Forest Research, 1 from MAF, 5 through NZFM (courtesy of MAF). There was no rain during the application.

MEASUREMENT, ASSESSMENT AND SAMPLING: METHODS AND RESULTS

Initial biomass

Individuals from each genotype were biomassed. Please refer to the installation report for the Balmoral Forest trial (Olykan *et al*. 2000) for more details.

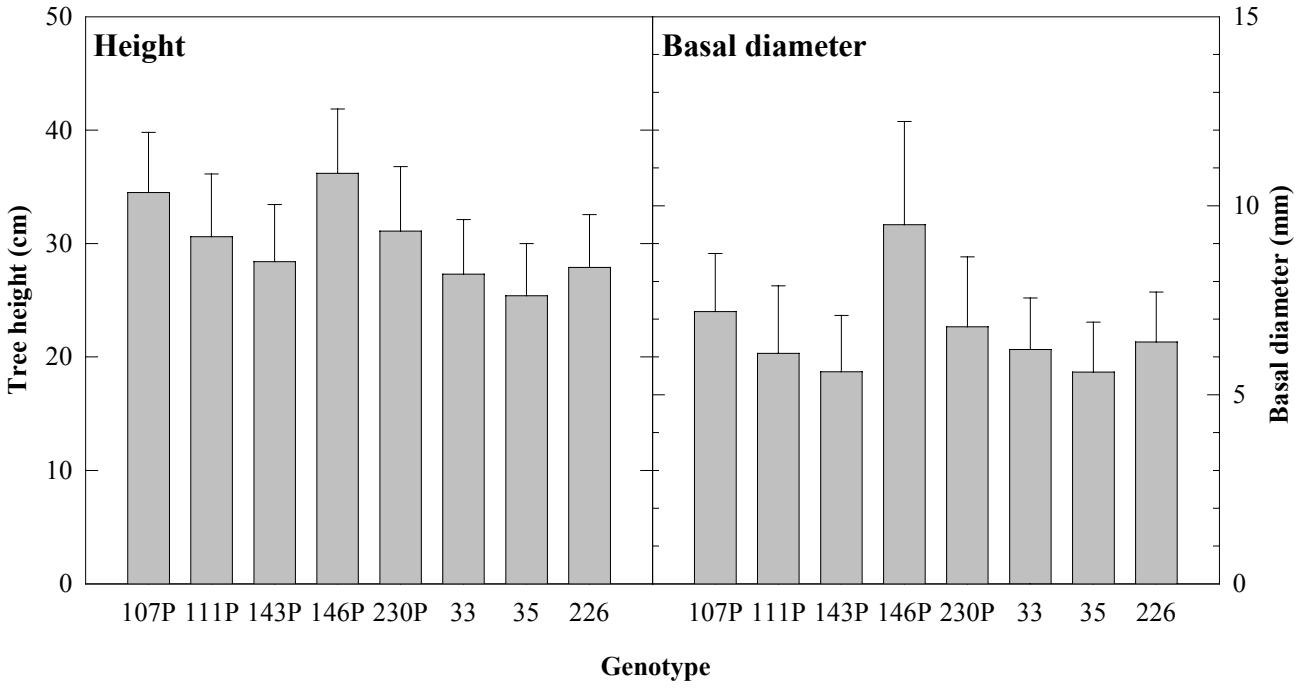
Mapping genotypes and initial measurement

The mapping of all genotypes in both the inner and outer plots was done in mid August 1998, immediately after planting. The initial measurements were carried out after fertilising in early November 1998. The procedure for numbering the individuals in the inner plot is shown in **Appendix 3**. The genotype of each individual in the inner plot was identified from its tag (see **Table 4**) and recorded and the height and root collar diameter measured and recorded. A summary of this data for

each plot is presented in **Appendix 4**. Between planting and measurement (approximately 12 weeks), survival across the trial was 100%.

Based on the individual data, mean tree height was 29.6 cm (individual range of 13 to 56 cm) and mean tree root collar diameter was 6.5 mm (individual range of 2.0 to 18 mm). As noted in the Balmoral trial report (Olykan *et al*. 2000) there were differences between the genotypes in terms of height and basal diameter once planted (**Figure 5**). Genotype 146P was the largest particularly in basal diameter.

Figure 5: Initial height and basal diameter measurement of the radiata genotypes planted in the Lake Taupo Forest B trial, FR358/1.



Weed control measures since 1998

A post-plant aerial spray of 20L terbuthylazine per ha was carried out in mid October 1998. An overall aerial spray of Velpar (4kg a.i. /ha) was used to control the rampant bracken growth in March 1999. The bracken kill was exceedingly good and dead bracken with patchy emerging broom (1.5 – 2m high) dominates the ground cover.

MAINTENANCE OF THE TRIAL

Forest Research staff will be regularly visiting the sites and will maintain the plot pegs and tree numbering. Should silvicultural management be required within the trial, it is expected that the forest company will provide personnel to carry this out.

Schedule of future measurements, assessments and sampling in FR358/2

There are a number of growth measurements, foliage and soil sampling, and visual assessments proposed for this trial (see **Table 4**). It is expected that the following will be funded by NZFSMC:

- Regular foliage sampling, by plot, and chemical analysis of samples.
- Periodic soil sampling and analysis.
- Regular measurements of tree height, root collar diameter/dbh.
- Periodic visual assessment of form with particular emphasis on identifying the presence of B deficiency symptoms.

Table 4: Schedule of general measurements, soil and foliage sampling, assessments and biomassing for the Lake Taupo Forest B trial, FR358/2, for the first 4 years.

Year†	Month	Measure	Sampling		Assess	Biomass
			Foliage	Soil		
1998	August	✓ Initial				✓ Seedlings
2000	August	✓			✓ Form	
2001	March		✓	✓		
2002	August	✓				

Shaded tasks have been completed.

Additional boron research projects will also be carried out in this trial using PGSF funding and may include the following pieces of work will be undertaken during the next 6 years:

- Investigation of the role of sugar alcohols in the internal retranslocation of B in radiata pine genotypes.
- Lysimeter studies to investigate B flux in relation to rainfall.
- Regular soil sampling to identify B fractions in the soil and determine the longevity of B in the soil as a result of fertiliser addition.
- Periodic biomass studies (above and below-ground radiata and weeds) to provide information relating to B cycling and tree growth and nutrient content and material for the measurement and assessment of wood cell characteristics (as done by M. Skinner and A. Singh) and wood quality.

Future foliage and soil sampling

These will be carried out as required. The first full foliage sample of this trial is scheduled for March 2001. Soil samples may also be taken at this time.

Weed control

The continuing maintenance of the weed control treatment is the responsibility of Forest Research. The weed control (as per trial design) will be carried out in 2001 as the trial is scheduled for a mechanical removal of dead standing broom in 2001 from the weed control treated plots. This will result in a much-reduced ground cover. A follow-up spray applied to re-emergent broom in the relevant plots in autumn 2002.

Reports and papers

Reports summarising the measurements, foliage and soil analysis results, and assessments (as outlined in **Table 5**) from all of the trials in this series will be produced for the NZFSMC periodically.

Data location

All data is being stored on the Forest Research PSP system and held on Excel spreadsheets by Forest research staff who are team members of this project.

BORON DECISION SUPPORT SYSTEM

In the medium term, a Decision Support System (DSS) will be produced for the management of B nutrition in radiata pine plantations in New Zealand. The development of a framework for a B DSS has been funded by NZFSMC for the 2000/01 financial year.

ACKNOWLEDGMENTS

We wish to acknowledge the assistance and contributions of the following companies and individuals:

- The Lake Taupo Forest Trust for having the trial on their land.
- CHH (Fred Burger, Grant Hastings, and Mike Sheerin) and FCF (Helen Chapman, Kathy Grant, Mark Ryan, Janet Scott, Brendan Slui, and Christine TeRenii) for supplying planting material.
- NZ Forest Managers and MAF for supplying the site and information, planting crew and assistance with the ongoing maintenance of the weed control treatments (Colin Dunstan, Warwick Foran, Bill Wheeler).
- D R Johnston Ltd for supplying the B fertiliser inkind.
- Alison Lowe and Kaye Eason (Forest Research) for their assistance during the installation.

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APPENDICES

Appendix 1: Allocation of blocking and treatments to plots in FR358/2.

Plot	Block	Tmnt	B kg/ha	Weed control	Hydro green
1	2	11	16	Yes	Yes
2	2	4	16	No	
3	3	8	8	Yes	
4	3	11	16	Yes	Yes
5	3	2	4	No	
6	3	9	16	Yes	
7	3	5	32	No	
8	3	7	4	Yes	
9	3	1	0	No	
10	2	3	8	No	
11	2	1	0	No	
12	1	6	0	Yes	
13	1	9	16	Yes	
14	1	8	8	Yes	
15	1	11	16	Yes	Yes
16	1	10	32	Yes	
17	1	5	32	No	
18	1	4	16	No	
19	1	2	4	No	
20	1	7	4	Yes	
21	1	3	8	No	
22	2	10	32	Yes	
23	3	4	16	No	
24	3	6	0	Yes	
25	3	10	32	Yes	
26	2	2	4	No	
27	2	6	0	Yes	
28	1	1	0	No	
29	4	10	32	Yes	
30	4	1	0	No	
31	4	4	16	No	
32	2	8	8	Yes	
33	2	7	4	Yes	
34	3	3	8	No	
35	2	5	32	No	
36	2	9	16	Yes	
37	4	6	0	Yes	
38	4	9	16	Yes	
39	4	11	16	Yes	Yes
40	4	5	32	No	
41	4	2	4	No	
42	4	7	4	Yes	
43	4	3	8	No	
44	4	8	8	Yes	

Appendix 2: Fertiliser requirements for FR358/2, Lake Taupo Forest

Fertiliser required for each treatment.

Fertiliser rate	No. plots	Total area (ha)	Ulexite required†	Hydro Green required‡
0 kg B/ha	8	1.62	-	-
4 kg B/ha	8	1.62	65	
8 kg B/ha	8	1.62	130	-
16 kg B/ha	8	1.62	261	-
32 kg B/ha	8	1.62	522	
Hydro Green + 16 kg B/ha	4	0.81	130	810 kg
		Total:	1108 kg	810 kg

† Based on using Boronat which is 9.94% B[2].

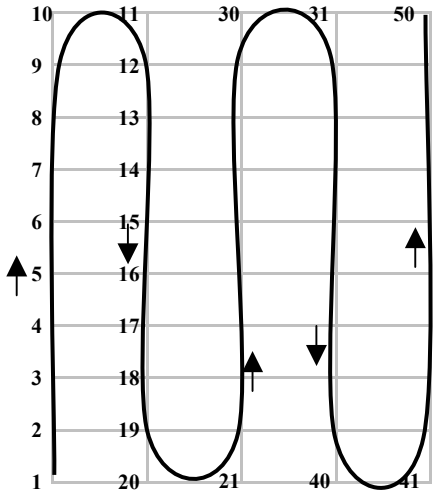
‡ Based on using Hydro Green (5% P) and applying at 50 kg P/ha.

Fertiliser requirement per plot.

Fertiliser rate	Trtmt no's	Area (ha)	Element required/plot	Ulexite required	Hydro Green required
0 kg B/ha	1, 6	0.2025	-	0 kg	-
4 kg B/ha	2, 7	0.2025	0.81 kg B	8.15 kg	
8 kg B/ha	3, 8	0.2025	1.62 kg B	16.30 kg	-
16 kg B/ha	4, 9	0.2025	3.24 kg B	32.60 kg	-
32 kg B/ha	5, 10	0.2025	6.48 kg B	65.21 kg	
Hydro Green + 16 kg B/ha	11	0.2025	10.13 kg P + 3.24 kg B	- 32.60 kg	202.6 kg

[2] MW of B_2O_3= 69.617 g. %B in B_2O_3 = 0.311. 100 kg of Boronat Ulexite = 32 kg B_2O_3 and 9.94 kg B. Boronat = 9.94 %B.

Appendix 3: Example of numbering of trees in the inner plot of FR358/2, Lake Taupo Forest.



Waitetoko Rd

Appendix 2: Mean, standard deviation, minium and maximum height and diameter measurements from each plot in FR358/2, Lake Taupo Forest.

Plot	Height (cm)				Root Collar Diam. (mm)			
	Mean	Std. Dev.	Min	Max	Mean	Std. Dev.	Min	Max
1	7	1.7	4	12	30	5.7	20	42
2	7	1.7	3	12	31	5.8	21	46
3	7	1.5	5	13	30	4.8	20	42
4	7	1.7	4	12	29	5.6	16	39
5	7	2.4	4	16	33	6.8	18	48
6	7	1.5	5	12	33	5.6	20	43
7	6	1.9	3	10	29	5.9	15	47
8	6	1.8	2	13	30	5.8	18	45
9	6	2.4	2	15	29	6.1	16	45
10	6	2.2	3	16	30	5.0	15	43
11	6	1.9	3	13	30	5.2	19	41
12	6	1.9	3	14	30	5.1	18	41
13	6	2.4	3	17	27	5.1	15	41
14	6	1.7	3	13	30	6.0	19	45
15	6	2.2	3	13	30	6.8	17	43
16	7	1.4	4	11	31	5.3	21	43
17	6	2.2	3	13	28	5.7	15	40
18	6	1.8	3	11	30	6.3	18	42
19	7	1.7	4	12	28	6.0	14	43
20	7	2.6	4	18	31	6.7	18	44
21	6	1.9	3	12	28	6.4	19	45
22	6	1.4	3	11	29	5.1	16	40
23	6	1.4	4	11	32	5.6	21	43
24	6	1.6	4	12	31	6.6	18	44
25	7	2.2	3	16	27	6.3	16	42
26	7	1.7	4	12	30	5.9	18	48
27	7	2.3	4	14	30	6.5	19	46
28	6	2.0	3	12	29	6.1	16	46
29	6	1.5	3	10	29	4.6	21	40
30	6	1.9	2	10	28	5.3	18	41
31	6	2.1	3	12	32	6.8	20	43
32	6	2.4	3	17	32	7.2	18	49
33	6	1.9	3	13	29	5.7	16	46
34	7	1.9	3	13	30	5.7	19	46
35	7	2.3	4	17	28	5.7	20	45
36	7	2.1	4	14	31	5.4	22	45
37	6	1.8	3	11	29	5.9	19	43
38	6	2.3	3	14	27	6.0	20	41
39	7	2.0	4	13	27	5.4	16	41
40	7	2.1	4	13	28	6.7	17	43
41	7	1.9	5	15	32	7.4	18	55
42	7	1.7	3	13	31	6.1	19	48
43	8	2.1	3	13	28	7.3	13	49
44	7	1.9	3	12	29	7.5	15	56