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FOREST OVERSOWING AND GRAZING TRIAL SERIES - PROGRESS TO JUNE 1997

By

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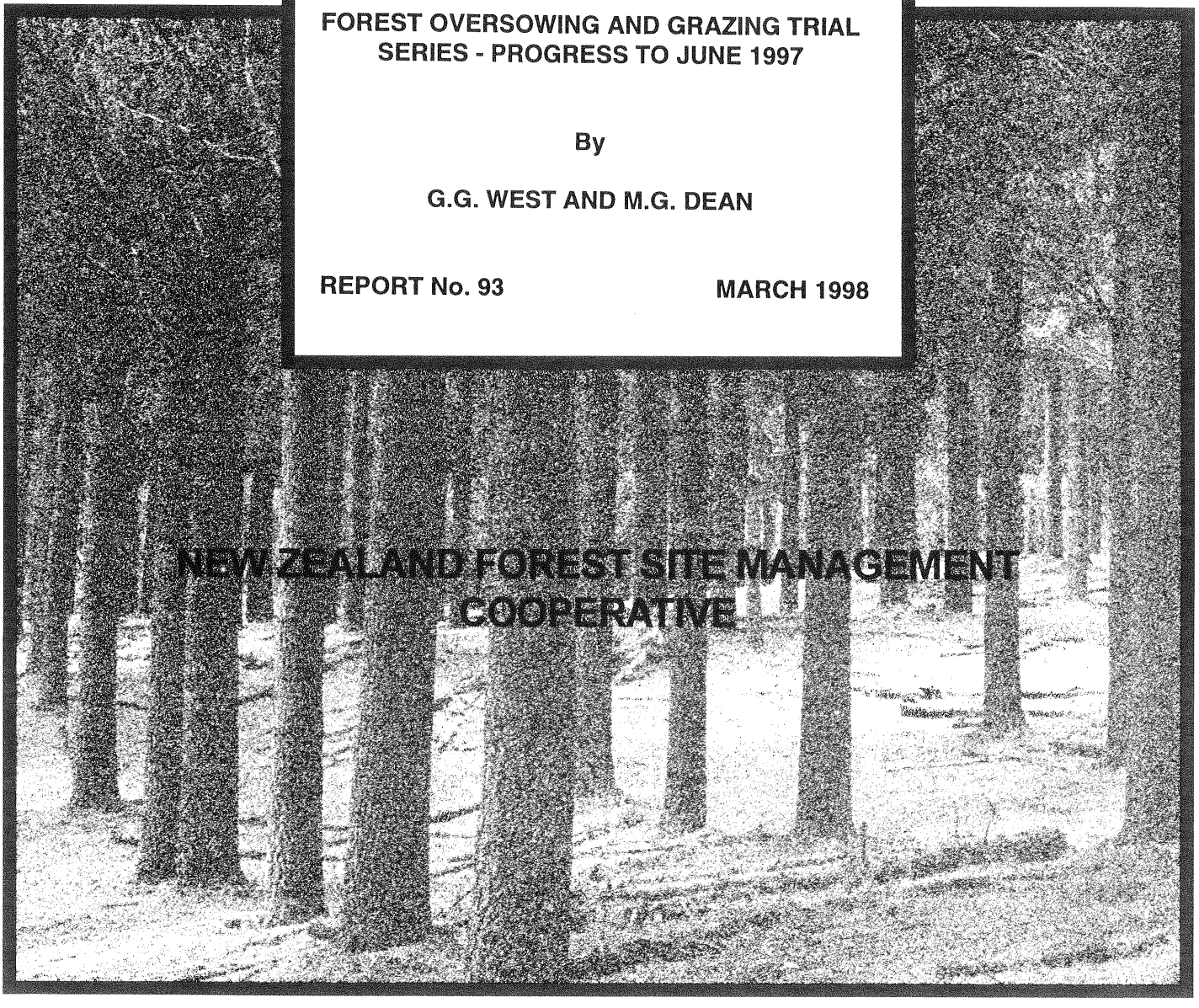

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FOREST OVERSOWING AND GRAZING TRIAL SERIES - PROGRESS to June 1997

GG. West and M. G. Dean

SUMMARY

Four major trials have been measured and maintained in Aupouri, Waiuku, Maramarua, and Kaingaroa forests to quantify the effects on tree growth of oversowing Maku lotus and grazing . Treatments of total weed control with herbicides, cattle grazing of pampas, and the addition of nitrogenous fertiliser have been included in these trials at sites where these treatments were appropriate.

These trials address the issues of improving productivity with legumes and controlling weeds with less herbicides. They indicate there is an opportunity to improve productivity by improving N supply and that Maku lotus is suitable for this purpose. Legume performance on most sites is likely to be influenced by the level of P supply and the amount of competition from woody weeds and pampas. Failure to control such weeds will mean the benefits of legumes are not possible and a substantial opportunity cost may result. For pampas grass, grazing with cattle provides a biologically benign and inexpensive method of control.

Specific results from these trials to date are :

1) Oversowing with lotus has significantly improved basal area growth on three of the trial sites - Aupouri, Waiuku, and Kaingaroa.

2) Oversowing with lotus has not improved height growth.

3) The benefits in basal area growth from lotus occurs with and without cattle grazing at Kaingaroa.

4) The benefit in basal area growth from lotus will depend on tree stocking.

5) Competition from pampas grass results in significant losses in tree diameter growth but not height growth.

6) Grazing of pampas will significantly reduce losses in basal area caused by pampas competition.

7) Considerable gains in basal area growth from N fertiliser have been indicated at the Aupouri trial.

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INTRODUCTION

These trials address the issues of improving productivity with legumes and controlling weeds with less herbicides. In June 1995 a report for this series of trials was prepared for the Site Management Cooperative (No. 70) documenting interim results of tree growth and foliage analysis (West and Dean, 1995). Details of trial treatments and plot layout, with maps, were included. Therefore this report will only give brief summaries of treatments and will rely on the previous report for detail.

Briefly the background to these trials is as follows:
1. From 1981 to 1985 five major trials were established in Aupouri, Waiuku, Maramarua, Kaharoa (NW Mamaku), and Kaingaroa forests to quantify the effects on tree growth of oversowing Maku lotus and grazing . Treatments of weed control with grazing or herbicides and the addition of nitrogenous fertiliser have been included in trials where this was appropriate. Early results from these trials have been reported in West *et al* (1988) , West and Dean (1990), West *et al* (1991), West and Dean (1992), West and van Rossen (1994).

2. In July 1991 this series of trials became part of the research programme funded by the Site Management Research Cooperative. Measurement of these trials every second year has been funded by the Cooperative. Measurement on alternative years has been funded by FRST.

3. The Kaharoa trial was abandoned in 1995. As previously reported, this was due to the contamination of the control plots with lotus, confounding the experiment.

This report gives progress with the management of these trials and an update of tree growth results.

Description of trials

These trials form a series of experiments with similar experimental design and treatments applied. Table 1 gives the year planted , year of trial establishment, and current age of the trials. Table 2 gives a comparison of treatments covered at each trial

Table 1: Trial description

Location	Year planted	Date established	Current tree age
Aupouri	1983	1985	14
Waiuku	1975	1981	22
Maramarua	1980	1984	17
Kaingaroa	1980	1983	17

Table 2: Treatments by trial

Treatments	Aupouri	Waiuku	Maramarua	Kaingaroa
Control	*	*	*	*
Herbicide#		*	*	
Graze to kill weeds		*		
Manage graze weeds		*		
Lotus+Graze weeds	*	*	*	*
Lotus ungrazed				*
Lupin	*			
N fertiliser	*			

* treatment represented in trial
# Total weed control with repeated herbicide applications

AUPOURI TRIAL - AK1021

Trial history and Treatments

This trial was established tree age 2 years with the objective of comparing the effects of a range of alternative sources of nitrogen on tree growth within a coastal sand forest. The trial design is a randomised complete block design. Treatments were as follows:

1. Control
2. Lupin
3. N fertiliser
4. Lotus + grazing

To encourage legume and tree growth the whole trial area was fertilised at the time of trial establishment with 200 kg/ha of superphosphate. Lupin was resown (at 10 kg seed/ha) in the "Lupin" treatment to encourage regrowth. N fertiliser (Urea) treatment involved two applications/yr (spring and autumn) of 50 kg N/ha every year. To date a total of approximately 1000 kgN/ha has been applied. Maku lotus was sown at 5 kg of seed /ha in the "Lotus + Graze" treatment. Grazing of the lotus began in the second year using cattle. Initially the trial received 2 grazings/year with some Marram grass included in the forage consumed. This changed to a single grazing by tree age 8 and since tree age 9 the trial has not been grazed due to a lack of cattle in the local area.

In 1989 the lupin was decimated by the fungus *Colletotrichum gloeosporioides*. To retrieve something from the plots of this treatment, they were oversown with Maku lotus in 1990. This proved to be unsuccessful with poor lotus establishment due to high tree stockings.

The silvicultural regime in this trial has been the standard Aupouri forest practice of pruning 270 stems/ha to 8.5m combined with a production thinning regime. The trial was waste thinned from approximately 1300 to 800 stems/ha at age 6. The second thinning occurred in December 1996 as a production thinning, leaving a residual stocking of 270 stems/ha.

Tree Growth

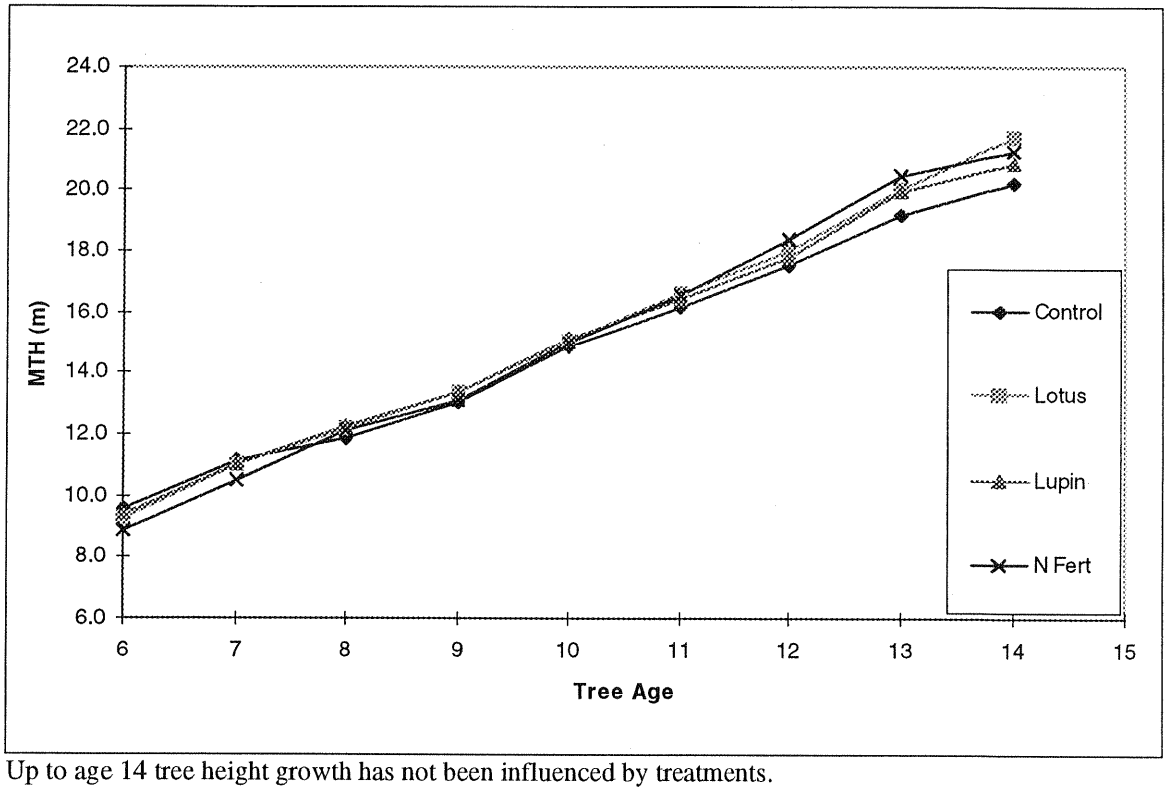
Measurement of tree growth and application of N fertiliser treatments has continued for the last two years. Table 3 gives results of height measurements.

Table 3: Mean top height by age and treatment

	Mean top height (m)			
Age	Control	Lotus	Lupin	N Fert
5	7.0	7.0	7.0	7.2
6	9.6	9.3	9.4	8.9
7	11.1	11.0	11.0	10.5
8	11.9	12.2	12.3	12.2
9	13.1	13.4	13.4	13.1
10	14.9	15.1	15.1	15.0
11	16.2	16.6	16.5	16.6
12	17.5	18.0	17.8	18.4
13	19.2	20.0	20.0	20.5
14	20.2	21.8	20.9	21.3

The development of height by tree age is given in figure 1.

Figure 1:MTH development through time by treatment at Aupouri



Up to age 14 tree height growth has not been influenced by treatments.

Tree basal area results are given in table 4.

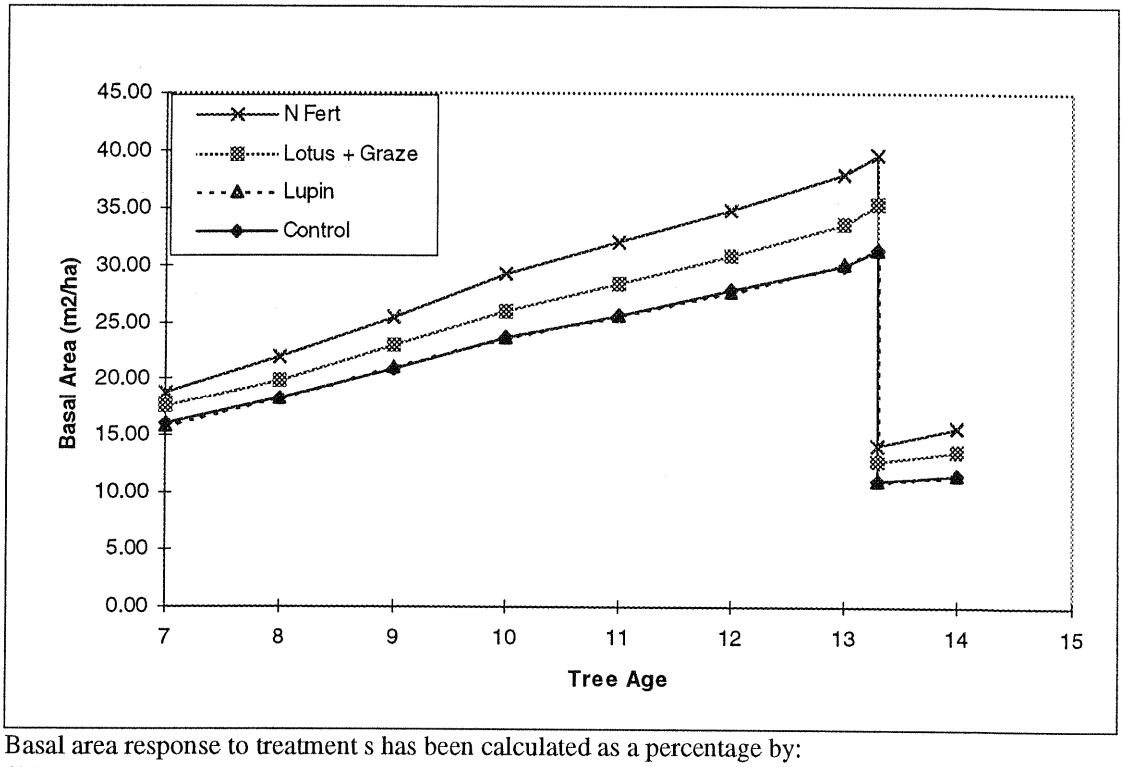
Table 4: Basal Area by tree age and treatment

Tree Age	Basal Area (m2/ha)			
	Control	Lotus + Graze	Lupin	N Fert
7	16.13	17.61	15.95	18.84
8	18.29	19.99	18.29	22.01
9	20.99	23.03	21.14	25.51
10	23.65	26.01	23.72	29.17
11	25.64	28.40	25.65	31.98
12	27.80	30.84	27.75	34.86
13	30.01	33.55	30.04	37.86
13.3*	31.35	35.30	31.39	39.71
13.3*	11.10	12.07	11.00	14.30
14	11.86	13.66	11.65	15.82

* Production thinned in November 1996 - giving pre and post-thinning basal area. Post-thinning values are adjusted for small variations in stocking.

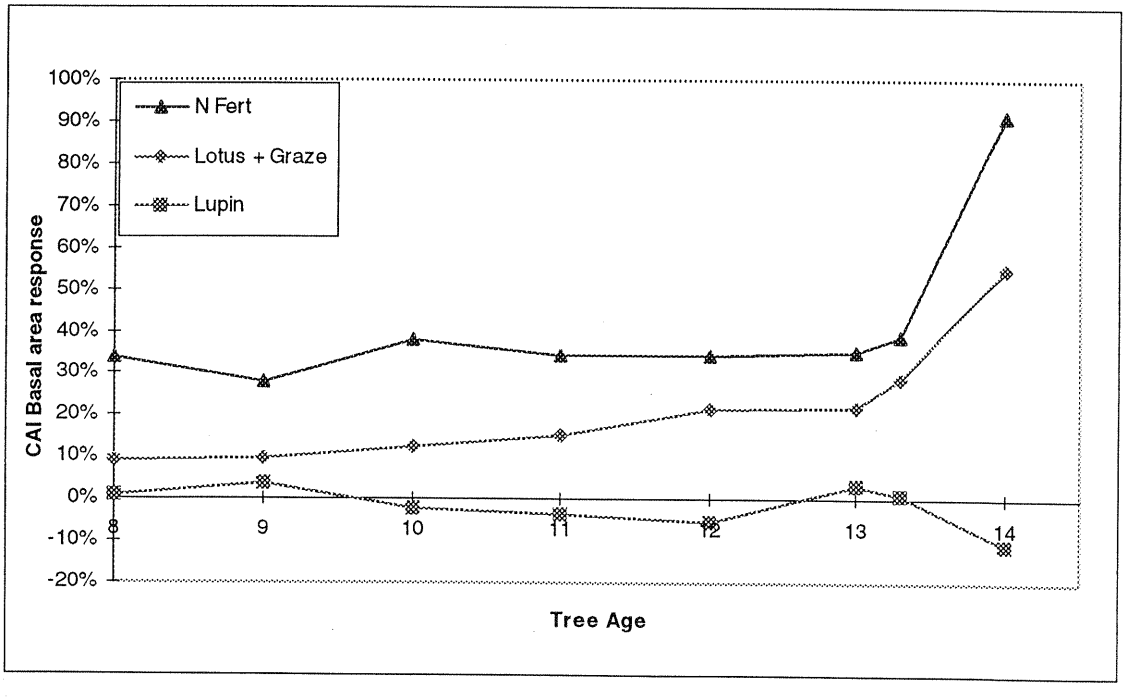
Basal area development through time by treatment is given in figure 2. Figure 3 gives the basal area response to treatments relative to the controls.

Figure 2: Basal area development by age and treatment



Basal area response to treatment s has been calculated as a percentage by:
((Treatment basal area - Control basal area)/ Control basal area) x 100

Figure 3: Basal area response to treatments relative to the control



For the last 6 years, basal area increment for the N fertiliser treatment (100 kg N/ha/yr) has shown a consistent 30% improvement over the control. Since the thinning in November 1996 (8 months) this has dramatically increased to 80-90%. The lotus + graze treatment has steadily improved from approximately 10% to 20 % improvement over the same period and has also jumped to 50-60% in the last period. These result show that both treatments receiving N have made far greater responses to

the thinning than the control. Foliar N levels (appendix 1) support this and indicate a more rapid post-thinning crown development occurred in these treatments.
Because of the early lupin mortality, and the failure of a late oversowing of lotus, the "Lupin" treatment should be considered the same as the control.
Table 5 gives results of analysis of variance of annual basal area increment.

Table 5: Results of analysis of variance of annual basal area increment

Tree age	7	8	9	10	11	12	13	14
N Fert	A	A	A	A	A	A	A	A
lotus + Graze	B	B	B	B	B	B	B	A
Lupin	B	B	B	C	C	BC	C	B
control	B	B	B	C	C	C	C	B

Treatments with the same letter are not significantly different - P= 0.05

WAIUKU TRIAL - AK 847

Trial history and Treatments

Treatments for this trial were developed to quantify the effect of pampas grass on tree growth and to examine alternative strategies for controlling this weed. Treatments in this trial include:
1. Control - Nil treatment resulting in dense pampas understorey.
2. Spray - repeat applications of glyphosate to achieve total weed control.
3. Manage Graze - grazing pampas with cattle 2-3 times a year to maintain a low understorey of pampas for forage.
4. Graze to Kill - graze pampas 4-6 times a year to kill plants (Due to light grazing this did not occur for the first 3-4 years)
5. Lotus + Graze - oversow with Maku lotus and graze as in 3 above.

The trial is a randomised complete block design with initial basal area used to identify blocking strata.
Prior to oversowing with lotus, the appropriate plots were grazed with cattle to reduce the ground cover. No fertiliser has been used in the treatments of this trial

The pruning and thinning within the trial has generally followed a direct sawlog regime thinning down to a final crop stocking of 200 stems/ha at 12-13m MCH and pruning to 6.0m by tree age 11 years.

Tree growth

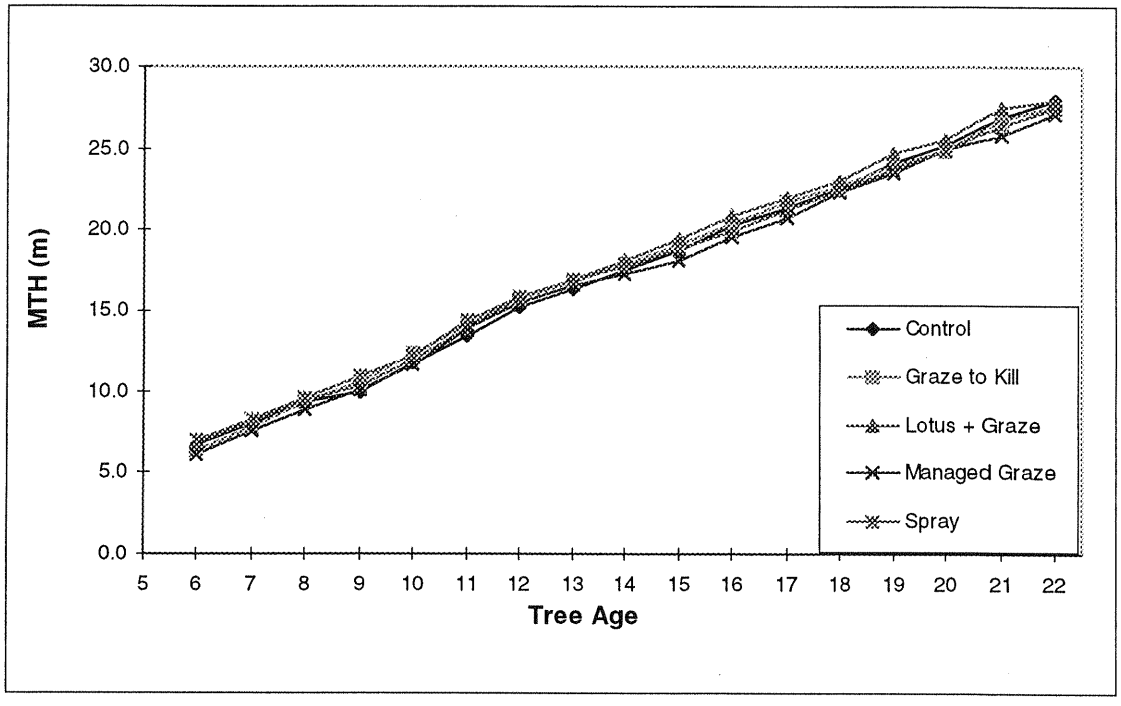
Table 6 gives results of height measurements.

Table 6: Mean top height by age and treatment

Tree Age	Control	Graze to Kill	Lotus + Graze	Managed Graze	Spray
6	6.7	6.4	6.8	6.1	6.9
7	8.0	7.8	8.1	7.6	8.3
8	9.3	9.4	9.5	8.9	9.6
9	10.0	10.5	10.3	10.1	10.9
10	11.8	12.4	12.0	11.7	12.3
11	13.5	14.2	13.9	13.9	14.5
12	15.2	15.7	15.8	15.5	15.9
13	16.4	16.8	16.9	16.6	16.9
14	17.6	17.9	18.1	17.3	17.8
15	18.7	19.0	19.5	18.2	18.9
16	20.3	20.4	20.9	19.6	19.9
17	21.4	21.7	22.0	20.8	21.3
18	22.6	22.7	23.1	22.3	22.5
19	24.2	24.0	24.7	23.5	23.7
20	25.2	24.8	25.6	24.9	25.0
21	26.9	26.8	27.5	25.8	26.4
22	28.0	27.6	27.9	27.2	27.5

The development of height by tree age is given in figure 4.

Figure 4: MTH development by age and treatment.



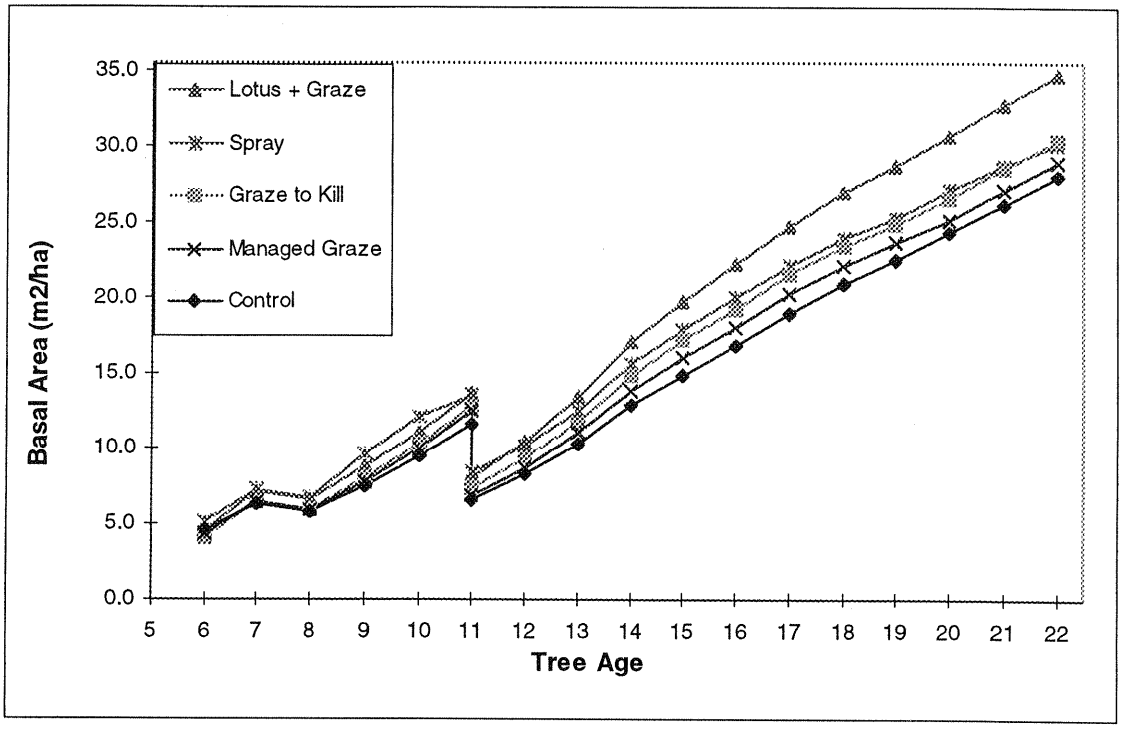
Height growth at this trial has not been effected by treatments. NB This includes severe competition from pampas in the controls.

Table 7 gives basal area results from age 6 to 22. Figure 5 gives basal area development through time for each treatment.

Table 7: Basal Area by tree age and treatment

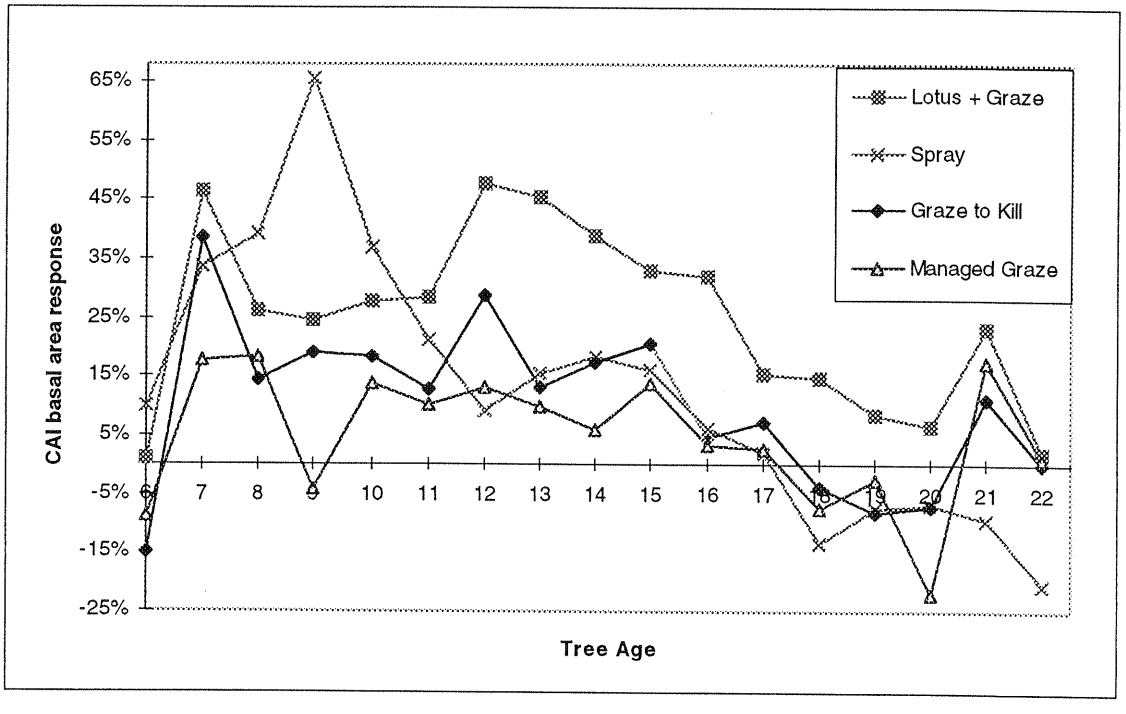
Tree Age	Control	Graze to Kill	Lotus + Graze	Managed Graze	Spray
6	4.6	4.1	4.6	4.4	5.1
7	6.4	6.4	7.2	6.5	7.2
8	5.8	5.9	6.6	6.0	6.8
9	7.6	8.0	8.8	7.7	9.6
10	9.4	10.2	11.0	9.9	12.1
11	11.6	12.8	13.7	12.4	13.6
11	6.6	7.3	8.0	6.9	8.4
12	8.2	9.4	10.4	8.7	10.1
13	10.3	11.7	13.4	11.0	12.5
14	12.9	14.8	17.0	13.8	15.6
15	14.9	17.2	19.7	16.1	17.9
16	16.8	19.2	22.2	18.0	19.9
17	18.9	21.5	24.7	20.3	22.1
18	21.0	23.4	27.0	22.1	23.9
19	22.5	24.9	28.7	23.6	25.3
20	24.4	26.6	30.7	25.1	27.1
21	26.1	28.5	32.8	27.1	28.6
22	27.9	30.4	34.7	29.0	30.1

Figure 5: Basal area development by age and treatment.



Basal area response to treatments relative to the controls has been calculated as in previous trials. Figure 6 gives the basal area response to treatments relative to the controls.

Figure 6: Basal area response to treatments relative to the controls



Relative to the controls, basal area growth has been significantly improved in the first five years by the removal of pampas with the "Spray" treatment (total weed control). Over most of the measurement period the "Lotus + Graze" treatment has also

significantly improved basal area growth. A considerable difference is evident between the "Manage Graze" and "Lotus + Graze" treatments. This difference is expected to be the contribution of lotus to tree growth through N fixation. A small difference between "Graze to kill" and "Manage Graze" is evident but both are significant improvements over the control.
Table 8 gives results of analysis of variance of annual basal area increment. Initial basal area has been used to provide covariance adjustment in the initial 7 years of basal area increment.

Table 8: Results of analysis of variance of annual basal area increment

Tree age	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Lotus + Graze	A	A	B	AB	A	A	A	A	A	A	A	A	A	A	A	A
Spray	A	A	A	A	A	C	B	B	A	B	A	B	B	AB	B	B
Graze to Kill	A	A	B	ABC	AB	B	B	B	A	B	A	B	B	AB	AB	A
Managed Graze	AB	A	B	BC	AB	BC	B	B	A	B	A	B	AB	B	AB	A
Control	B	A	B	C	B	C	B	B	A	B	A	AB	AB	AB	AB	A

Treatments with the same letter are not significantly different
- P= 0.05

MARAMARUA TRIAL - AK1005

Trial history and Treatments

Treatments in this trial were aimed at quantifying the effects on tree growth of grazing pampas grass and oversown lotus. The treatments are as follows:
1. Control
2. Spray - repeat applications of herbicide for total weed control
3. Lotus + graze - grazing of pampas and lotus with cattle

The trial is a randomised complete block design with percentage ground cover of pampas grass used to identify blocking strata.

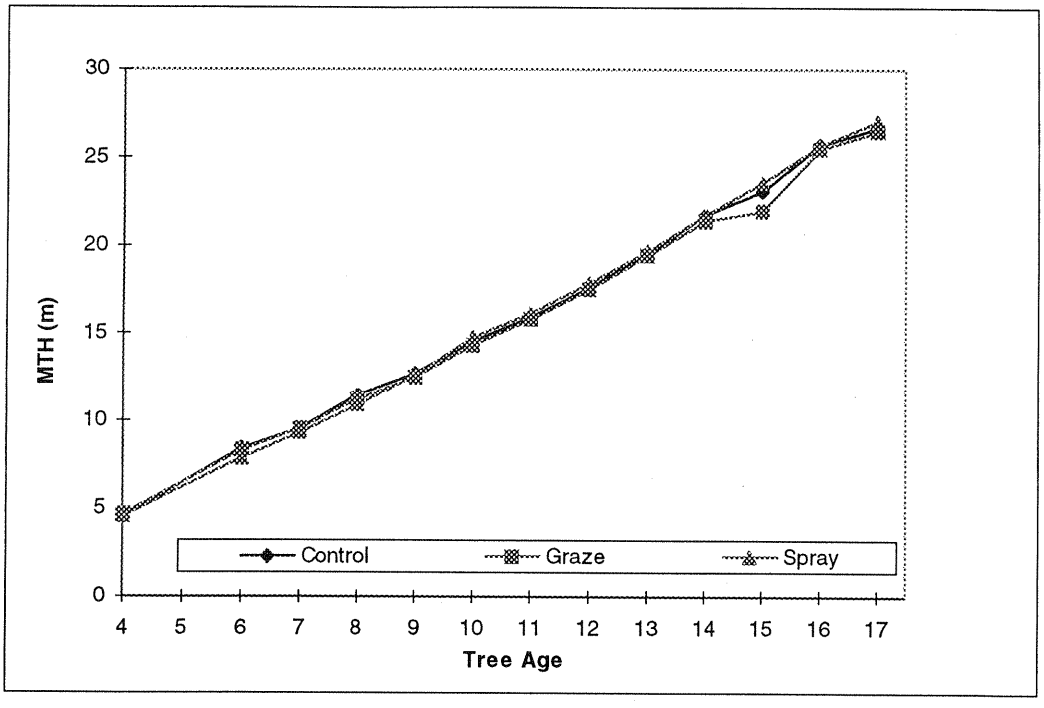
Although repeated applications with glyphosate attempted to achieve total weed control, some woody weeds and Gahnia grass persisted at low intensities. Grazing in the appropriate plots has occurred with cattle as part of the normal rotational grazing of the forest. Grazing has been 3-4 times a year up to tree age 8 and then declined in frequency (due to canopy closure) to where grazing currently occurs only once a year.

The pruning and thinning regime at this trial has generally followed a direct sawlog regime; thinning to a final crop of 250 stems/ha and pruning to 4.3m by tree age 7 years. Table 9 gives results of height measurements. Figure 7 gives height development through time for each treatment.

Table 9: Mean top height by age and treatment

	Mean Top Height (m)		
Tree Age	Control	Lotus +Graze	Spray
4	4.6	4.7	4.5
6	8.4	8.3	7.8
7	9.5	9.5	9.3
8	11.5	11.2	10.9
9	12.7	12.5	12.6
10	14.6	14.3	14.8
11	15.9	15.8	16.1
12	17.6	17.5	17.8
13	19.5	19.4	19.7
14	21.7	21.4	21.7
15	23.1	21.9	23.5
16	25.7	25.5	25.7
17	26.7	26.5	27.0

Figure 7:Mean Top Height development by age and treatment



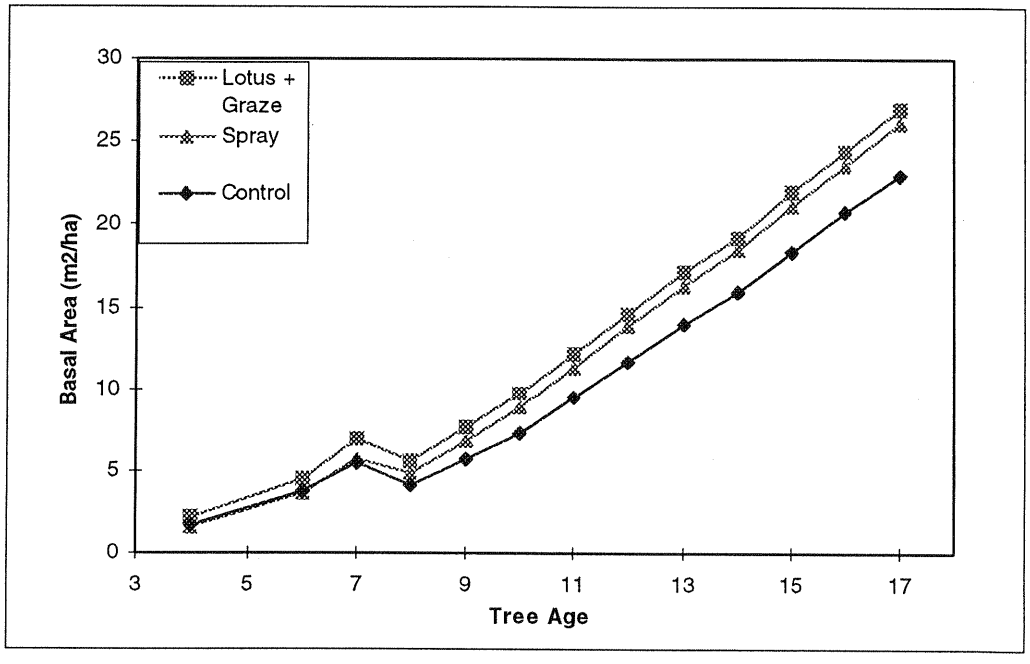
Height growth in this trial has not been influenced by treatments , NB This includes severe competition from pampas grass in the controls.

Tree basal area results are given in table 10. Figure 8 gives basal area development through time for each treatment.

Table 10: Basal Area by tree age and treatment

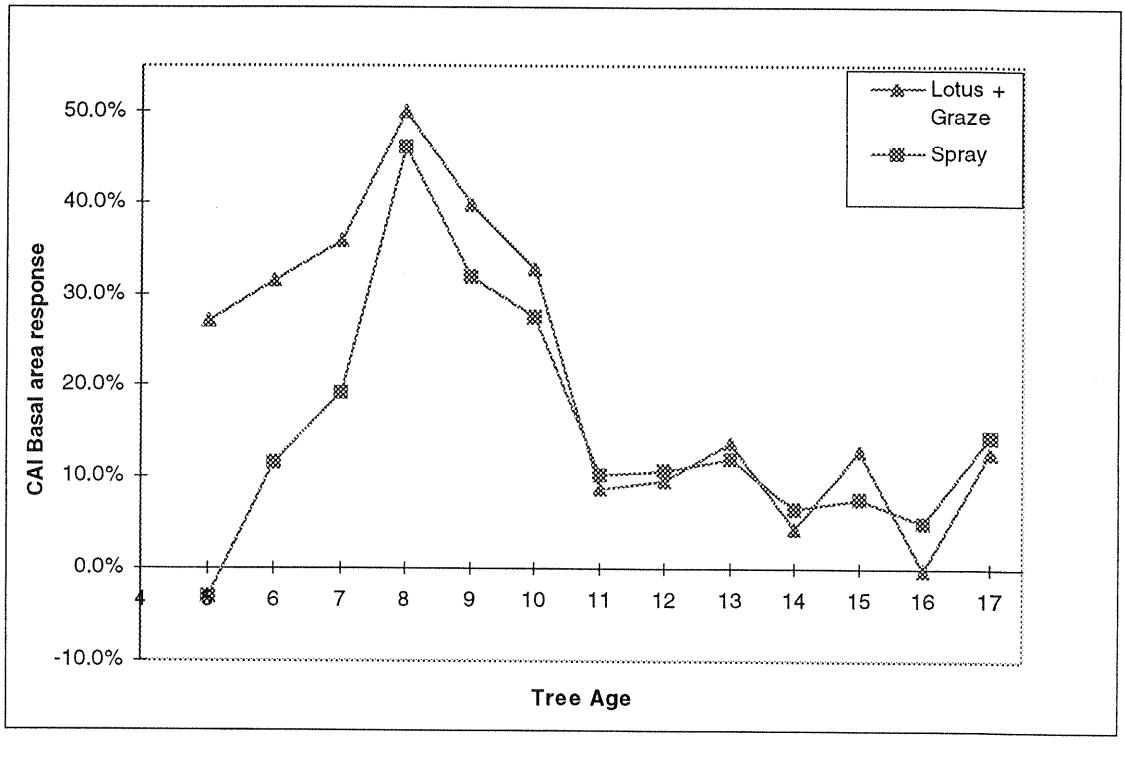
Tree Age	Basal Area m2/ha Control	Lotus + Graze	Spray
4	1.73	2.13	1.54
6	3.71	4.55	3.66
7	5.41	6.88	5.69
8	4.18	5.56	4.89
9	5.7	7.67	6.84
10	7.3	9.71	8.84
11	9.45	12.16	11.33
12	11.7	14.62	13.81
13	13.93	17.16	16.32
14	15.92	19.23	18.43
15	18.38	22.01	21.08
16	20.73	24.36	23.55
17	23.00	26.92	26.15

Figure 8:Basal area growth at Maramarua by age and treatment



Basal area response to treatments relative to the controls has been calculated as in previous trials. Figure 9 gives the basal area response to treatments as a percentage.

Figure 9: Basal area response relative to the controls.



Relative to the controls annual basal area increment for the "Spray" and "Lotus + Graze" treatments has shown significant improvement. This peaked at age 8 (4 years after treatments started) and has since declined. The "Lotus + Graze" treatment has indicated little difference from the "Spray" treatment.

Initially the "Spray" treatment (no competition) was intended to be equivalent to a grazing only treatment (with no lotus) with any difference between the two treatments being attributable to the

lotus. However as indicated by the Waiuku trial this is not the case. The comparison to give the lotus effect is confounded by a number of factors and cannot be used, ie this treatment can only be compared with a treatment of grazing with no lotus. Table 11 gives results of analysis of variance of annual basal area increment. Initial basal area has been used to provide covariance adjustment in the initial three years of basal area increment.

Table 11: Treatments with the same letter are not significantly different - P= 0.05

Tree age	5	6	7	8	9	10	11	12	13	14	15	16	17
Lotus + Graze	A	A	A	A	A	A	A	A	A	A	A	A	A
Spray	A	A	A	A	A	A	A	A	A	A	A	A	A
Control	A	A	B	B	A	A	A	A	A	A	A	A	A

For many years a substantial response to treatment is recorded (fig 9) but shown in table 11 as not statistically significant. This is partly due to the small residual degrees of freedom resulting from 3 treatments x 4 replicates. However many years would be significant at P=0.10.

KAINGAROA TRIAL - RO1891

Trial history and Treatments

The objectives of this trial were to measure the effect on tree growth of establishing Maku lotus and grazing with cattle. Because lotus growth was expected to be influenced by tree stocking, a range of tree densities were included. The following treatments were used:

Legume and grazing
1. Cattle grazing of oversown lotus (plus wild grasses and weeds)
2. Oversown lotus, no grazing (at 200 stems/ha only)
3. Control - No oversowing and no cattle grazing

Tree crop
1. Final stocking of 100 stems/ha
2. Final stocking of 200 stems/ha
3. Final stocking of 400 stems/ha

The trial is a randomised complete block design with tree stocking as the main plot treatment and lotus + grazing as a split plot application.
At trial establishment, lotus was oversown at 5 kg seed/ha and superphosphate (with molybdenum and cobalt) applied at 400 kg/ha. After the first year grazing occurred 3 times / year until age 14 when the trial was not grazed. Unfortunately cattle are no longer available from the nearby farm for this treatment.
Figure 10 gives height development through time for each treatment.

Figure 10: MTH by age and treatment at Kaingaroa

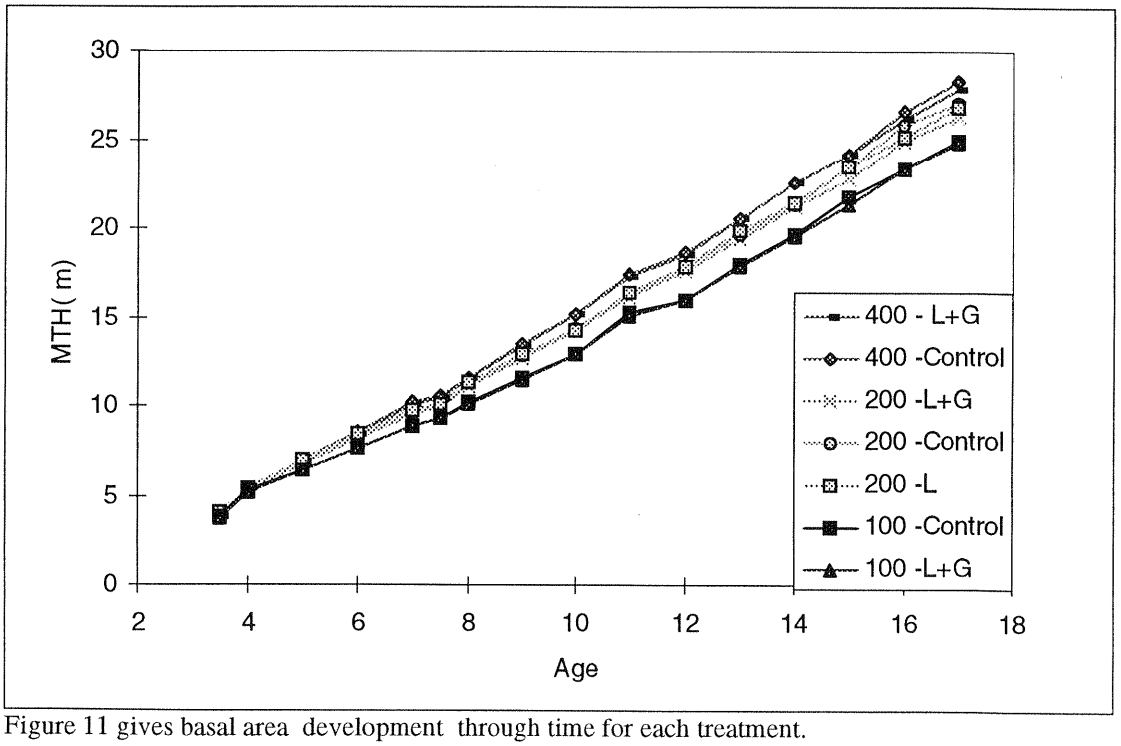
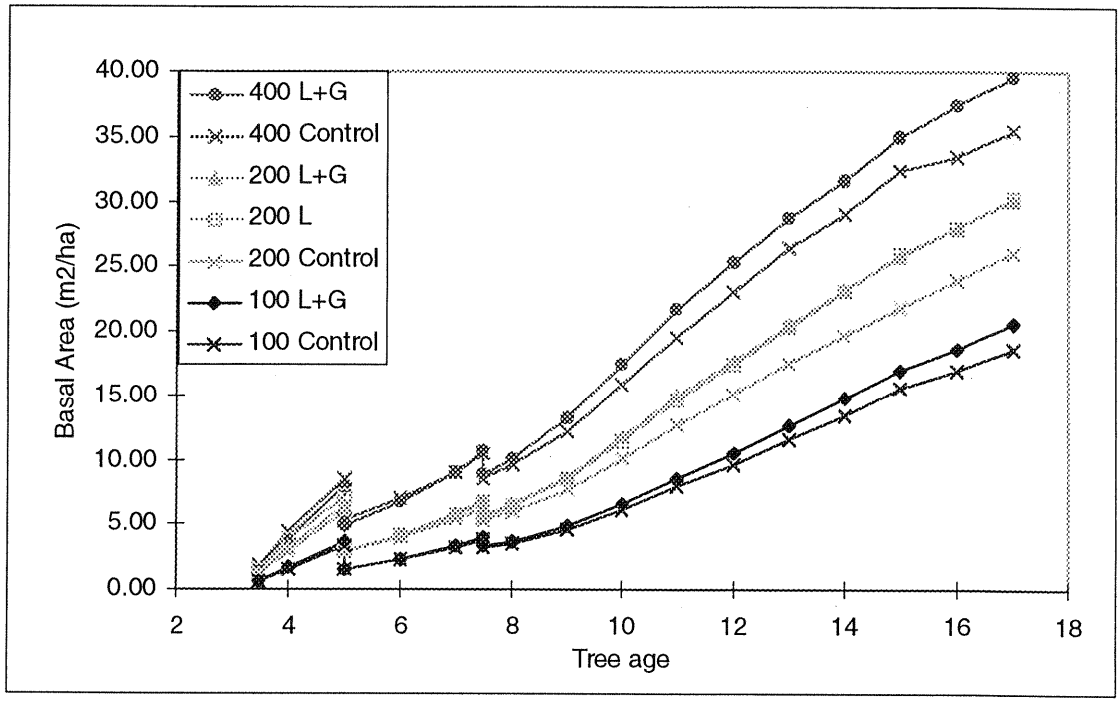


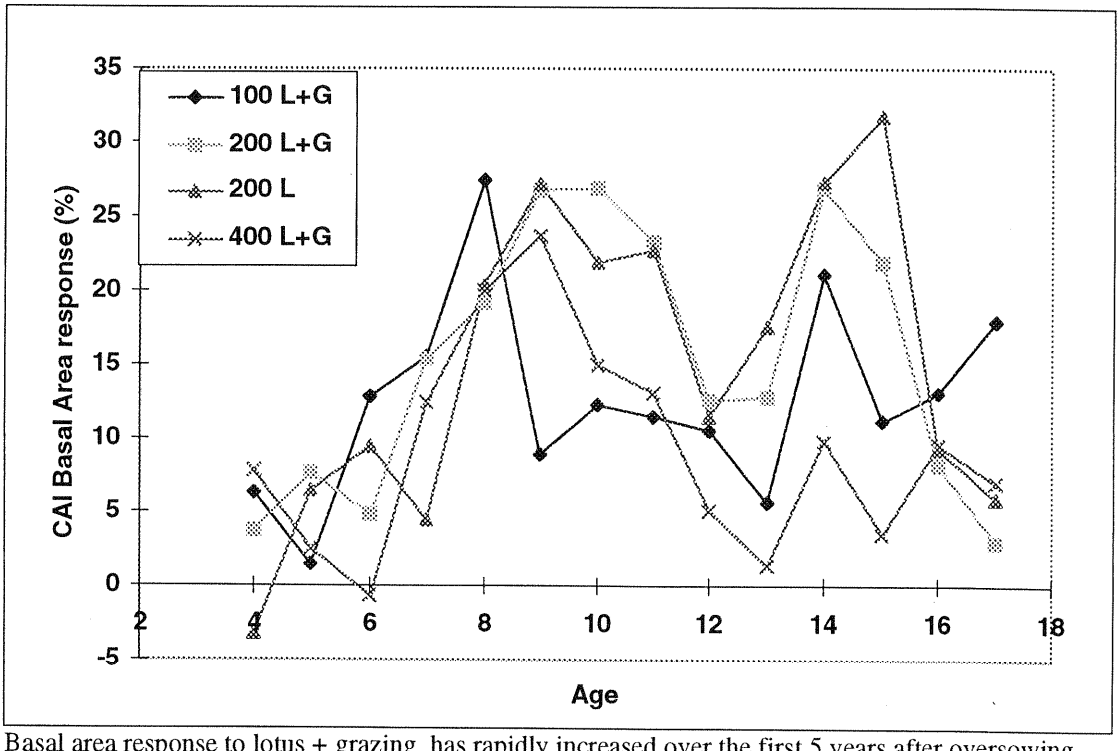
Figure 11 gives basal area development through time for each treatment.

Figure 11: Basal area growth by tree age and treatment at Kaingaroa



Height growth in this trial has not been affected by the lotus + graze treatment. However, height growth has been considerably affected by tree stocking. This phenomenon has been reported by Maclaren *et al* (1995), with lower height growth often being recorded on sites where trees are grown at stockings below 400 stems/ha. Figure 12 gives the response in basal area relative to the controls.

Figure 12: Basal area increment response to treatments at Kaingaroa



Basal area response to lotus + grazing has rapidly increased over the first 5 years after oversowing. Response has generally peaked at 27% improvement (for tree age 8-10) , then declined for several years before improving again (years 14-15). The response to the ungrazed lotus treatment (200 stems/ha only) has been very similar.

The response to lotus has been influenced by tree stocking with the 100 and 400 stockings showing less improvement than the 200 stocking. At age 17 the total accumulated basal area difference between the lotus plots and controls, at 200 stems/ha, is now 4 m2/ha (a 15 % improvement). Table 12 gives results of analysis of variance of annual basal area increment across all stocking treatments.

Table 12: Analysis of variance results (p >F) for Basal area annual increment

	Tree age (at start of increment period)													
Source of variation	3.3	4	5	6	7	8	9	10	11	12	13	14	15	16
Main experiment														
Initial DBH	0.0769	0.0781	0.4245	0.0910	0.2235	0.1246	0.1926	0.0070 **	0.1259	0.2200	0.6764	0.1825	0.5269	0.0457
Block	0.3339	0.1466	0.2346	0.0247 *	0.8115	0.4707	0.5747	0.0607	0.0622	0.0154 *	0.2790	0.1159	0.2397	0.3806
Stocking (N)	0.0003 **	0.0001 **	0.0001 **	0.0001 **	0.0001 **	0.0001 **	0.0001 **	0.0001 **	0.0001 **	0.0001 **	0.0028 **	0.0012 **	0.0120 *	0.0441 *
Legume (L)	0.2304	0.0998	0.3684	0.0093 **	0.0045 **	0.0003 **	0.0009 **	0.0001 **	0.0223 *	0.0486 *	0.0213 *	0.0373 *	0.2645	0.1297
N x L	0.7764	0.4619	0.9970	0.3322	0.0780	0.0207 *	0.1025	0.0057 **	0.5829	0.4247	0.4910	0.7938	0.9065	0.4904
Sub experiment														
Initial DBH	0.0538	0.0053	0.3256	0.2656	0.3555	0.1741	0.6165	0.2282	0.9125	0.8294	0.9287	0.8837	0.8312	0.4646
Block	0.4124	0.0234 *	0.0521 *	0.3236	0.2517	0.0433 *	0.0642	0.0237 *	0.1330	0.1344	0.9422	0.4714	0.2980	0.2280
Treatment	0.4139	0.1699	0.4125	0.1180	0.0007 **	0.0071 **	0.0108 *	0.0054 **	0.3445	0.1020	0.0811	0.1693	0.8055	0.9103

* = significant at P ≤ 0.05, ** = significant at P ≤ 0.01

To test the fourth hypothesis the Least Squares Means for the control, lotus grazed and ungrazed treatments in the sub experiment were compared for the years that had indicated a significant treatment effect. Table13 and 14 gives the results of the LSD test.

Table 13: LSD test of treatment means of basal area increment in sub experiment

Treatment	Tree age			
	7	8	9	10
Lotus + Grazing	3.16 a	2.17 a	3.05 a	3.22 a
Lotus Ungrazed	2.87 b	2.13 a	2.90 a	3.15 a
Control	2.43 c	1.71 b	2.40 b	2.61 b

Treatments with the same subscript are not significantly different at P = 0.05

Table 14 gives results of analysis of variance of annual basal area increment within stocking treatments. Initial basal area has been used to provide covariance adjustment in the initial two years of basal area increment.

Table 14: Analysis of variance of annual basal area increment within stocking treatments

		Tree age												
Treatment	Stocking	4	5	6	7	8	9	10	11	12	13	14	15	16
Lotus + Graze	100	A	A	A	A	A	A	A	A	A	A	A	A	A
Control	100	A	A	A	A	A	A	A	A	A	A	A	A	A
Lotus + Graze	200	A	A	A	A	A	A	A	A	A	A	AB	A	A
Lotus only	200	AB	A	A	A	A	A	A	A	AB	A	A	A	A
Control	200	B	A	A	B	B	B	B	A	B	B	A	A	A
Lotus + Graze	400	A	A	A	A	A	A	A	A	A	A	A	A	A
Control	400	A	A	A	B	B	B	B	A	A	A	A	A	A

Treatments with the same letter are not significantly different - P= 0.05
NB: Tree age is the age at the start of the increment period and initial DBH was used as a covariate

DISCUSSION

On all four sites of the trial series a positive basal area response has been indicated from the oversowing of lotus however at the Maramarua trial this effect was confounded and not statistically significant. At Kaingaroa and Waiuku the response in basal area is substantial. Converting this to volume indicates an improvement in growth of at least 10% (merchantable volume) (also see West and van Rossen, 1994).
At Kaingaroa the response to lotus has declined in the last two years (now age 17).This is expected as the green crown in the 200 stocking is beginning to rise (now 9.3m) indicating canopy closure. Beets and Whitehead, (1996) have reported that photosynthetic rate per unit leaf area, or the efficiency of the needles, increases with improved nitrogen supply, implying that the effect of N should continue . after canopy closure. Also, the allocation of growth within the tree is changed so that the proportion of total tree growth partitioned to the tree crown and stem is increased and less is given to roots. However in the longer term the benefits of additional nitrogen are expected to cease after canopy closure when light rather than nutrients such as N becomes the most limiting factor for diameter growth. Growth gains achieved up until canopy closure have been shown to be sustained through the length of a normal rotation (Andrew 1988).

Further details of results of the Kaingaroa experiment including ground cover assessments and modelling of legume response up to age 15 are given in West (1997).

Height growth has not been influenced by lotus oversowing or from severe weed competition from pampas grass.

The removal of pampas grass competition at the Waiuku and Maramarua trials has provided substantial improvements in basal area growth. The use of cattle grazing to achieve this has been very successful particularly when combined with oversowing lotus.

Foliage samples have been taken and analysed annually (or biennially for the last three/four years) for N and P. Results from the foliage analysis are given in appendices 1 to 4. Using the Lotus + Graze treatment as a standard, appendix 5 compares foliar N and P for all five trial sites for each year.

These results help to provide some explanation of the tree growth responses. For the Lotus and Graze treatment (appendix 5) P levels at Aupouri and Maramarua have been noticeably low through the early stages of stand growth and this has probably restricted lotus growth and hence N fixation.

At the Aupouri trial (appendix 1), foliar N levels have been noticeably improved by the N fertiliser treatment (and to a lesser extent the lotus treatment) over the last five years. However, the significant tree growth response to legumes at Waiuku and Kaingaroa has not been reflected in foliar N levels.

More detail on this data, will be provided in a final and more formal publication. Data on ground cover achieved with lotus and biomass of weeds will also be included.

CONCLUSIONS

Recent results from these trials have continued to reinforce past conclusion from this trial series, ie :

1) Oversowing with lotus has significantly improved basal area growth on three of the trial sites - Aupouri, Waiuku, and Kaingaroa. At Maramarua the trial design does not allow this treatment effect to be analysed.

2) Oversowing with lotus has not improved height growth.

3) The benefits in basal area growth from lotus occurs with and without grazing at Kaingaroa.

4) The benefit in basal area growth from lotus will depend on tree stocking.

5) Competition from pampas grass results in significant losses in tree diameter growth but not height growth.

6) Grazing of pampas will significantly reduce losses in basal area caused by pampas competition.

7) Considerable gains in basal area growth from N fertiliser have been indicated at the Aupouri trial.

These trials address the issues of improving productivity with legumes and controlling weeds with less herbicides. They indicate there is an opportunity to improve productivity by improving N supply and that Maku lotus is suitable for this purpose. Legume performance on most sites is likely to be influenced by the level of P supply and the amount of competition from woody weeds and pampas. Failure to control such weeds will mean the benefits of legumes are not possible and a substantial opportunity cost may result. For pampas grass, grazing with cattle provides a biologically benign and inexpensive method of control.

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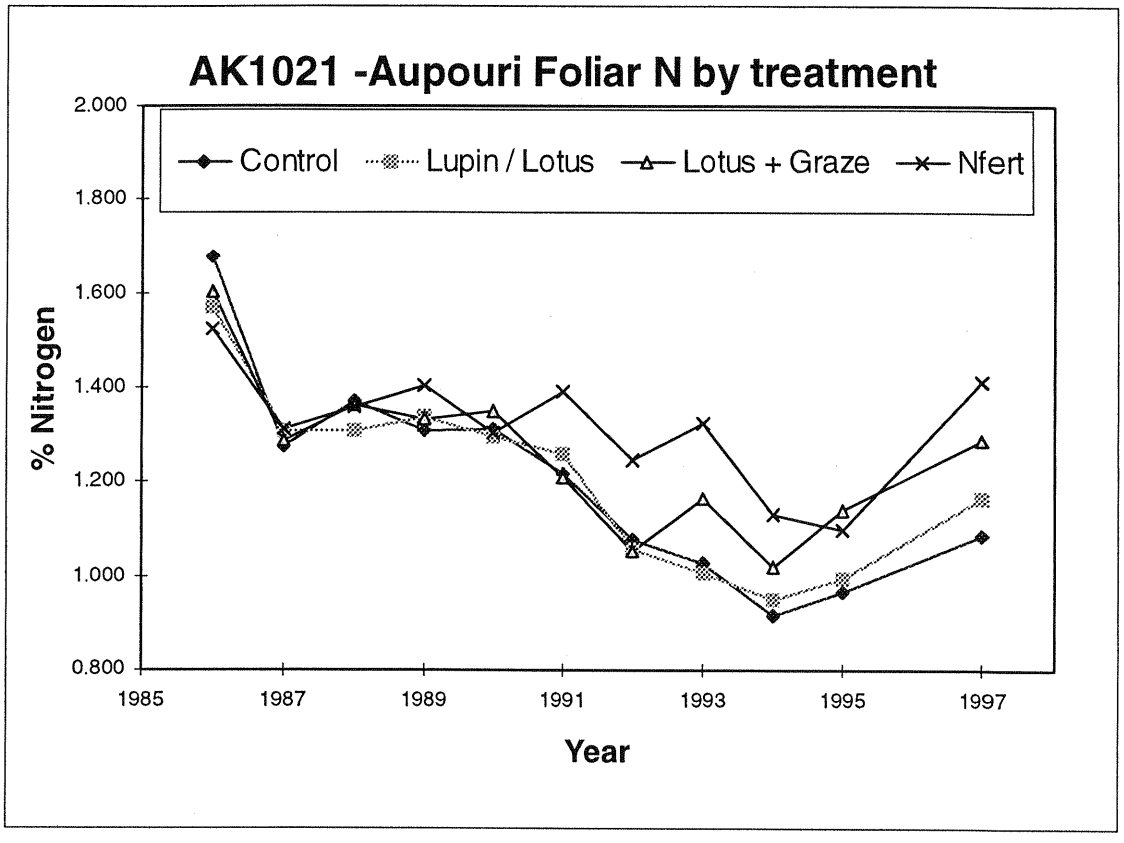
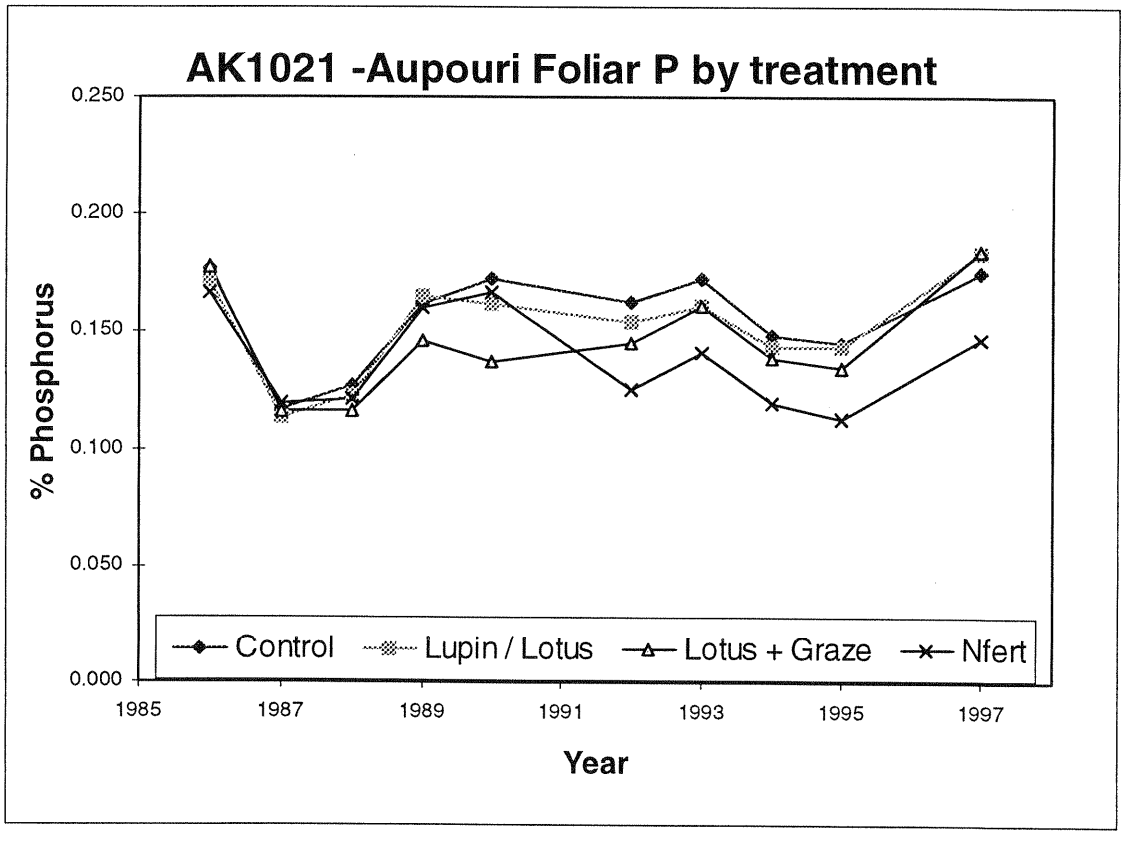
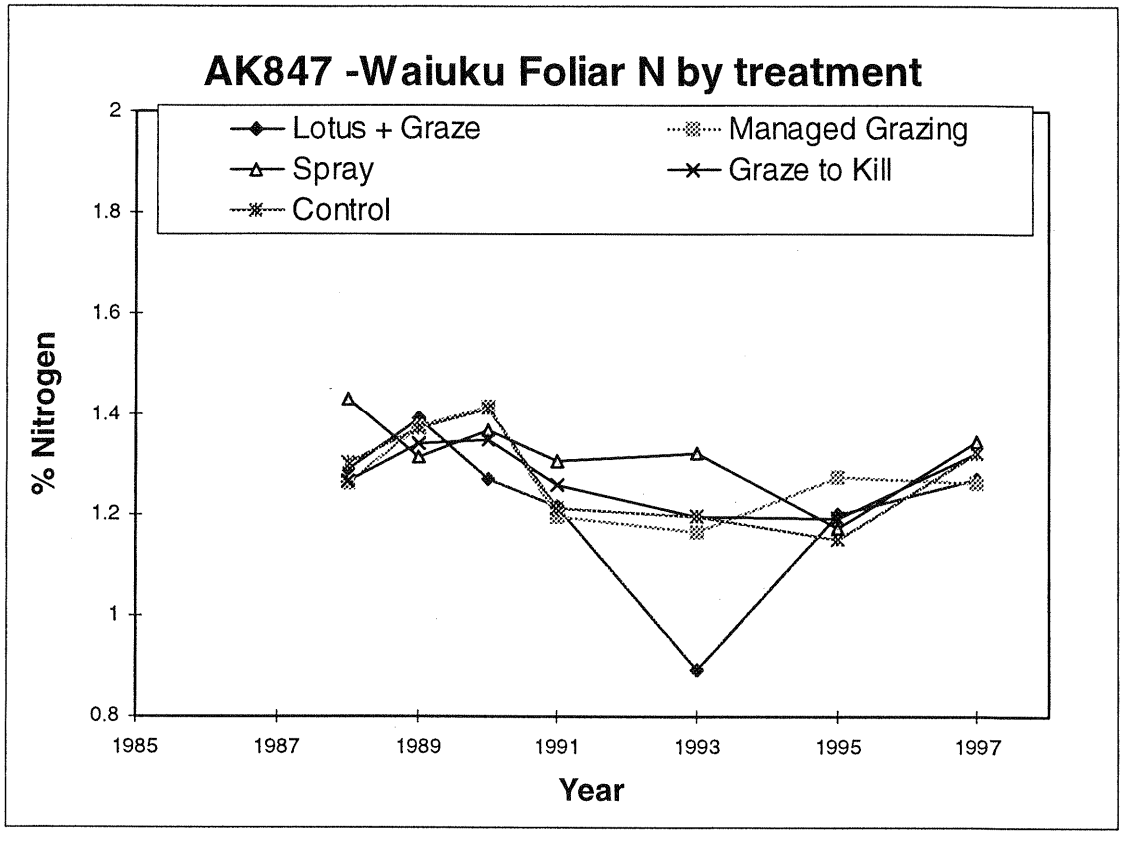
Appendices

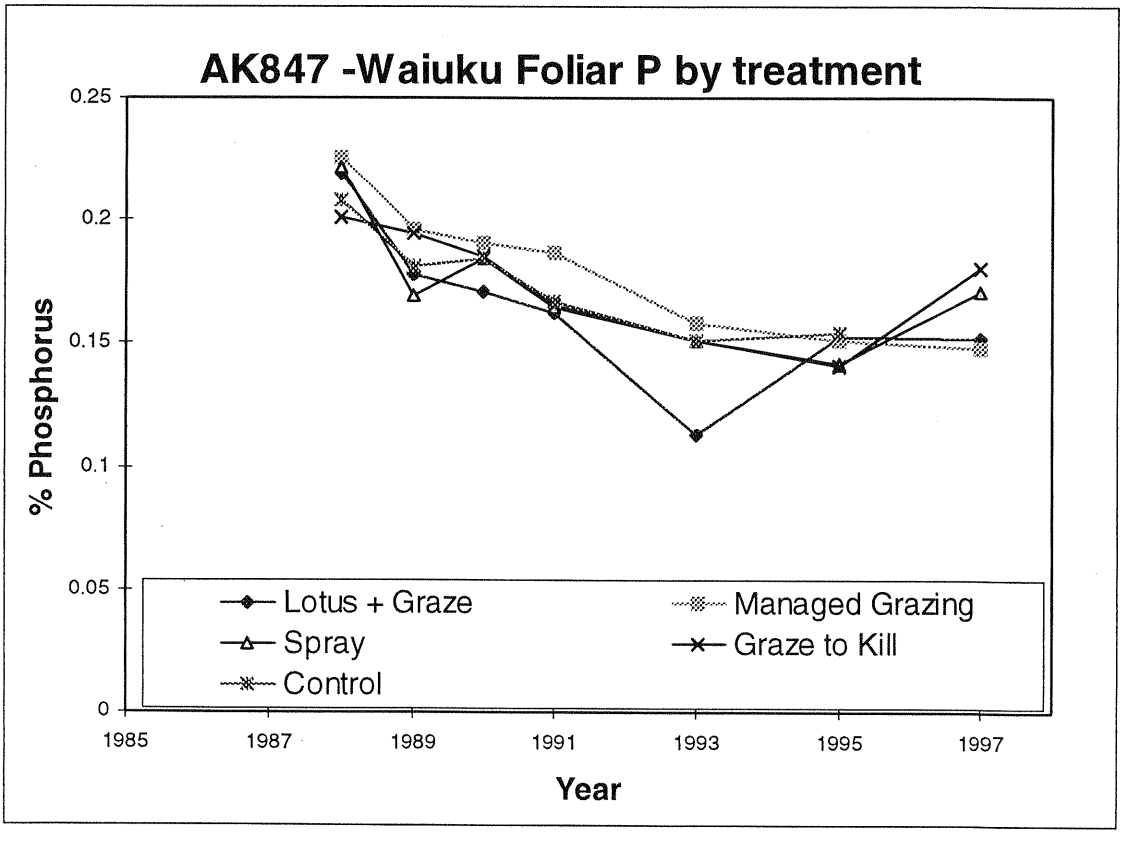
Appendix 1: AK 1021 Foliage Analysis



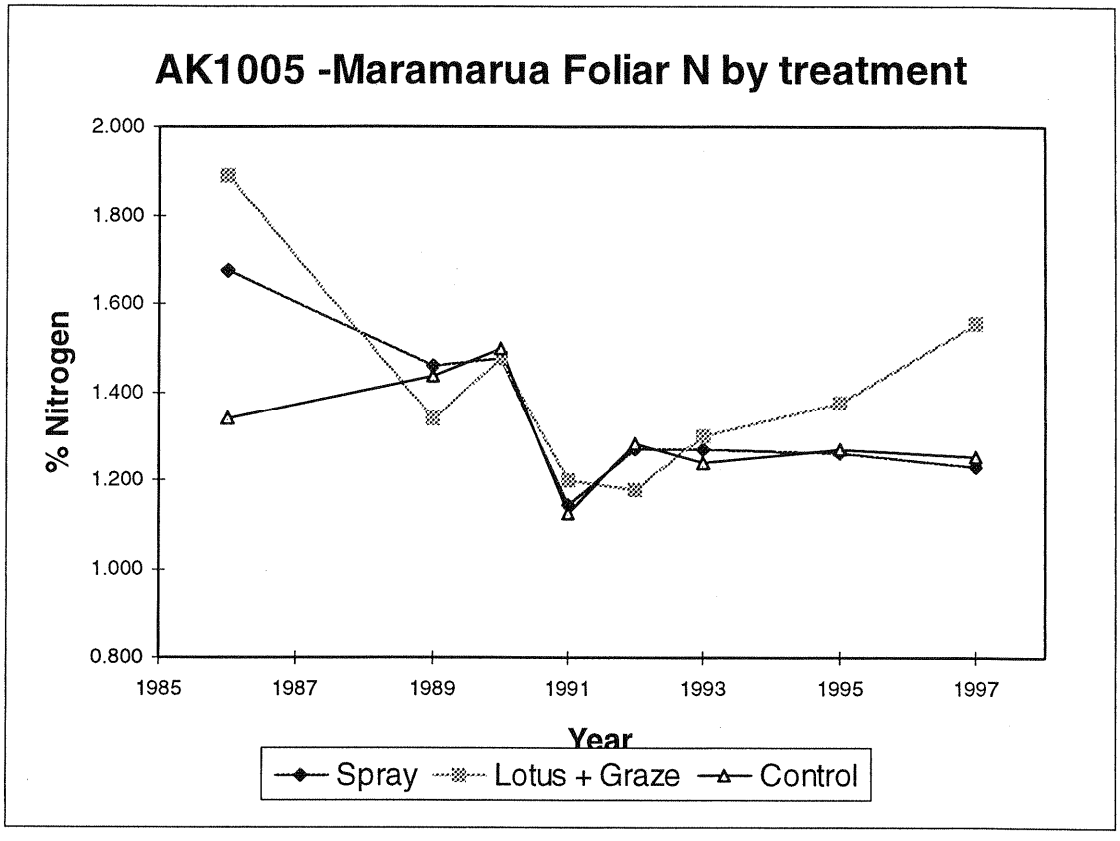


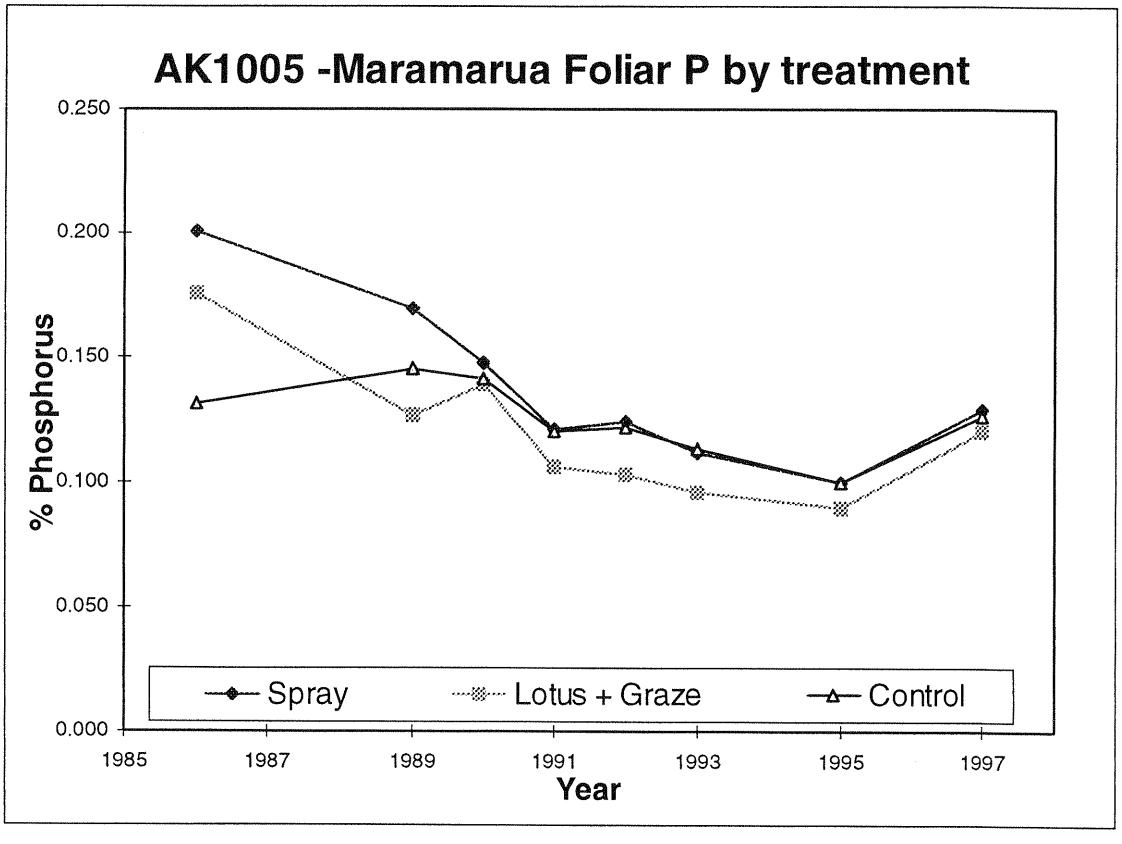
Appendix 2: AK 847 Foliage Analysis



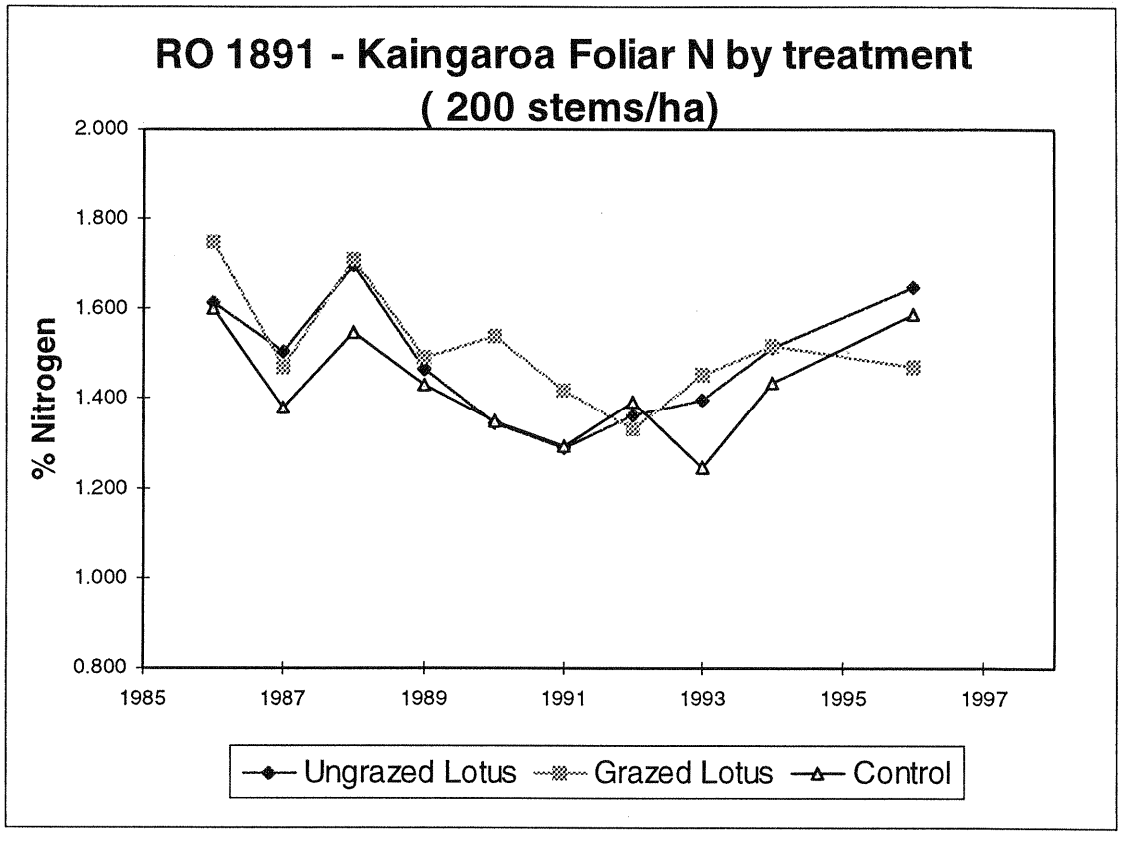


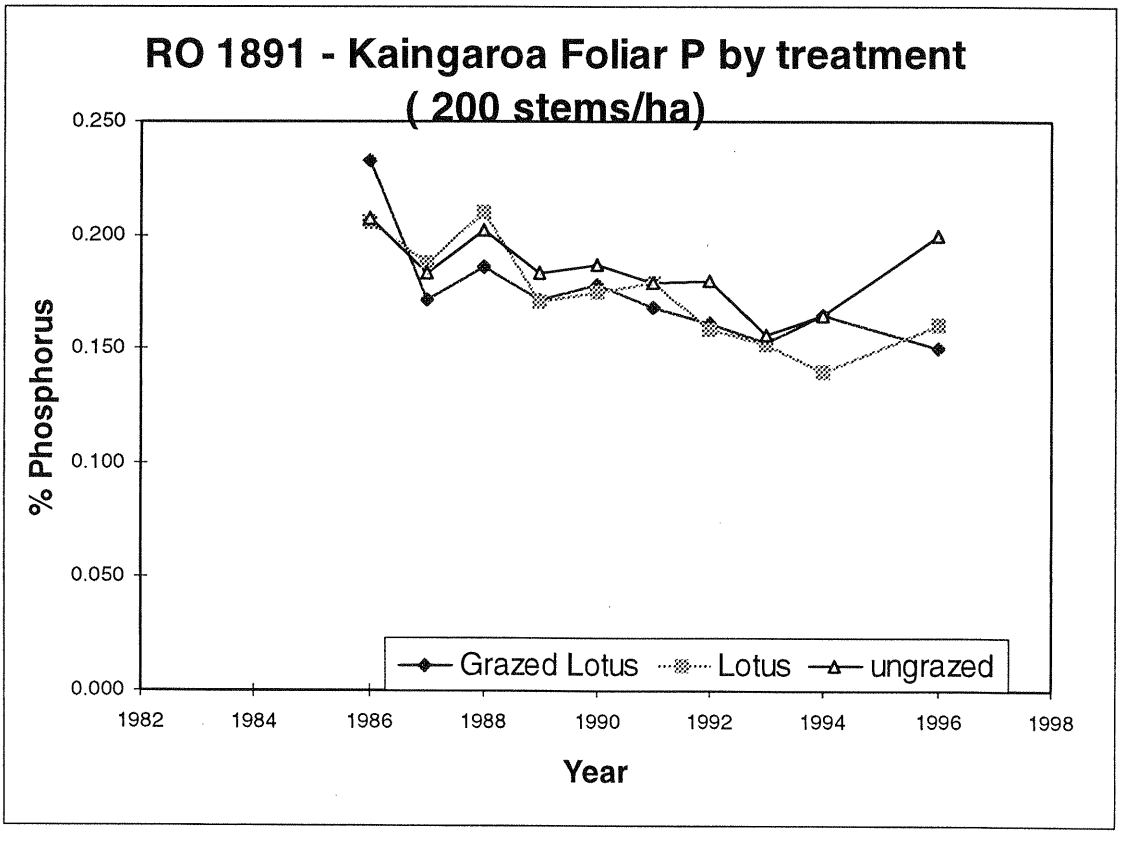
Appendix 3: AK 1005 Foliage Analysis





Appendix 4: RO 1891 Foliage Analysis





Appendix 5: Foliage analysis of lotus plus grazing treatment against tree age at all trials.