AKATORE AGROFORESTRY TRIAL
RESULTS FROM 1974-1995

G.G. Cossens and G.S. Crossan

Report No. 26 November 1995

FOREST & FARM PLANTATION MANAGEMENT COOPERATIVE

EXECUTIVE SUMMARY

AKATORE AGROFORESTRY TRIAL
RESULTS FROM 1974 — 1995

G. Cossens & G. Crossan

Report No. 26 **November 1995**

The Akatore trial on Otago Coast was established over two years, 1975 and 1976 on moderately steep oversown silver tussock land. Final tree stockings of *Pinus radiata* were 0, 100, 200 and 400 sph, made up of 16 replicates with a total area of 38 ha. Half of each replicate was grazed with cattle and half with sheep.

Silviculture was completed by 1984. Tree growth was measured regularly; tree height increased with tree stocking but there was a decrease in DBH. No significant differences in pasture yield were measured between the two years of planting nor between sheep and cattle treatments. There were no differences in pasture yield up to tree age 11, but significant reductions from year 15 with increasing tree stocking. Pasture composition under the trees gradually changed from year 16. The 100, 200 and 400 sph comprised 37, 25 and 0% grasses respectively at tree age 18 years.

Livestock carrying capacity both in the sheep and cattle treatments mirrored the pasture yield reductions. Soil phosphorus levels have increased over time due to regular topdressing From year 16 soil phosphorus levels at 400 sph have increased relative to other treatments. Soil sulphur levels have declined over time although at 200 and 400 sph levels are significantly higher than open pasture. pH has significantly decreased at 400 sph at tree age 19.

This report is an update of and replaces the Agroforestry Research Collaborative Report No. 12, May 1991.

CONTENTS

AKATORE AGROFORESTRY TRIAL
RESULTS FROM 1974 — 1995

G. Cossens & G. Crossan

MAF PROJECT FD110
MOF PROJECT S474

AKATORE

The Akatore trial was established over two years, 1975 and 1976, on moderately steep oversown silver tussock land. Grazing was by sheep or by cattle as separate treatments and initial tree densities were 0, 600 and 1200 stems/hectare. Thinning and pruning on both 1975 and 1976 stands was completed in 1986, the final tree densities being 0, 100, 200 and 400 stems/hectare. Grazing is common across all tree densities.

Animal Stock

Sheep treatments were stocked with Perendales and the cattle treatments with Hereford cross animals, and, as far as practical, all paddocks were rotationally grazed (there were 8 paddocks each with 2 replicates of the 4 tree densities). Sheep were introduced at 6 months and cattle 18 months after tree planting in order to reduce tree damage. Stocking rates over-all were 0.3 su/ha/year in 1976/77 rising to a maximum of 8.1 in 1982/83 and then declining as the tree canopy closed to 0.9 in 1994/95. Stocking rates were balanced so that grazing pressure was similar in sheep and cattle paddocks. Limited animal production data indicate satisfactory lambing and animal growth in what was essentially an easy-care flock. There have been problems of winter growth in the cattle which appears to relate to their transfer from grazing the high fertility Waiora or Invermay Farm pastures to the rougher pastures under the trees at Akatore.

Tree Stock

The trial design called for planting over two years, 1975 and 1976, such that the 1976 treatments were a reversed image of the 1975. A manipulation to overcome the shading effect as the sun moves across the sky. Thinning, was in 3 lifts, the initial densities being 0, 600, 1200 stems/hectare and the final 0, 100, 200, 400 stems/hectare achieved 1984. Pruning was completed by 1984 in 4 stages for 1975 trees, but in 3 stages for 1976 trees, the latter leading to excess slash with the delay of first pruning.

Initial and final tree densities and spacing are shown more clearly in Table 1.

TABLE 1 — Tree density and spacings - Akatore

Tree density (stems/ha)		Spacing of stems (m)	
Initial	**Final**	**Initial**	**Final**
0	0	0	0
600	100	10 x 1.6	10 x 10
600	200	10 x 1.6	10 x 5
1200	400	5 x 1.6	5 x 5

With a site index of 22.5 years, tree growth over 20 years has averaged about 1 to 1.2 m per year with some differences among the different tree densities and years of planting. Tree height increased with planting density but with a corresponding decrease in diameter (Table 2).

Table 2 — Tree height and diameters - Akatore 1995

Stems/ha	100		200		400	
Planting Year	75	76	75	76	75	76
Height (m)	20.4	20.6	22.4	21.6	24.0	23.4
Diam. breast height (cms)	52	47	41	51	46	41

Pasture grazing lost through slash was most severe at 400 stems/hectare where it ranged between 39 and 46% in 1989 and 1990. By 1995 slash cover reduced grazing by 11%, 12% and 23% at 100, 200 and 400 stems/hectare respectively.

In the early years of the trial from 1975 to 1980 there was some stock damage to the young pines, with no apparent difference between sheep and cattle. Wind and torrential rains from April to June 1980 contributed much to tree damage which was further accentuated by earth movement and slips. However tree losses were not in any way severe enough to affect final tree densities.

Needle Fall

Needle fall at 100, 200 and 400 stems/ha was respectively 3.2, 5.2 and 9.7 kg/ha/day in 1989/90 and 8.3, 8.8 and 13.4 kg/ha/day in 1994/95 Visual observations would suggest that needle fall had been light at least prior to 1989, no measurements being taken prior to 1989.

A comparison of needle fall between Tikitere and Akatore indicates that needle fall at Tikitere at years 11 to 12 is similar to Akatore at year 20 for 200 and 100 stems/ha respectively, Akatore trees being some 8 years later than Tikitere (Table 3).

TABLE 3 — Needle fall at Akatore (1990/95) and Tikitere (1984/87) (kg/ha/day)

		Stems/hectare			
Tree age (yrs)		100		200	
Tikitere	Akatore	Tikitere	Akatore	Tikitere	Akatore
11 (1984)	15 (1990)	4.9	3.2	10.8	5.2
12 (1985)	18 (1993)	8.8	4.1	17.4	4.8
13 (1986)	19 (1994)	7.2	4.2	13.7	5.8
14 (1987)	20 (1995)	11.3	8.3	18.1	8.8

Pasture Composition

In 1977 the ground cover was dominantly 65% "other grasses" (browntop, sweet vernal, Yorkshire fog) with minor cocksfoot (4%) and clovers (6%). At this stage there was 28% of bare ground, a remnant of the giant discing land preparation in 1974-75 prior to tree planting. By 1984 the species making up the annual herbage yield were still dominated by "other grasses" (56%) with minor cocksfoot (11%), clovers (12%) and some tussock now being recorded. Seven years later in 1990 the sward still comprised other grasses 70%, cocksfoot 8% and clovers 4%. There was a general tendency for sheep pastures to be more grass and less clover dominant than cattle pastures, and by 1994-95 the control pastures (no trees) still had a similar composition. However during 1993 and 1994 Pine needles were an increasing component of the tree treatments. Grass species declined rapidly so that by November 1994 grass made up 37% and 25% of the yield and pine needles 51 and 69% at 100 and 200 stems/ha. At 400 stems/ha no pasture yield was recorded in 1994-95, the ground cover being over 90% pine needles.

Pasture Yield

There have been no significant herbage yield differences between the two years of planting, nor between sheep and cattle treatments. Nor were there any differences in pasture yield among the tree densities up until 1986/87 (i.e. in the first 11 years of the trial), however by 1989/90 trees were having a marked effect on pasture yield giving a 19%, 27% and 49% reduction respectively at 100, 200 and 400 stems/hectare as compared to open pasture. When the slash cover is included with the tree effect on pasture, a marked reduction in pasture availability is apparent, particularly at 400 stems/hectare where the average reduction was 65%. By 1994/95 there was a 75% reduction in livestock carrying capacity at 100 and 200 stems/ha and 100% at 400 stems/ha (Table 4).

TABLE 4 — Livestock carrying capacity at 100, 200, 400 stems/hectare as a percentage of open pasture — Akatore 1989/90 and 1994/95

Year of planting	Stems per hectare					
	100		200		400	
	89/90	94/95	89/90	94/95	89/90	94/95
1975	72	25	62	26	37	0
1976	67	25	56	26	32	0
Mean	70	25	59	26	35	0

Soil Chemical Analyses

Soils were analysed for pH, Ca, K, P, Mg, S, C, N and there were no indications of any detrimental effect of trees on any of the elements analysed. In fact organic carbon and nitrogen doubled between 1975 to 1990 on all treatments; however this may be a chance effect as initial samples were from unimproved but giant disced tussock sward. Soil pH varied between 5.0 and 5.5 over the 19 years of the trial. The decrease in pH at 400 SPH compared with open pasture at year 19 is following the same trend noticed at Tikitere. Soil P rose steadily from a very low test of 4 in 1981 to a medium level of 15 in 1994, the result of topdressing about every 2½ years with a rate equivalent to about 118 kg/ha superphosphate annually.

There was some tendency by 1994 for soil P levels to rise at 400 sph. Soil sulphur declined from a mean of all treatment of 20 in 1985 to 8 in 1994 with a significant increase at 200 and 400 sph compared to control (Table 5).

TABLE 5 — Soil chemical analysis (0-8 cms) per pH, P and S in 1981 (S = 1985) and 1994

	pH		P		S	
Stems/ha	**1981**	**1994**	**1981**	**1994**	**1985**	**1994**
0	5.4	5.5	5.0	14.8	24.3	5.4
100	5.4	5.4	4.6	13.6	19.1	6.5
200	5.4	5.2	3.5	14.3	16.1	8.7
400	5.3	5.2	4.0	16.5	20.9	10.6
Mean	5.4	5.3	4.3	14.8	20.1	7.8

FOREST GRAZING TRIAL - AKATORE

MAF PROJECT FD110
MOF PROJECT S474

1. Location, Soil, Environment

Location:	Otago Coast Forest, Milburn Block 157, Creighton
Map Reference:	NZMS1 S172 776 445 NZMS260 H45 822 533
Land Capability:	Lo/Cg - 31bH - E + D 2Sh - M_4, 6n6p2 VIe 15
Soil:	Kaitangata Silt Loam
Altitude:	195-225 m
Rainfall:	730 mm (estimated)
Aspect:	NNW, moderately steep (some slopes up to 30°)
Initial Vegetation:	Volunteer grasses, sweet vernal, browntop, timothy, Yorkshire fog, white clover, sparse silver tussocks; bracken fern in steep gullies; patches of gorse and manuka scrub. Isolated pine trees.
Previous Fertiliser:	Not known - probably nil.
Previous Stocking:	Lax grazing with mainly sheep - occasionally cattle.
Trial Design:	(a) Two years of planting 1975, 1976. (b) 3 tree densities initially 0 600 1200 stems/hectare 4 tree densities final 0 100 200 400 stems/hectare (c) Eight paddocks

Final stocking: 2 years x 4 tree densities x 8 paddocks = 64 plots.

Final stocking: each tree density has 16 replicates.

Partially randomised skew image blocks.

Area:	Eight paddocks:	38.31 ha
	Lanes, run-off:	1.14 ha
	Total:	38.45 ha

The Farming Year: All annual measurements, unless otherwise stated, are from June to May inclusive. The seasons are:
Winter - June July August
Spring - September October November
Summer - December January February
Autumn - March April May

Note: As from November 1990 the timber stand of the Otago Coast Forest has been taken over by Wenita Forestry Ltd, an overseas consortium. This includes the agroforestry trial, however, we have been assured of their continued co-operation to the conclusion of the trial.

2. Establishment problems

(a) Pre-Planting History

Paddocks 5 to 8 (figures 4 and 5) were giant disced and the steeper faces ripped in winter 1974. *Pinus radiata* trees were planted into this in September 1974 but because of vigorous grass growth, the lateness of the tree planting and premature browsing by cattle, the tree establishment was unsatisfactory. The paddocks 5 to 8 were therefore giant disced again in May 1976 and replanted in August 1976 at proposed density of 0, 800 and 1,600 stems per hectare. Actual density when checked for initial stocking was 0, 600, 1,200 stems per hectare.

Paddocks 1 to 4 were similarly giant disced and the steeper faces ripped during winter 1975 and planted out with radiata pine at proposed density of 0, 800 and 1,600 stems per hectare in August 1975. Actual density for initial stocking was 0, 600, 1,200 stems per hectare when checked.

(b) Post-Planting History

Three to four months after planting, vigorous pasture growth occurred with a dominance of cocksfoot and Yorkshire fog in paddocks 1 to 4 and browntop in 5 to 8. Release spraying was then necessary around the trees to aid their growth and prevent smothering by the grasses. In August 1976 the whole area was oversown with Ruanui ryegrass and Huia white clover (see also section 9).

(c) Stock Water Supply

A water supply dam was built in May 1976 in the main stream at the west end of the centre lane of the trial (figures 4 and 5). Leakage occurred at the base of the dam and although bentonite added to the dam-water assisted sealing, it was not until summer of 1978 that seepage virtually ceased.

A reciprocating pump was installed adjacent to the dam, the water being pumped up 57 m to a 10,000 litre tank at the top (east) end of the centre lane and from there distributed by gravity to troughs in the main paddocks.

The dam withstood the very heavy flooding on 4-5 June 1980 when 102 mm of rain fell in about 12 hours.

(d) Fencing

The initial trial design called for individual fencing of all treatments and required 32 paddocks. Because of financial restrictions, the design was altered in November 1975 to the present eight paddock layout. This meant that individual grazing of the various tree densities was no longer possible and stock grazed across all tree treatments.
Prior to planting out, the boundary of the trial block was fenced and at the time of stock introduction the 1975 plantings were break-fenced from the 1976 plantings.

Paddocks 1 to 8 were fenced in spring 1978 as shown in figure 4. Since the Perendale sheep flock tended to push through to adjacent paddocks, additional posts and standards were added in winter 1981 and the fences restrained. Stock were now completely contained in the paddocks and strict rotational grazing was possible.

Stock yards with a capacity for 400 sheep were also built in winter 1981, and later cattle yards were built near the central access lane to the stock water dam (see figure 5) in winter 1983.

3. Experimental design

Proposed Design

There were to be two replicates of four partially randomised sub-plots (trees) within two main plots (stock) repeated in two blocks (years) which were skew images of each other (figure 4).

or 4 (tree density) x 2 (stock) x 2 (years) x 2 (times of stock introduction) = 64 plots

(i) Trees

	Tree Density (stems/ha)	**Spacing of Stems (m)**		
	Initial	**Final**	**Initial**	**Final**
1.	0	0	0	0
2.	800	200	1.25 x 10	5 x 10
3.	800	400	1.25 x 10	2.5 x 10
4.	1,600	800	1.25 x 5	2.5 x 5

(ii) Times of Planting

5. August 1975
6. August 1976

(iii) Type of Stock

7. Sheep
8. Cattle

(iv) Time of Introduction of Stock

9.	Sheep:	6 months after planting	April 1977 in 1976 planting
10.	Sheep:	18 months after planting	April 1977 in 1975 planting
11.	Cattle:	30 months after planting	April 1978 in 1975 planting
12.	Cattle:	30 months after planting	April 1979 in 1976 planting

The two times of stock introduction were abandoned because of financial restrictions. However, the 64 plots remained and effectively increased the tree densities to 16 replicates.

After planting and measurement of tree densities it was found that actual tree spacings were as follows:

600 stems/ha at 10 x 1.6 m (the proposed 800 sph)
1,200 stems/ha at 5 x 1.6 m (the proposed 1,600 sph)

Final Actual Design

The final trial design was therefore:

1. Trees:

	Tree Density (sph)		Spacing of Stems (m)	
	Initial	*Final*	*Initial*	*Final*
4 tree densities	0	0	0	0
	600	100	10 x 1.6	10 x 10
	600	200	10 x 1.6	10 x 5
	1,200	400	5 x 1.6	5 x 5

2. Times of planting:

   August 1975
   August 1976

3. Type of stock:

Sheep
Cattle

That is: 4 tree densities x 2 stock types x 2 years of planting x 4 replicates.

Paddock Areas

Paddock:	1	4.75 ha sheep	5	4.76 ha cattle
	2	4.62 ha cattle	6	5.33 ha sheep
	3	5.04 ha sheep	7	4.71 ha sheep
	4	4.66 ha cattle	8	4.44 ha cattle

Each tree block is approximately 0.6 ha and there are about 26 rows of any tree spacing in a paddock. Tree, sheep, cattle, and year areas are:-

Trees	Sheep	Cattle	Total
1975	9.79ha	9.28ha	19.07ha
1976	10.04ha	9.20ha	19.24ha
Total	19.83ha	18.48ha	38.31ha
Lanes			1.14ha
Grand Total			39.45ha

4. AERIAL PHOTOGRAPHY

Originally it was proposed to aerially photograph the trial annually. However, this was not possible and flights have been made as follows:

(i) 18 July 1974 prior to discing and ripping. Vertical monochrome print at a scale of 1 cm to 20 metres, that is 1:2,000. The reduction (figure 6a) at 1:4000 shows clearly the areas of scrub and bracken as well as the initial roading.

(ii) 8 May 1975 (figure 6b), also a monochrome print, vertical - depicts the trial just prior to the discing and ripping of section 1 on what would ultimately be paddocks 1 to 4. Scale 1 cm = 60 m or 1:6000

(iii) 25 February 1980, this time a colour photograph, vertical - a scale of 1 cm to 100 metres or 1:10,000 with an enlargement at 1:5,000. Although visible at the smaller scale, the larger scale photograph outlines the paddock fence lines and the bulldozer rip marks (the pale herringbone pattern) in detail as well as the dam and stock water tank (figure 6c).

(iv) 9 February 1981, also in colour at a scale of 1 cm to 110 metres or 1:11,000, vertical (figure 6d).

(v) October 1983, colour aerial photograph, vertical - at a scale of 1 cm to 100 m or 1:10000 (figure 6e).

(vi) June 1989, colour aerial photograph, vertical - at a scale of 1 cm to 60 m or 1:6000 (figure 6f).

5. CLIMATE EFFECTS

No observations on climate were made at the site. However, two meteorological stations were within a few kilometres of the trial. These stations are Taieri Mouth, on the sea coast and 3.4 km distant and Milton on the Tokomairiro Plain, 1.8 km away, but protected by the coastal hills (figure 2). Selected climate data for these two sites are given in Table 1.

Although the official climate stations record about 750 mm annually there is only slight variation depending on site location, and adjustment to a long term, 1951-1980, 30 year normal would indicate district rainfall to be very similar as shown in recordings from nearby rainfall stations (Table 2).

Taieri Mouth and Akatore are very similar nearby coastal sites adjacent to the Pacific Ocean. Milton and Milburn are both inland adjacent sites; Milburn, in particular is only 1 km from the trial site. On the basis of these data for rainfall the agroforestry site would be intermediate between the coastal and inland plain sites, with an annual precipitation of approximately 730 mm and a monthly distribution similar to Milton.

Temperature-wise, the site, since it has a sunny and reasonably sheltered north-western facing slope, would be slightly warmer than Milton. In fact, on a calm summer's day, when lunching on the trial site, it is like sitting on the shores of the Mediterranean - balmy and idyllic; a land of Lotus eaters!!

6. SOIL MOVEMENT AND LAND SUBSIDENCE

The land use capability map of the trial block classes it as:

Lo/Cg - 31bH - E + D
2Sh - M4, 6n6p2

or

Lo/Cg Loess over soft conglomerate

31bH Kaitangata hill soils

E + D { E slopes 21-25° dominant over D slopes of 16-20°
{ Which generally fits the slopes of the trial as shown in fig 7

2Sh Moderate sheet erosion

M4,6n6 Fern native scrub association and in places over 40% native forest, associated with low producing native grasslands.

p2 Low producing nature and exotic pasture.

Pre-planting land preparation - giant discing, dozing and ripping - exposed the sub-soil (B horizon) of the main stream slopes dissecting the 1975 and 1976 blocks (figures 4 and 5). However, a thin, mainly browntop, grass cover established rapidly within the year of working and no soil erosion was observed, save for some minor slumping near the boundary fence line of paddocks 2/3 where it crosses the creek. There were no other signs of earth movement. Control plots of paddocks 3 and 4 - at the south end of the trial - on a slope of 26° gave the impression of being at risk to erosion but remained stable until June 1980.

Heavy rains on the night 4/5 June 1980 (about 102 mm) left the soil profile in a sodden condition and within three weeks of that date, earth movement was observed. There were a number of minor slips but the greatest movement was in paddocks 2 and 3 where trees moved down-hill some three metres (figure 7). The number of trees affected in the various paddocks is given in table 3. During the summer of 1980/81 the subsidence areas stabilised and no further movement was noted after June 1981.

Over the period of the trial, a number of under-runners developed. Some were very large. The largest being on the central access road to the dam which provided the water supply to the trial. This, when it collapsed in 1989, would have been large enough to take a 4WD Land Cruiser. Others were smaller, and very occasionally sheep and cattle were lost in them and ultimately died or had to be destroyed.

7. BRACKEN FERN, MANUKA, GORSE

Prior to development, a considerable area of the trial was covered by bracken fern (figure 7), manuka and gorse. After ripping, the area of these weed plants was considerably reduced, nevertheless, small pockets remained in the steeper parts of the of the gullies of the main stream dissecting all paddocks. Because of the persistence of bracken in the gullies, cattle were used occasionally in all paddocks until December 1981, mainly with the aim of crushing the bracken; an operation which has been moderately successful (table 4). Gorse control was by means of Tordon pellets. Most of the manuka was removed by ripping and giant discing.

Further stocking, better pasture management, and tree growth, should have seen the almost complete elimination of scrub weed species, perhaps assisted by herbicides and rotary slashers. However, this was not to be the case and Tordon herbicide applied in granule form in December 1981, whilst partially successful in suppressing some gorse growth, also killed six trees, by downhill movement of the herbicide in paddocks 3 and 4. During January and February 1982 gorse areas were sprayed with 245T in control areas and easier slopes of paddock 5 were rotary slashed, and further Tordon prills applied in paddocks 1 to 8. As can be seen in the 1989 aerial photograph (figure 6f), there are clumps of gorse in control plots of paddocks 1 and 2 and 7 and 8 respectively at the south and north ends of the trial.

Further gorse control was carried out in 1993 the effect of spraying being apparent in figure 6g (6/1/94) and by December 1994 much of the gorse had disappeared. By June 1995 only isolated patches remained.

8. TOPDRESSING

The trial has been aerially topdressed on six occasions (table 5) and the interval between topdressings was decreased as stocking rate increased and vice versa after 1985.

Phosphate levels for pre-trial soil testing (Table 21,) in May 1975 showed soil phosphorus to be very low. The application of 250 kg/ha Mo super in 1976 was a minimal amount as it was thought a higher rate may have stimulated native and oversown grasses and legumes to such an extent the trees would suffer from pasture competition at the light stocking rate used. Although 375 kg/ha super was applied in July 1979, the soil test of July 1980 showed phosphate levels to be very low to low indicating either too low a topdressing rate or too long an interval between topdressing. By June 1981 phosphate soil tests were still very low and appeared to have declined since the previous soil sampling. It was decided, because of this, to topdress in 1981, again with 375 kg/ha Super, as stocking rate and pasture consumption were increasing.

Subsequently the trial was topdressed in July 1983 and at this stage the mean P soil analysis prior to topdressing was 9; an improvement on the low figure of 4 recorded prior to topdressing in June 1981. Two years later in 1985 the trial was again topdressed at 250 kg/ha super (it was also 250 kg super in 1983) and at this stage the pre-topdressing P analysis was 14; a substantial improvement over 1983. The trial was again topdressed in March 1988 with 250 kg/ha Super and by June 1990 the P soil analysis over all treatments averaged 17. The final topdressing was on 14.10.92 with 250 kg/ha super. By 1994 P level on control was 14.8 increasing at 400 sph to 16.5. This would indicate the topdressing as being adequate for P from 1982 on. Peak stocking rate of 8.1 su per hectare was reached in the 1982/83 season and thereafter declined slowly at the same time as the tree canopy was increasing, however the soil phosphate levels were also increasing. The period between topdressings after 1985 (i.e. topdressing every 3rd year) was dictated more by available finance than a deliberate policy to topdress every three years.

Soil chemical analyses for sulphur are available for 1985, 1990, 1992 and 1994 and these show a marked fall between 1985 and 1994, an indication that S fortified Super would have been a more suitable fertilizer.

Over the 17 years from 1975 to 1992 average superphosphate application was 118 kg/ha/year, which approximates to 9 kg P/ha/yr and 13 kg S/ha/year. This, at least to 1992, seems slightly more than adequate for P but not for S.

From 1993 to 1995 no further topdressing was carried out and this is apparent in the decline in Sulphur soil test values by 1994. So in effect there has been a steady fall in S values from 1985 to 1995. The decline being greatest on the control plots (S = 24.3 to 5.4) and becoming less as the tree density increases to 400 sph (S = 20.9 to 10.6), by 1994.

9. STOCK AND GRAZING MANAGEMENT

Stock for the trial were supplied by Lands and Survey Department, from April 1977 to April 1982, from stock in their forest grazing operation in the Otago Coast Forest. The sheep were Perendale and the cattle mainly Hereford or Hereford cross and as far as practical these were rotationally grazed, although set stocking was used in the early period of stock introduction from April 1977 until the paddock fencing was completed in 1978. It should be noted that sheep were first introduced onto trial in April 1977 and cattle in April 1978. (See also page 21).

No stock measurements were made until May 1982 other than grazing days. This occurred because stock supply to the trial by Lands and Survey had been partly dependent on the needs of the remainder of the forest; the absence of good fencing on the paddock treatments until 1978; and the lack of stock yards until 1981. A flock of 150 Perendale ewes, supplied by Lands and Survey, was continuously on the trial from May 1981 until April 1982. After this, 200 culled Perendale hoggets from MAF's Invermay Farm was placed on the trial in May 1982. This flock and its replacements remained to March 1989. From 1989 to 1990 the sheep flock comprised ram lambs and rams from Invermay. From 1981 until 1995 the cattle were supplied from the MAF Waiora or Invermay Farms as yearlings and removed at two or four years of age and then replaced with a new herd of yearlings. During the 1989-90 year drought and shortage of replacement stock limited carrying capacity, and drought in 1994-95.

In the 1991-92 and 1992-93 years the trial was stocked with dry ewes and in 1993-94 and 1994-95 with ewes and hoggets. As noted above 1994-95 was a difficult year with limited feed supply because of drought during summer 1994/95.

After the introduction of cattle to the trial in April 1978 it was found necessary to briefly mob stock the cattle paddocks with sheep in order to clean up the rather rank browntop pasture which had developed and which cattle avoided. All paddocks therefore have had sheep on them up until August 1981 and to some extent the cattle paddocks were heavier stocked than sheep paddocks. After this stock remained on their own treatments through to 1995.

Similarly, as already noted (page 16), cattle were used to clean up bracken in sheep paddocks. In general, short periods of sheep introduction were necessary in all years up until June 1995 on all cattle paddocks to "clean up".

The problem of having surplus feed in the early life of the trial could have been resolved by very intensive break-feeding and management, although the labour demands of such a situation may not be practical in a normal commercial operation. In the trial situation as it developed here, there was some rank pasture because of the lack of sufficient stock and control fencing.

Stocking rates increased steadily (tables 6 and 7) as expertise was gained in management and as the trees became taller and so less subject to damage.

The problem of excessive pasture growth in the first year after planting was difficult to solve on the large blocks unless intensive electric break fencing was used. Although the original trial design had 32 paddocks, it was abandoned because of financial restrictions. The sheep and cattle grazed over all treatments and because strict rotational grazing was not possible initially, stock had to be removed from the whole trial at the first sign of damage to the trees. The net result was under-grazing, and the development of, a rank stalky pasture composed much as shown in the point analysis of table 19. It was not until the 1980/81 season there was any real improvement in the percentage of clover present with a suggestion this might be higher in the cattle paddocks (table 20).

Mean annual stocking rates for the period 1976-77 to 1985-86 were sheep 5.1 and cattle 4.6 stock units/ha and the mean stocking rate of sheep plus cattle over all tree an animal treatments was 4.9 su/ha. From 1986-87 to 1994-95 mean annual stocking rates were sheep 3.6 su/ha and cattle 4.0; the overall mean being 3.8 stock units/ha. The 19 year mean being, sheep 4.2 su/ha and cattle 4.1 su/ha (Table 7, 7a).

Fleece and animal weights were taken over a number of periods (table 8) but not consistently over the life of the trial because of staffing and financial constraints

Stock performance - Sheep: The limited data of table 8 shows sheep performance to be average. The line of Perendale ewe lamb culls supplied by Waiora in May 1982 were not in any way star-class. However, they and their replacements which came from the same stock but bred on the trial, remained there until March 1989 and as mixed age ewes averaged 92% lambing and this as an easy care flock - stock were checked only once a week at times. Sheep liveweights at Tupping (approx. 1 May each year) were about 45 kg and lamb weights were

about 24 kg at five months of age, the mid point of lambing being about 15 October. There are insufficient data to comment on ewe or lamb wool weights. Stock were completely replaced in April 1989 with a new line of ewe hoggets and these remained on the trial until 1991 when they were replaced with further ewes and later in 1994 additional hoggets.

Financial problems and drought caused some sheep stocking difficulties throughout the 1989 period until June 1995. During part of this time rams from Invermay were used and performed very indifferently - possibly due to a change in diet from the more lush Invermay pasture to the harder steeper Akatore grazing.

Stock performance - Cattle. The same line of Hereford/Aberdeen Angus steers remained on the trial from February 1982 until February 1984 increasing in weight from 135 kg as yearlings (born August 1981) to 430 kg in this period (table 8A). Cattle tended to loose weight during the two winter periods they were on the trial. After 1984 cattle (from Waiora) were replaced usually annually except between 1986 and 1988 when replacement yearlings increased in weight from 172 kg to 327 kg. The last cattle weighing in August 1993 gave an average weight of 432 kg.

10. TREE MANAGEMENT

Thinning and Pruning

Silvicultural activities were the responsibility of the Forest Research Institute and the New Zealand Forest Service (now Ministry of Forests and Timberlands (Otago) Ltd. However, some initial observations were made by MAF up to and including part of the 1980 year. The initial layout and planting of the trees has been outlined in section 2 (establishment and pre-trial history) with further detail below.

A summary of pruning and thinning 1975 to 1990 is as follows:

The trial in the Otago Coast forest was planted in *Pinus radiata* as a half replicate in each of two years. The south half replicate in August 1975 and the north half replicate in August 1976 at 600 and 1,200 sph.

The 1975 stand was thinned in September 1981 (600-200, 600-400, 1,200-600 sph) and in October 1984 (200-100, 400-200, 600-400 sph) which gave the final densities. Pruning of the 1975 planting was carried out in September 1981 to 2 m; March 1984 to 4 m; to half tree

height December 1984; and finally in April 1986 to 10 m using a 10 cm calliper. There was an adjustment thinning in October 1982 on some of the 1,200 sph group (table 13).

Thinning of the 1976 stand was in October 1983 (600-200, 600-400, 1,200-400 sph) and again in October 1984 (200-100, 400-200, 400-400 sph) to give the final tree density. The 1,200-400 thinning of October 1983 was in error and should have been 1,200-600 and resulted in excessive slash on the ground. There was also some adjustment thinning in late 1983. Pruning of the 1976 trees was in October 1983 to 2 m; to half tree height in December 1984 and finally in April 1986 to 6 m using a 10 cm calliper (table 14).

Tree assessments were taken by MAF from 1976 to 1979 inclusive but only included height and damage estimates. From 1980 on, tree assessments were made by New Zealand Forest Service.

Tree height in 1976 was a mean of 200 observations for each planting year.
" " " 1977 " " " " " 100 " " " " " " " "
" " " 1978 " " " " " 200 " " " " " " " "
" " " 1979 " " " " " 400 " " " " " " " "

The difference in the number of observations for each year was taken merely to determine the minimum number of samplings necessary for an accurate mean. As shown (table 9) the 1975 trees have a height increment of 0.7 metres/year, and the 1976 trees 0.6 metres/year between 1976 and 1981.

Tree Damage

Damage 1977 to 1978

April 1977

Sheep were introduced into the trial in April 1977 at 5 su per hectare.

1976 Planting: The damage to the 7 month trees with a tree height of 37 cms, was 8% of growing tips eaten.

1975 Planting: The damage to the 19 month trees was nil with a tree height of 55 cms.

Sheep were in trial for 16 days when damage occurred. They were then removed. There was abundant feed on offer.

September 1977

Sheep introduced at 8 SU per hectare. Damage occurred three weeks after introduction.

1976 Planting: Damage to the 14 month, 37 cm trees was again 8% of growing tips eaten and 10 trees trampled.

1975 Planting: Damage to the 26 month, 55 cm trees, was nil.

By Autumn 1978 most of the 16% of trees damaged at the tips had recovered and were growing satisfactorily, but more slowly than untouched trees. Probably, they were retarded by a year, but hopefully compensatory growth made up for this by now. The stock were removed after 21 days to prevent further tree damage, even
though there was abundant feed on offer.

February 1978

1975 Trees: Wethers, at 8 SU per hectare, were introduced to 30 month old, approximately 100 cm tall trees, and caused no damage. Stock were removed from trial after 21 days.

1976 Trees: Stock were excluded from these 18 month old trees.

April 1978

1975 Trees: Cattle at 12 su/ha were introduced to 32 month old, 130 cm tall trees, for 10 days causing no damage.

1976 Trees: Again stock were excluded from the younger 1976 trees.
These early introductions can be summarised as follows in relation to tree age and height:

7 month (37 cm) trees; 8% damaged by ewes in autumn after 16 days at 5 su/ha

19 month (55 cm) trees; not damaged by ewes in autumn after 16 days at 5 su/ha

14 month (37 cm) trees; 8% damaged by ewes in spring after 21 days at 8 su/ha

25 month (55 cm) trees; not damaged by ewes in spring after 21 days at 8 su/ha

30 month (100 cm) trees; not damaged by wethers in summer after 21 days at 8 su/ha

32 month (120 cm) trees; not damaged by cattle in autumn after 10 days at 10 su/ha

Stock were removed when damage occurred, or was imminent, as indicated by leaders being nibbled.

Damage After 1977/1978 Year

Detailed assessments of tree damage were made at the end of the 1978-79 year (the first full year of sheep and cattle grazing) and in 1979-80. The farming year was from June to May but the damage assessments were made in the August or early September period following, and as the trial area was free of stock for most of the winter months, and stock damage therefore non-existent at that time.

Damage in the 1978-79 Year

Comments on the 1978-79 year tree damage are as follows:

The tree damage assessments have a high degree of variability and partly reflected our lack of experience (G G Cossens and G S Crossan) to manage the trial, rather than to treatment effects per se. Time of removal of stock was the critical factor in preventing tree damage. In this respect the high degree of tree damage recorded at 600 sph in 1975 plantings with cattle (table 10) indicates the considerable damage to trees around stock camps and along tracks leading to gateways. Because of the randomisation within the paddocks, all gates in the dividing lane fall in the 600 sph treatment (figure 5) and to a certain degree on flat stock camp areas. So a bias is probable. The damage to the trees was severe in cattle paddocks, particularly within 40 metres of gateways. When plantings were at 1,200 sph there was a truer picture of the damage, with little difference between sheep and cattle being observed. The slightly less damage on the 1976 trees (table 10) probably reflects an increase in management expertise rather than anything else.

A breakdown of the positional damage on the tree is also given (table 10). Predominantly damage occurs to the branches and to the crown and least to the bole of the tree.

Damage in the 1979/80 Year

The trial suffered some tree damage from stock during April, May and June of 1980. These were months of very strong winds and very heavy rain. The cattle showed a tendency to walk over some of the smaller trees when being mustered rather than go through the gap between trees. Inadequate planting also resulted in poor root development of some trees and as a result they screwed in the high winds, were subject to wind throw and finally complete pushing over by stock (table 11). Torrential rain on the night of 4/5 June 1980 triggered off a number of slips which became very evident as earth movement some three weeks later. Most were minor but the major ones are shown in figure 7 (see also section 7)

If 2,500 trees is assumed to be the number per paddock prior to pruning, then there were 20,000 trees on the whole trial of which 1,036 (5.2%) were bent over, 218 (1.1%) were lying flat on the ground and 82 (0.4%) were stripped bare of the lower branches. In total, 1,336 (6.7%) trees were damaged by wind, water and stock.

Over the years from August 1975 to August 1980 some 20% of the trees have been damaged to a greater or generally lesser degree by stock, wind and slips. Some would have recovered to produce a good tree, some would be distorted and would be removed at thinning. However, tree losses have not been anywhere near severe enough to affect final tree densities.

Damage after 1980

After 1980 there was some tree damage either from stock or wind. There was some wind-throw but at no stage was this serious. High winds in October 1991 and January 1993 caused considerable tree crown damage with falling tops and trees damaging fences. As a rough rule-of-thumb stock (sheep, cattle) cause little damage to trees provided trees are shoulder height on the animal, provided of course there is adequate feed on offer. At Akatore (as compared to Invermay) there was almost no barking of trees possibly because there was always a fair supply of hard pasturage available.

Pruning, Thinning, Slash

A summary of slash counts is given in tables 13 and 14 (1975, 1976 trees) with the detail in Appendix 1, Tables 1 and 2. Tables 13 and 14 also give pruning and thinning dates.

Needles

Visual observations prior to 1989 suggested that needle fall from all tree densities was comparatively light but was increasing in 1989. Needle boxes were therefore placed on the tree measurement plots in February 1990, and needle fall observed until 1995.

Needle fall in the years 1989-90, 1992-93, 1993-94, and 1994-95 were as follows:

Tree age			Sph		
15	1989-90 Part Year		100	200	400
	12.2.90 to 30.7.90	kg/ha	530	880	1630
	(168 days)	kg/ha/day	3.2	5.2	9.7
			(100)	(163)	(303)
16	1990-91 No assessment				
17	1991-92 No assessment				
18	1992-93 Part Year				
	12.9.92 to 3.6.93	kg/ha	1040	1230	2410
	(256 days)	kg/ha/day	4.1	4.8	9.4
			(100)	(117)	(229)
19	1993-94				
	4.6.93 to 11.5.94	kg/ha	1420	1980	3290
	(342 days)	kg/ha/day	4.2	5.8	9.6
			(100)	(138)	(229)
20	1994-95 Part Year				
	11.5.94 to 16.9.94	kg/ha	1060	1130	1710
	128 days	kg/ha/day	8.3	8.8	13.4
			(100)	(106)	(161)

There was a tree stocking effect and over the period 1990 to 1994, 400 stems per hectare yielded 130 percent more needle fall than 100 sph, while 200 sph yielded 31% more. Although the records for the seasons (spring etc.) are incomplete late autumn - early winter yield appeared to give a heavier needle fall than other seasons. Needle fall at Akatore was considerably less than for the Tikitere agroforestry trial near Rotorua for trees of the same age (see page 24).

Based on needle fall Akatore trees appear to be 8 years later in maturity than these at Tiktere. The needle fall in year 12 for 100 sph at Tikitere being similar to Akatore (100 sph) at year 20. At 200 sph Akatore at year 20 is approaching the needle fall of Tikitere at year 11 (Table p. 25). However the data are rather incomplete for Akatore and the best that can be said is that Akatore is 7-9 years behind Tikitere. This arises because needle collection at Tikitere is monthly and that at Akatore 3 to 4 times a year. There was also a large variation between collection cages with variation at 100 sph > 200 sph > 400 sph.

Needle fall at Akatore (1990/95) and Tikitere 1984/87 (kg/ha/day)

		Stems/hectare			
Tree age (yrs)		100		200	
Tikitere	Akatore	Tikitere	Akatore	Tikitere	Akatore
11 (1984)	15 (1990)	4.9	3.2	10.8	5.2
12 (1985)	18 (1993)	8.8	4.1	17.4	4.8
13 (1986)	19 (1994)	7.2	4.2	13.7	5.8
14 (1987)	20 (1995)	11.3	8.3	18.1	8.8

During 1993 because of chlorosis in the needles Potash deficiency was suspected. They were chemically analysed for K at 100 and 400 stems per hectare. The % K in the foliage of 0.21% indicated inadequate levels of potassium where 0.3%K or less is usually associated with chlorosis and reduced tree growth. No steps were taken to check this on site with potassium topdressing.

Needle Chemical Analysis for K on 3 June 1993

Tree Density	100	200	400
Needle analysis % K	0.213		0.215

11. PASTURE HERBAGE YIELD

Cutting and probing dates are given in table 15 and herbage dry matter yield in table 16.

Pasture herbage dry matter yields (Tables 15, 16) were measured from 1980-81 to 1983-84 using rate-of-growth pasture cages. These cages (figure 8) approximately 3.3 x 1.5 m in size had a 4 or 5 m^2 pasture sample taken from them using a sickle bar mower. With 64 plots in quite rugged, and at times steep country, cutting was arduous and difficult, particularly as all 64 cages had to be shifted manually after each cut and placed on newly trimmed areas. The rate-of-growth cages were removed by helicopter on 22.1.85 as the easiest method of shifting on account of the tree cover.

In order to cut down the work load, an electronic pasture probe was used from 1984-85 to 1986-87 to estimate pasture yield. Calibration of pasture probe yield was against hand cut DM yields from 10 cages of 0.15 m^2 each at each cut. Yield was then determined by pasture probing of 64 of the 0.15 m^2 cages and estimating the yield from the calibration curve. The cages were shifted onto newly hand trimmed sites after each probing.

Statistical analysis of yields showed no differences between sheep and cattle nor between 1975 and 1976 plantings and little difference in variability between the two different techniques (sickle bar mower vs pasture probe) as evidenced by the SED value (table 16 and 16a). Because of financial restrictions limiting staff, there were no cuts during 1987-88 nor 1988-89. A single probe was made on 19.3.90 covering the growth from 6.9.89 to 19.3.90, but the results were unreliable because of the presence of needles.

In 1990-91, the technique of pasture assessment was again changed. Calibration techniques were similar, but the standing herbage mass was estimated by 30 probes of each plot (i.e. each tree density) before and after stock movement into or out of the plots. Herbage yield was then estimated as the growth in the period during which the plot was unstocked, however again because of the presence of needles the probe readings were erratic and no results are given for 1990/91. Nevertheless estimates of yield for winter and summer were used to derive tree

effect on pasture (Table 17, 18).

In 1991/92, and 1992/93 no pasture yield measurements were made because of financial restrictions.

In 1993/94 and 1994/95 pasture dry matter yields were estimated by cutting 0.5m^2 cages. However only paddocks 3-4 (1975 plantings) and 7-8 (1976 plantings) were cut. In effect this meant that the number of replicates of each tree density was reduced from 16 to 8 the result again of financial constraints imposed over those years. Herbage dry matter yields for 1993 to 1995 are the pasture yields in the absence of needles.

12. PASTURE COMPOSITION

Point Analysis

Point analysis (table 19) prior to grazing in April 1977 showed a dominantly browntop/sweet vernal sward. Paddocks 1-4 which had been disced once (May 1975) had less browntop but more Yorkshire fog and cocksfoot than paddocks 5-8 which had been disced twice (June 1974, May 1976). However, the mean composition was similar for sheep and cattle treatments. Figure 6b taken on 9.5.75 shows the bare patches and ground cover of the 1976 tree section (paddocks 5-8) after the ripping of June 1974, with a great deal of bare ground on what was ultimately paddock 5 (in centre of photo). At this stage, the 1975 section was unworked. The point analysis of March 1977 shows a high browntop cover in paddock 5 but not an unduly high percentage of bare ground. The browntop rapidly colonised the bare areas in paddocks 5 to 8 (the 1976 tree block which had two discings) and it was probably fortuitous there was more adventitious cocksfoot and fog in paddocks 1 to 4. However, it is also possible these last two grasses were more common in paddocks 1 to 4 as they had only one discing compared to the two of paddocks 5 to 8. One hundred cover hits were recorded in each tree density plot per paddock. This means the 800 stems per hectare treatment had twice as many observations as the nil or 1,600. However, the 800 sph treatment occupies twice the area so a balance is maintained between all densities.

Herbage Yield Composition

The herbage species from the dry matter yields were dissected in three years: 1980-81, 1982-83 and 1983-84 (table 20). From 1984-85 through to 1988-89 herbage yield was by electronic

pasture probe and no herbage composition was determined. However, in the 1989-90 season four 0.1 m^2 quadrats in each tree density were cut by hand on 19.12.89 and the species composition determined (Table 21).

In 1993/94 herbage species were dissected for every cut (5 cuts), dissections being ryegrass, cocksfoot, other grasses dead and live pine needles, white clover, red clover, tussock, weeds and dead matter. For 1994/95 herbage dissection was incomplete and carried out as follows:-

For 1994/95	cut 1	grasses and needles only dissected
	cut 2	ryegrass, cocksfoot, needles, clovers, dead matter
	cut 3	grasses and needles only
	cut 4	not done
	cut 5	not done

In assessing pasture yield in the absence of needles the mean needle percentage for the first three cuts of 1994/95 (20/10/94, 30/11/94, 6/1/95) was used for the last two cuts (13/2/95 and 22/5/95) in order to obtain the corrected dry matter pasture production. This was done as needles were not assessed in these last two cuts.

13. HERBAGE CHEMICAL ANALYSES

No pasture herbage chemical analyses were undertaken, however as noted on page 25 needle foliage was analysed for potassium and shown to be below the adequate level of 0.3 to 0.5% K.

14. SOIL CHEMICAL ANALYSES

The trial has been soil sampled on nine occasions (table 22, 23, 24) for pH, Ca, K, P, S, Mg, Na, C, N; the dates of sampling being:

9.5.75	0-15 cms	13.7.830-8 cms
8.7.80	0-8 cms	31.7.850-8 cms
19.6.81	0-8 cms	17.6.900-8 cms
1.6.82	0-8 cms	14.9.920-8 cms
		21.9.940-8 cms

Note: The MAF test for soil P levels was changed from the Troug test to the Olsen in March 1976 and all P values after that date relate to the Olsen test.

Soil samples were taken half way between the tree rows on all occasions and no attempt was made to stratify the samples within or between the rows.

The soil test values are low to medium except for Mg which is very high. Phosphorus was in the "very low" class until 1985. The wide C/N ratios of May 1975 and June 1990 were due to the low soil nitrogen levels (table 23). In some paddocks the random soil sampling of 1975 would fall on bulldozed areas where the A horizon had been partially stripped resulting in very low soil tests. The 1975 soil samples were 0-15 cms because of the effect of giant discing in partially over-tuning the turf and partly burying the top 0-8 cms. Because of this and the "soil" variability over the whole block caused by the land preparation, it was doubtful if any treatment differences would show up readily unless very intensive soil sampling was undertaken. Soils in 1980 were very wet when sampled and the Olsen soil test values for technical reasons may have been anomalous. However, in case some trends might occur, the number of soil samples taken in 1981 was increased such that each main treatment effect was the mean of 16 replicates. The result confirmed the variability of the site and lack of treatment differences in 1981. From 1981 to 1990 all plots were sampled. In 1992 all plots were again sampled but in 1994 replicates were bulked for each tree density in each paddock (see Table 24b).

Further comment on P and S soil chemical analyses is made in Section 8 - "Topdressing", p17.

TABLE 1 — Climate data for Taieri Mouth and Milton Climate Stations

Taieri Mouth I60021	Grid Refs	NZMS1	1:63,360	S172	895	467
		NZMS260	1:50,000	I45	927	557
		Lat 46° 05′S	Long 170° 12′E	HT. 15M		

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Rainfall (mm)	69	46	62	71	84	66	57	55	59	70	59	75	773
Mean daily max. TIC	18.3	18.4	17.5	15.1	12.3	10.0	9.9	11.0	12.7	14.3	15.7	17.0	144
Mean daily min TIC	9.3	9.3	8.9	6.9	4.6	2.3	1.8	2.6	3.9	5.3	6.7	8.6	5.9
Mean daily temp TIC	13.8	13.9	13.2	11.0	8.4	6.2	5.9	6.8	8.3	9.8	11.2	12.8	10.1
Ground frosts				0.4	3.8	11.0	11.6	9.4	3.2	1.8	0.4	0.1	42.1
Air frost				0.1	1.3	6.1	6.8	5.0	1.3	0.4	0.1	-	21.1

Milton I69191 Grid Refs NZMS1 1:63,360 S172 708 418
NZMS260 1:50,000 H45 757 507
Lat 46° 07′S Long 169° 58′E HT. 18M

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Rainfall (mm)	69	58	62	62	71	70	59	46	49	57	65	71	739
Mean daily max. TIC	20.0	20.4	19.0	15.8	11.8	9.4	9.1	11.1	13.5	15.4	17.2	19.2	15.2
Mean daily min TIC	9.2	8.9	8.1	5.5	3.0	0.6	0.1	1.3	3.2	5.0	6.6	8.4	5.0
Mean daily temp TIC	14.6	14.7	13.6	10.6	7.4	5.0	4.6	6.2	8.4	10.2	11.9	13.8	10.1
Ground frosts	0.1	0.4	0.9	3.9	10.1	19.3	20.9	17.6	11.4	5.5	2.4	0.7	93.2
Air frost	-	0.1	0.4	1.5	6.3	13.3	14.9	9.9	3.9	1.6	0.8	0.3	53.0

TABLE 2 — 1951-80 Rainfall normals for sites near to Taieri Mouth and Milton (mm)

	J	F	M	A	M	J	J	A	S	O	N	D	Year
Akatore	85	62	71	68	70	69	51	68	53	55	78	73	803
Taieri Mouth	70	52	63	71	80	63	57	48	49	60	70	70	753
Milton	71	52	62	63	78	73	59	47	47	58	65	72	747
Milburn	55	38	56	53	61	64	48	35	42	51	55	55	613

TABLE 3 — Percentage of trees affected by slip movement in trial paddocks
Akatore — June 1981

Paddock	1	2	3	4	5	6	7	8
Percent trees	0.2	0.4	0.8	-	0.2	0.04	-	0.1

TABLE 4 — Areas of bracken fern, manuka and gorse (ha)
Akatore — 1974 and 1981

Prior to ripping and discing July 1974			Established trial June 1981		
Bracken	**Manuka**	**Gorse**	**Bracken**	**Manuka**	**Gorse**
3.61	6.04	2.31	1.71	Trace	0.72

*Areas by planimeter from aerial photos and ground checks

TABLE 5 — Dates and fertiliser rates applied to Project FD110
Akatore

Date	Fertiliser Applied	P kg/ha	S kg/ha	Mo g/ha	SU/ha	DM kg/ha
20.8.76	250 kg/ha Mo Superphosphate*	18	23	70		ND
77	Nil				0.3	ND
78	Nil				1.0	ND
19.7.79	375 kg/ha Superphosphate	27	33		3.5	ND
80	Nil				5.6	ND
23.6.81	375 kg/ha Superphosphate	27	33		5.5	6,990
82	Nil				5.0	5,720
27.7.83	250 kg/ha Superphosphate*	21	32		8.1	7,020
84	Nil				7.4	10,390
2.8. 85	250 kg/ha Superphosphate	21	32		6.8	9,240
86	Nil				5.5	7,520
87	Nil					7,390
19.3.88	250 kg/ha Superphosphate	21	32			ND
89	Nil					ND
90	Nil	1				6,990
10.10.92	250 kg/ha Superphosphate	21	32			ND
Total 17 yrs	2000 kg Superphosphate	156 kg P	217 kg S	70 g Mo		
Mean/ha/yr	118 kg Superphosphate	9.2	12.8	4.1		
Approx/ha/yr	120 kg Superphosphate	9	13	4		

*Chemical Analyses	Total P%	Citric P%	Water Sol P%	SO -S%	Mo%
1976	8.4	5.3	-	9.0	0.027
1983	8.4	7.6	6.9	12.8	-

17 year total is to 1992, last year of topdressing. Amount is same to 1995
ND = Not determined.

TABLE 6 — Mean annual stocking rates of sheep and cattle 1976-1995

	su/ha		
1976-77	0.3	1986-87	6.0
1977-78	1.0	1987-88	5.7
1978-79	3.5	1988-89	4.2
1979-80	5.6	1989-90*	2.6
1980-81	5.5	1990-91	2.7
1981-82	5.0	1991-92	2.9
1982-83	8.1	1992-93	3.1
1983-84	7.4	1993-94	2.0
1984-85	6.8	1994-95*	0.9
1985-86	5.5		

* Dry conditions December, January, February 1989-90, 1994-95 (very dry)

TABLE 7 — Actual grazing days for year June to May inclusive:
Akatore 1976 - 1986

Year	Sheep	Cattle	Total	Area (ha)	SU/ha/yr
1976-77	3,360	Nil	3,360	38.31	0.25
1977-78	13,930	2,400	16,330	38.31	1.01
1978-79	15,100	30,110	45,210	38.31	3.47
1979-80	59,320	19,560	78,880	38.31	5.62
1980-81	25,640	51,010	76,650	38.31	5.48
1981-82 (76)	29,050	15,826	44,876	19.24	6.39
1981-82 (75)	13,864	10,472	24,336	19.07	3.50
1981-82 (75 & 76)	42,914	26,298	69,212	38.31	4.95
1982-83 (76)	30,725	25,970	56,695	19.24	8.07
1982-83 (75)	20,905	35,480	56,385	19.07	8.10
1982-83 (75 & 76)	51,630	61,450	113,080	38.31	8.09
1983-84 (76)	27,230	18.790	46,020	19.24	6.55
1983-84 (75)	30,553	27,040	57,595	19.07	8.25
1983-84 (75 & 76)	57,785	45,830	103,615	38.31	7.29
1984-85 (76)	22,920	19,205	42,125	19.24	6.00
1984-85 (75)	37,320	16,190	53,510	19.07	7.69
1984-85 (75 & 76)	60,240	35,395	95,635	38.31	6.84
1985-86 (76)	21,934	17,123	39,057	19.24	5.56
1985-86 (75)	16,980	20,306	37,286	19.07	5.37
1985-86 (75 & 76)	38,914	37,429	76,343	38.31	5.46
10 years total		368,833	309,482	678,315	
10 year mean su/ha		5.10	4.59	4.85	

Note: Sheep paddock area is 1.3 ha greater than that of cattle paddocks.

TABLE 7A — Actual, grazing days for year June to May inclusive:
Akatore 1986 — 1995

Year	Sheep	Cattle	Total	Area (ha)	SU/ha/yr
1986-87 (76)	20,391	12,328	32,719	19.24	4.66
1986-87 (75)	27,307	23,628	50,935	19.07	7.32
1986-87 (75&76)	47,698	35,956	83,654	38.31	5.98
1987-88 (76)	20,636	17,580	38,216	19.24	5.43
1987-88 (75)	20,769	21,200	41,969	19.07	6.02
1987-88 (75&76)	41,405	38,780	80,185	38.31	5.72
1988-89 (76)	14,196	13,904	28,100	19.24	4.00
1988-89 (75)	18,298	12,784	31,082	19.07	4.47
1988-89 (75 & 76)	32,494	26,688	59,182	38.31	4.23
1989-90 (76)*	8,400	7,824	16,224	19.24	2.31
1989-90 (75)*	12,129	8,349	20,478	19.07	2.94
1989-90 (75 & 76)	20,529	16,173	36,702	38.31	2.63
1990-91	14,036	24,268	38,304	38.31	2.74
1991-92	18,573	21,719	40,292	38.31	2.88
1992-93	12,445	31,484	43,929	38.31	3.14
1993-94	16,965	11,294	28,259	38.31	2.02
* 1994-95	4,578	7,852	12,430	38.31	0.90
19 year total	577,556	523,696	1,101,252		
19 year mean su/ha	4.20	4.09	4.15		

*1989-90, 1994-95 very dry conditions December, January, February

Table 8 - Sheep - Live and Wool Weights, Lambing percentages and StockNumbers Akatore — 1982-1995

Date	Wt (kg)	SD (kg)	% lambs surv.	Trial stock no's.	Notes
11.5.82	23.6	2.2		185	Ex Invermay, born Sept 1981
7.9.82	19.1	2.2		188	
8.11.82	1.6	Wool		180	Wool wts Hoggets
10.2.83	38.6	3.6		180	
25.5.83	40.6	4.5		185	Tupping wt 2 Tooths
29.8.83	2.6	Wool		185	Wool Wts 2 Tooths
22.9.83	38.4	3.8		185	Post Winter
15.3.84	38.1	6.1	84%	177	83/84 Lambing
25.6.84	45.0			174	Tupping wt
16.1.85	40.9			171	
18.4.85			112%	132	84/85 Lambing
23.5.85					Tupping wt
30.9.85				130	Post Winter
6.1.86			90%	130	85/86 Lambing
20.5.86	43.6	5.9		132	Mixed Age Ewes, Tupping
28.7.86	43.8	5.8			
16.9.86				128	Post Winter
16.1.87	41.9	5.1		120	Mixed Age Ewes
16.1.87	17.6	3.7			90
23.2.87	22.6 Lambs		78%		86/87 Lambing
6.4.87				124	
3.6.87	50.3	4.5		73}	Woolly: Mixed Age Ewes
3.6.87	43.2	7.5		52}	Feb Shorn: 2 Tooth
14.9.87				121	Post Winter
27.1.88			98%		87/88 Lambing
18.4.88	47.3			111	Tupping
10.9.88				108	Post Winter
14.3.89	26.8 Lambs	5.6	87%		88/89 Lambing
14.3.89	46.3	6.2			100 Ewes to Invermay
3.4.89				110	Hoggets ex Waiora
1.6.89				110	Hoggets
4.9.89				0	Stock to Invermay
1.12.89				0	No sheep on trial

Table 8 - Sheep - Live and Wool Weights, Lambing percentages and StockNumbers Akatore — 1982-1995 (cont'd)

Date	Wt (kg)	SD (kg)	% lambs surv.	Trial stock no's.	Notes
4.3.90				84	84 rams ex Invermay
8.5.90				153	69 ewes ex Invermay
17.5.90				70	84 rams to Invermay
1.6.90				60	Ewes
1.9.90				55	Ewes
10.10.90				48	Ewes to Invermay
7.11.90				71	Ewes ex Invermay
6.5.91				67	Ewes on trial
30.6.91				67	Ewes on trial
22.7.91				71	Ewes on trial
31.8.91				71	Ewes on trial
30.9.91				71	Ewes on trial
30.11.91				71	Ewes on trial
31.12.92				62	Ewes on trial
28.1.92				62	Ewes to Invermay
5.3.92				65	Ewes from Invermay
30.6.92				65	Ewes on trial
1.7.92				56	Sheep
31.12.92				56	Sheep
2.3.93				56	Ewes to Invermay
16.3.93				46	Ewes shorn, 40 back on trial
8.6.93				39	Sheep on trial
8.6.93					6 back to IAC, 1 lost
1.7.93 to 30.6.94				39	Ewes
30.9.93 to 30.6.94				20	Hoggets on trial ex Invermay
1.7.94 to 17.8.94				36	Ewes
1.7.94 to 6.1.95				20	Hoggets on trial
7.1.95 to 30.6.95				0	No sheep on trial - drought

TABLE 8A — Cattle: Hereford-Aberdeen Angus Steers: Live Weights and Stock Numbers Akatore 1982-1995

Date	Weight (kg)	SD (kg)	Stock Nos	Notes
11.2.82	135	34.2	40	Ex Invermay Farm
				born September 1981
11.5.82	211	21.3	40	42 kg weight loss winter 82
11.9.82	169	20.2	37	
11.2.83	265	27.2	35	
8.6.83	305	25.8	34	
6.10.83	301	36.8	34	4 kg weight loss winter 83
9.2.84	430	34.0	34	
22.2.84				34 Steers to Waiora Farm
1.5.84			40	New Stock ex Waiora Farm
28.3.85				40 Steers to Waiora Farm
18.4.85			32	New stock ex Waiora Farm
30.9.85			32	
17.1.86			31	
30.4.86				31 Steers to Waiora farm
30.4.86			28	28 Yearlings ex Waiora Farm
20.5.86	175	28.8	28	
16.9.86			27	
6.4.87			28	
14.9.87			28	
15.4.88	327			28 Steers to Waiora Farm
15.4.88			20	20 Yearlings ex Waiora Farm
10.9.88			20	
4.3.89				20 Steers to Waiora Farm
17.4.89			20	13 Calves + 7 Yearlings ex Waiora
1.6.89			20	
1.9.89			19	1 steer died in under-runner
1.12.89			18	
12.2.90			0	18 cattle off trial to Invermay
17.2.90			22	22 cattle onto trial ex Invermay

TABLE 8A — Cattle: Hereford-Aberdeen Angus Steers: Live Weights and Stock Numbers Akatore 1982-1995 (cont'd)

Date	Weight (kg)	SD (kg)	Stock Nos	Notes
1.6.90			22	
17.7.90			21	1 steer broke leg - shot
1.12.90			21	
21.4.91	318		21	Cattle to Invermay
21.4.91	230		20	Steers ex Invermay
21.5.91			3	Yearlings ex Invermay
22.7.91			23	Cattle on trial
30.9.91			23	Cattle on trial
29.6.92			23	Cattle on trial
1.7.92 to 30.6.93			23	Cattle on trial
1.8.93	432 kg		0	All cattle off trial
18.11.93 to 18.5.94			16	Heifers on trial
18.5.94 to 30.6.94			0	No cattle on trial
1.7.94 to 31.12.94			0	No cattle on trial
1.1.95 to 3.5.95			15	Steers on trial

TABLE 9 - Tree Height (cms) 1975 to 1981 —Akatore

	Planted Aug 1975		Planted Aug 1976	
	Height (cm)	Age from planting (months)	Height (cm)	Age from planting (months)
August 75	No data	-	-	-
August 76	39 (9)**	12	27 (5)	0
August 77	55 (16)	24	37 (10)	12
August 78	131 (30)	36	61 (17)	24
September 79	163 (45)	48	110 (31)	36
August 80	389 (53)	60	ND*	48
August 81	429 (77)	72	321 (73)	60
	** (SE)			

* ND = not determined

** (SE) = standard error

TABLE 10 - Mean tree damage and heights for year - October 1978 to August 1979 (observed 5 September 1979) —Akatore

	600 sph					1200 sph				
	% Trees damaged				Ht (m)	% Trees damaged				Ht (m)
	Branch	Crown	Bole	Total		Branch	Crown	Bole	Total	
1975	14.0	5.2	3.8	23.0	1.53	3.0	4.8	6.5	14.3	1.75
1976	8.8	5.7	1.5	16.0	1.10	5.8	6.0	0.5	12.3	1.10
Mean	11.4	5.5	2.6	19.5	1.32	4.4	5.4	3.5	13.3	1.43
Sheep	6.8	5.0	2.2	14.0	1.33	5.0	5.2	4.8	15.0	1.35
Cattle	16.0	6.0	3.0	25.0	1.30	3.8	5.5	2.2	11.5	1.50
Mean	11.4	5.5	2.6	19.5	1.32	4.4	5.4	3.5	13.3	1.43
SEM	7.7	4.5	2.6	12.2	0.25	2.4	2.8	4.7	6.6	0.41

The 1979-80 year has been extended to include damage following heavy rains in June 1980.

TABLE 11 — Mean Tree Damage for Year September 1979 to August 1980 (observed 13 August 1980) % Damaged — Akatore

	Bent over	Lying flat	Stripped bare or branches broken off	Disappearing in slips	Total excluding slips
1975					
Sheep	7.9	1.5	0.8	1.0	10.2
Cattle	6.4	3.2	0.7	0.4	10.3
Mean	7.2	2.5	0.8	0.7	10.3
1976					
Sheep	14.1	1.5	0.6	0.04	16.2
Cattle	13.2	2.3	1.2	0.3	16.7
Mean	13.6	1.9	0.9	0.3	16.5
Sheep	11.0	1.5	0.7	0.5	13.2
Cattle	9.8	2.8	1.0	0.4	13.5
Mean	10.4	2.2	0.9	0.5	13.4
SEM	2.0	0.6	0.2	-	2.5

TABLE 12 — Tree measurements 1975 to 1995 — Akatore

Year	Age years	Ht (m)		100		200		400	
	75/76	75	76	75	76	75	76	75	76
8.75	0/-	-	-						
8.76	1/-	0.4	0.3						
8.77	2/-	0.6	0.4						
8.78	3/2	1.3	0.6						
9.79	4.1/3.1	1.6	1.1						
8.80	5.0/4	3.9	-						
11.81	6.3/5	Ht(m)		4.9	-	4.6	-	5.5	-
		dbh(cms)		7.9	-	7.6	-	8.7	-
		DOS(cms)		14.2	-	12.8	-	15.4	-
10.82	7/6	Ht		5.5	-	5.3	-	6.3	-
		dbh		10.9	-	10.4	-	11.5	-
7.83	8/7	Ht		6.6	5.8	6.6	5.9	7.4	6.8
		dbh		12.9	-	13.8	-	13.5	-
84	9/8	Ht		8.1	7.2	7.8	7.2	9.6	8.5
		dbh		16.1	13.8	15.3	13.8	16.1	15.0
6.85	10/9	Ht		8.7	8.0	8.9	8.3	11.8	9.8
		dbh		19.6	16.7	17.7	17.0	19.6	17.7
		DOS(cms)		22.4	19.4	20.0	20.7	21.1	25.7
86	11/10	Ht		9.9	9.4	10.3	9.4	11.8	10.8
		dbh		22.3	20.3	20.6	19.7	22.1	20.4
		DOS		18.9	20.0	18.3	18.7	17.8	17.6
87	12/11	Ht		11.1	10.6	11.8	11.0	13.4	12.3
		dbh		24.8	22.9	23.2	22.0	24.1	22.5
88	13/12	Ht		ND	ND	ND	ND	ND	ND
		dbh							
89	14/13	Ht		ND	ND	ND	ND	ND	ND
		dbh		"	"	"	"	"	"
90	15/14	Ht		14.4	14.3	15.6	14.6	17.0	16.1
		dbh		34.7	33.1	32.7	30.8	31.3	30.4
95	20/19	Ht		20.4	20.6	22.4	21.6	24.0	23.4
		dbh		51.5	50.7	46.9	45.9	40.6	40.6

TABLE 13 — Slash counts - % available pasture
Akatore 1982 to 1995

1975 Trees

	600-200-100	600-400-200	1,200-600-400
23.2.82	89	91	76
21.3.83	94	95	90
6.10.83	91	93	86
6.10.84	78	83	66
28.8.85	86	88	80
11.9.87	85	80	73
9.6.88	89	85	72
30.4.90	89	82	54
1.7.91	94	87	77
11.8.95	96	95	84
Sheep (means 1982-95)	89	89	75
Cattle (means 1982-95)	89	88	77

Thin			Prune		
1.	9.8.81	600-200 600-400 1,200-800	1.	9.8.81	To ½ tree height or 2 m
2.	10.82	Adjustment thin 1,200	2.	4.84	To ½ tree height or 4 m
		sph (1,200-)800-600			
3.	10.84	(600-200)-100 (600-400)-200 (1,200-600)-400	3.	12.84	100% pruned using 10 cm caliper
			4.	4.86	To 6 m 100% pruned using a 10 cm caliper

TABLE 14 — Slash counts - % available pasture
Akatore 1982 to 1995

1976 Trees

	600-200-100	600-400-200	1200-600-400
23.2.82	-	-	-
21.3.83	-	-	-
6.10.83	72	80	55
6.10.84	66	82	57
28.8.85	79	86	76
11.9.87	82	82	69
9.6.88	83	77	61
30.4.90	87	84	67
1.7.91	96	91	61
11.8.95	96	95	84
Sheep (means 1983-95)	83	85	65
Cattle (means 1983-95)	83	85	67

Thin			Prune		
1.	Oct 1983	600-200 600-400 1,200-400*	1.	Oct 1983	To ½ tree height or 2 m
* Mistake - should have been to 600					
2.	Dec 1983	Adjustment thinning	2.	Dec 1984	100% pruned using 10 cm calliper
3.	Oct 1984	(600-200)-100 (600-400)-200 (1,200-400)-400	3.	Apr 1986	100% pruned using 10 cm calliper all to 6 m

TABLE 15 — Cutting and probing dates for herbage yield
Akatore 1980 - 1995

1980-81 (Cages)	1984-85 (Probe)
Trimmed 7.10.80	Trimmed 4.9.84
Cut 1 - 10.12.80	Cut 1 - 22.11.84
Cut 2 - 21.1.81	Cut 2 - 18.12.84
Cut 3 - 25.3.81	Cut 3 - 5.2.85
	Cut 4 - 29.3.85
1981-82 (Cages)	1985-86 (Probe)
Trimmed 10.9.81	Trimmed 20.5.85
Cut 1 - 21.10.81	Cut 1 - 23.9.85
Cut 2 - 26.11.81	Cut 2 - 26.11.85
Cut 3 - 22.12.81	Cut 3 - 27.1.86
Cut 4 - 3.2.82	Cut 4 - 4.4.86
Cut 5 - 5.5.82	Cut 5 - 29.5.86
1982-83 (Cages)	1986-87 (Probe)
Trimmed 13.9.81	Trimmed 29.5.86
Cut 1 - 3.11.82	Cut 1 - 16.9.86
Cut 2 - 14.12.82	Cut 2 - 7.11.86
Cut 3 - 9.2.83	Cut 3 - 11.12.86
Cut 4 - 23.3.83	Cut 4 - 2.3.87
Cut 5 - 1.5.83	Cut 5 - 15.5.87
1983-84 (Cages)	1987-88 No yields taken
Trimmed 1.5.83	1988-89 No yields taken
Cut 1 - 28.9.83	1990 - 91 No yields taken
Cut 2 - 28.11.83	1991 - 92 No yields taken
Cut 3 - 8.2.84	1992 - 93 No yields taken
Cut 4 - 24.5.84	
1993 - 94	1994 - 95
Trimmed 12.8.93	Trimmed 2.5.94
Cut 1 - 5 + 19.10.93	Cut 1 - 30.10.94
Cut 2 - 6.12.93	Cut 2 - 30.11.94
Cut 3 - 7.2.94	Cut 3 - 6.1.95
Cut 4 - 31.3.94	Cut 4 - 13.2.95
Cut 5 - 2.5.94	Cut 5 - 22.5.95

Note: When probe is used:
"trim" = time of enclosure of stock
"cut" = date of probing

TABLE 16 — Mean pasture production at 4 tree densities, 1980-81 to 1994-95 (slash excluded) : Akatore

Pasture Production (DM kg/ha)								
Year	**Tree age**	**0**	**100**	**200**	**400**	**Mean**	**SED**	**Reps**
1980-81	5	6990	-	6800	8080	7290	696	8
1981-82	6	5720	5520	6140	5530	5730	576	16
1982-83	7	7020	7570	7250	5470	6830	618	16
1983-84	8	10,390	8870	8940	7070*	8820	723	16
1984-85	9	9240	9260	9970	9640	9530	432	16
1985-86	10	7520	7980	8210	7350	7770	648	16
1986-87	11	7390	7590	8000	7140	7530	489	16
1987-88	12	No cuts						
1988-89	13	No cuts						
1989-90	14	6990	5640	5070	3560**	5310	220	16
1990-91	15		No yields taken					
1991-92	16		No yields taken					
1992-93	17		No yields taken					
1993-94	18	5710	2370**	2411**	460**	2740	527	8
1994-95	19	4080	1080**	1120**	0**	1570	515	8
1980-87		7750	7800	7890	7180	7660	-	-
1989-95		5590	3030	2870	1340	3210	-	-

Mean of 1980-81 to 1986-87 7 years cut
Mean of 1989-90 to 1994-95 3 years cut

The 1994-95 year was very dry in December 94, January 95, February 95

Significant at 5% = *
Significant at 1% = **

TABLE 16A — Pasture herbage yield, 1975 and 1976 trees
Akatore : 1980-1995

1980-81	**1975**	**1976**	**Grand Mean**
Mean	-	-	7,280
Sheep	-	-	8,570
Cattle	-	-	5,960
SED	-	-	503
CV%			9.8
1981-82			
Mean	5560	5920	5730
Sheep	5010	6360	5660
Cattle	6120	5470	5800
SED	1197	491	789
CV%	21.5	8.3	19.5
1982-83			
Mean	-	-	6,830
Sheep	-	-	6,810
Cattle	-	-	6,840
SED	-	-	561
CV%			11.6
1983-84			
Mean	-	-	8,820
Sheep	-	-	8,620
Cattle	-	-	9,010
SED	-	-	804
CV%	-	-	12.9
1984-85			
Mean	9640	9400	9530
Sheep	9980	9290	9650
Cattle	9300	9500	9400
SED	318	1808	798
CV%	3.3	19.2	11.8
1985-86			
Mean	8250	7300	7770
Sheep	8410	7900	8150
Cattle	8080	6710	7380
SED	1447	187	651
CV%	17.5	2.6	11.9

TABLE 16A — Pasture herbage yield, 1975 and 1976 trees
Akatore : 1980-1995 (cont'd)

1980-81	**1975**	**1976**	**Grand Mean**
1986-87			
Mean	-	-	7,530
Sheep	-	-	7,800
Cattle	-	-	7,260
SED	-	-	187
CV%	-	-	3.5
1989-90			
Mean	-	-	5,310
Sheep	-	-	5,280
Cattle	-	-	5,340
SED			182
CV%			4.9
1993-94			
Mean	-	-	2740
Sheep	-	-	3360
Cattle	-	-	2120
SED	-	-	141
CV%	-	-	10.3
1994-95			
Mean	-	-	1570
Sheep	-	-	1730
Cattle	-	-	1410
SED	-	-	212
CV%	-	-	24.5

TABLE 17 — Livestock carrying capacity (LCC) as a fraction of open pasture at 0, 100, 200, 400 stems/hectare : Akatore**

1975 Tree Plantings

	Tree age	Pasture DM kg/ha		Sig.	Tree effect	Slash effect	LCC potential
		0	100 sph				
1980/81	5	6,990	6,800	NS	1.00	0.90	0.90
1981-82	6	5,720	5,740	NS	1.00	0.89	0.89
1982-83	7	7,020	7,570	NS	1.00	0.90	0.90
1983-84	8	10,390	8,870	NS	1.00	0.89	0.89
1984-85	9	9,240	9,260	NS	1.00	0.78	0.78
1985-86	10	7,520	7,980	NS	1.00	0.84	0.84
1986-87	11	7,390	7,590	NS	1.00	0.86	0.86
1987-88	12	ND*	-	-	-	0.85	-
1988-89	13	ND	-	-	-	0.89	-
1989-90	14	6,990	5,640	1%	0.81	0.89	0.72
1990-91	15	-	-	-	0.77	0.94	0.72
1991-92	16	ND	-	-	-	-	-
1992-93	17	ND	-	-	-	-	-
1993-94**	18	5710	2370	-	0.42	0.96	0.40
1994-95**	19	4080	1380	-	0.26	0.96	0.25
			0	200 sph	Sig	T effect	S effect
1980-81	5	6,990	6,800	NS	1.00	0.93	0.93
1981-82	6	5,720	5,760	NS	1.00	0.91	0.91
1982-83	7	7,020	7,250	NS	1.00	0.92	0.92
1983-84	8	10,390	8,940	NS	1.00	0.91	0.91
1984/85	9	9,240	9,970	NS	1.00	0.83	0.83
1985/86	10	7,520	8,210	NS	1.00	0.85	0.85
1986-87	11	7,390	8,000	NS	1.00	0.80	0.80
1987-88	12	ND	-	-	-	0.80	-
1988/89	13	ND	-	-	-	0.85	-
1989-90	14	6,990	5,070	1%	0.73	0.85	0.62
1990-91	15	-	-	-	0.57	0.87	0.50
1991-92	16	ND	-	-	-	-	-
1992-93	17	ND	-	-	-	-	-
1993-94**	18	5710	2410	-	0.42	0.95	0.40
1994-95**	19	4080	1120	-	0.22	0.95	0.21

TABLE 17 — Livestock carrying capacity (LCC) as a fraction of open pasture at 0, 100, 200, 400 stems/hectare : Akatore** (cont'd)

	Tree age	Pasture DM kg/ha		Sig.	Tree effect	Slash effect	LCC potential
		0	100 sph				
1980-81	5	6,990	8,080	NS	1.00	0.80	0.80
1981-82	6	5,720	6,460	NS	1.00	0.76	0.76
1982-83	7	7,020	5,470	NS	1.00	0.78	0.78
1983-84	8	10,390	7,070	5%	0.68	0.83	0.57
1984-85	9	9,240	9,640	NS	1.00	0.66	0.66
1985-86	10	7,520	7,350	NS	1.00	0.75	0.75
1986-87	11	7,390	7,140	NS	1.00	0.73	0.73
1987-88	12	ND	N D	-	-	-	-
1988-89	13	ND	N D	-	-	-	-
1989-90	14	6,990	3,560	1%	0.51	0.71	0.37
1990-91	15	-	-	-	0.32	0.77	0.25
1991-92	16	ND	-	-	-	-	-
1992-93	17	ND	-	-	-	-	-
1993-94**	18	5710	460	1%	0.08	0.84	0.07
1994-95**	19	4080	0	1%	0.00	0.84	0.00

*ND = Not Determined

** Tables based on means of 1975 and 1976 plantings

Note 1990-91:Tree effect is based on winter and summer (90/91) pasture probe yields where meter readings were affected detrimen by the presence of needles. The results given appear the most reliable estimate for that season

TABLE 18 - Livestock carrying capacity (LCC) as a fraction of open pasture at 0, 100, 200, 400 Stems/Hectare. Akatore**

1976 Tree Planting

	Tree age	Pasture yield DM kg/ha		Sig.	Tree effect	Slash effect	LCC
		0	**100 sph**				
1980-81	4	6,990	6,800	NS	1.00	0.97	0.97
1981-82	5	5,720	5,740	NS	1.00	0.97	0.97
1982-83	6	7,020	7,570	NS	1.00	0.97	0.97
1983-84	7	10,930	8,870	NS	1.00	0.80	0.80
1984-85	8	9,240	9,260	NS	1.00	0.68	0.68
1985-86	9	7,520	7,980	NS	1.00	0.76	0.76
1986-87	10	7,390	7,590	NS	1.00	0.79	0.79
1987-88	11	ND*	-	-	-	0.81	-
1988-89	12	ND	-	-	-	0.83	-
1989-90	13	6,990	5,640	1%	0.81	0.83	0.67
1990-91	14	-	-	-	0.77	0.96	0.74
1991-92	15	ND	-	-	-	-	-
1992-93	16	DN	-	-	-	-	-
1993-94**	17	5710	2370	-	0.42	0.96	0.40
1994-95**	18	4,080	1,320		0.26	0.96	0.25
		0	**200**	**200 sph**	**Sig**	**T Effect**	**S Effect**
1980-81	4	6,990	6,800	NS	1.00	0.97	0.97
1981-82	5	5,720	5,760	NS	1.00	0.97	0.97
1982-83	6	7,020	7,250	NS	1.00	0.97	0.97
1983-84	7	10,390	8,940	NS	1.00	0.86	0.86
1984-85	8	9,240	9,940	NS	1.00	0.81	0.81
1985-86	9	7,520	8,210	NS	1.00	0.85	0.85
1986-87	10	7,390	8,000	NS	1.00	0.86	0.86
1987-88	11	ND	-	-	-	0.83	-
1988-89	12	ND	-	-	-	0.77	-
1989-90	13	6,990	5,070	1%	0.73	0.78	0.56
1990-91	14	-	-	-	0.57	0.91	0.51
1991-92	15	ND	-	-	-	-	-
1992-93	16	ND	-	-	-	-	-
1993-94**	17	5710	2400	-	0.42	0.95	0.40
1994-95**	18	4,080	1120	-	0.22	0.95	0.21

TABLE 18 - Livestock carrying capacity (LCC) as a fraction of open pasture at 0, 100, 200, 400 Stems/Hectare. Akatore** (cont'd)

	Tree age	Pasture yield DM kg/ha		Sig.	Tree effect	Slash effect	LCC potential
		0	400				
1980-81	4	6,990	8,080	NS	1.00	0.97	0.97
1981-82	5	5,720	6,460	NS	1.00	0.97	0.97
1982-83	6	7,020	5,470	NS	1.00	0.97	0.97
1983-84	7	10,390	7,070	5%	0.68	0.69	0.46
1984-85	8	9,240	9,640	NS	1.00	0.56	0.56
1985-86	9	7,520	7,350	NS	1.00	0.71	0.71
1986-87	10	7,390	7,140	NS	1.00	0.76	0.76
1987-88	11	ND	-	-	-	0.71	-
1988-89	12	ND	-	-	-	0.61	-
1989-90	13	6,990	3,560	1%	0.51	0.62	0.32
1990-91	14	-	-	-	0.32	0.69	0.22
1991-92	15	ND	-	-	-	-	-
1992-93	16	ND	-	-	-	-	-
1993-94**	17	5710	460	1%	0.08	0.84	0.07
1994-95**	18	4,080	0	1%	0.00	0.84	0.00

*ND = Not Determined

** Tables based on means of 1975 and 1976 plantings

Note 1990-91: Tree effect is based on winter and summer (90/91) pasture probe yields where meter readings were affected detrimentally by the presence of needles. The results given appear the most reliable estimate for that season.

TABLE 19 — Point analysis prior to stock introduction. Percent total cover. March 1977. 800 points (cover) per paddock

Paddock	Ryegrass	Cocksfoot	Yorkshire fog	Sweet vernal	Browntop	Red clover	White clover	Sub clover	Weeds	Bare ground
1	0	7	8	10	30	2	3	1	8	31
2	0	5	12	9	25	1	3	4	9	32
3	0	8	4	20	26	1	4	1	4	32
4	1	8	7	15	23	2	1	2	6	35
5	1	1	3	15	50	2	4	2	6	26
6	0	2	2	20	45	1	2	1	3	24
7	0	1	4	16	46	3	3	1	5	21
8	0	1	1	17	40	1	2	1	4	23
1975	0.2	7.0	7.8	13.5	26.0	1.5	2.8	2.0	6.8	32.5
1976	0.2	1.2	2.5	17.0	45.3	1.8	2.8	1.2	4.5	23.5
Sheep	0.0	4.5	4.5	16.5	36.8	1.8	3.0	1.0	5.0	27.0
Cattle	0.5	3.7	5.8	14.0	34.5	1.5	2.6	2.2	6.2	29.0
Mean	0.25	4.13	5.23	15.25	35.63	1.63	2.75	1.63	5.63	28.0
SEM	0.16	1.14	1.29	1.44	3.82	0.26	0.36	0.37	0.73	1.81
CV %	185.2	78.1	71.0	26.6	30.4	45.6	37.6	65.3	36.7	18.3

TABLE 20 — Herbage species dissection for 1980-81; 1982-83; 1983-84 DM kg/ha. Akatore

1980-81

	Ryegrass	Cocksfoot	Other	White clover	Red clover	Tussock clover	Pine	Weeds needles	Dead	Total matter
1975	70	880	4,600	740	-	-	-	50	850	7,190
1976	70	980	4,800	530	-	-	-	130	860	7,370
Sheep	100	1,410	5,030	700	-	-	-	70	1,260	8,570
Cattle	40	450	4,360	570	-	-	-	80	460	5,960
Mean	70	930	4,700	640	-	-	-	80	860	7,280
SED	42	242	414	134	-	-	-	37	133	696

1982-83

	Ryegrass	Cocksfoot	Other grasses	Needles dead	Needles live	Tussock grasses	White clover	Red clover	Suckling clover	Dead matter	Weeds	Total
0	250	980	1,770	70	550	470	440	670	300	840	680	7,020
100	610	1,240	990	510	410	910	410	190	480	1,010	810	7,570
200	710	1,320	1,250	220	610	460	880	300	650	760	90	7,250
400	360	620	1,330	480	300	430	450	410	310	550	220	5,470
Mean	480	1,040	1,340	320	470	570	550	400	430	790	450	6,830
SED	460	572	475	266	380	410	178	284	428	515	469	618
Sheep	510	960	1,571	350	600	600	570	360	370	770	160	6810
Cattle	460	1,120	1,100	290	340	540	520	430	500	810	740	6,840
SED	338	365	446	198	110	229	300	119	295	238	112	561

1983/84

	Ryegrass	Cocksfoot	Other grasses	Live pine needles	Dead pine needles	Tussock grasses	White clover	Red clover	Suckling clover	Dead matter	Weeds	Total
0	320	1,210	5,930	0	TR	70	1,900	4	41	1,350	23	10,350
100	60	1,110	5,230	0	48	1	1,070	TR	9	1,100	45	8,670
200	190	700	5,490	3	83	44	1,230	0	70	1,080	81	8,970
400	110	540	4,430	37	187	33	700	1	24	740	88	6,890
Mean	340	890	5,270	10	80	40	1,100	2	40	1,070	60	8,720
SED												
Sheep	150	710	4,980	10	74	73	1,060	TR	32	1,110	47	8,240
Cattle	7	1,080	5,570	10	84	0	1,150	2	40	1,030	72	9,210
Mean SED	170	890	5,270	10	80	40	1,100	2	40	1,070	60	8,720

TABLE 21 — Ground cover species composition (%). December 1989, December 1993, March 1994, November 1994. Akatore

	Ryegrass	Cocksfoot	Other grasses	Needles dead	Needles live	Tussock grasses	White clover	Red clover	Suckling clover	Dead matter	Weeds
11/12/89											
0	4	5	69	Tr	Tr	5	6	Tr	Tr	9	1
100	1	10	72	3	0	2	4	0	Tr	7	2
200	Tr	6	76	4	Tr	4	3	0	Tr	6	1
400	1	11	65	13	Tr	Tr	3	0	0	5	2
Mean	2	8	70	5	Tr	3	4	Tr	Tr	7	2
SED	1.3*	2.1*	3.0	1.1*	-	1.3*	1.0	-	-	-	-
Sheep	Tr	5	72	6	Tr	4	5	0	Tr	6	2
Cattle	3	11	69	4	Tr	2	3	Tr	Tr	8	1
Mean	2	8	70	5	Tr	3	4	Tr	Tr	7	2
SED	1.1*	1.5*	2.0	1.4*	-	1.4*	2.0	-	-	-	-

*SED Unreliable in these comparisons as species missing in many plots

11 December 1993

Sph	Ryegrass	Cocksfoot	O.Grasses	Legumes	P.Needles	Weeds	D.Matter
Nil	0	4	70	12	3	1	10
100	0	7	75	1	9	0	8
200	0	3	75	0	20	0	2
400	0	1	25	0	66	0	8

6 March 1994

sph	Ryegrass	Cocksfoot	O.Grasses	Legumes	P.Needles	Weeds	D.Matter
Nil	4	2	56	16	0	2	20
100	2	4	45	1	24	1	23
200	1	2	40	2	31	4	20
400	0	3	19	0	68	1	9

30 November 1994

Sph	Ryegrass	Cocksfoot	O.Grasses	Legumes	P.Needles	Weeds	D.Matter
Nil	8	2	73	8	0	3	6
100	1	2	34	1	51	2	9
200	1	1	23	TR	69	1	5
400*	-	-	-	-	-	-	-

* Nil Pasture yield at 400 s.p.h. - Ground Cover over 90% Pine Needles

TABLE 22 — Soil chemical analyses for pH, Ca, P, K, S, Mg, Na; 1975-94

Element pH

Date	Depth (cms)	Control	100	200	400	Mean	SED
9.5.75*	0-15	-	-	-	-	5.4	-
8.7.80	0-8	-	-	-	-	5.2	-
19.6.81	0-8	5.4	5.4	5.4	5.3	5.4	0.05
1.6.82	0-8	5.1	-	5.0	5.1	5.1	-
13.7.83	0-8	5.2	5.1	5.2	5.2	5.2	0.05
31.7.85	0-8	5.0	5.1	5.0	5.0	5.0	0.05
17.6.90	0-8	5.2	5.2	5.2	5.1	5.2	0.04
3.8.92	0-8	5.1	5.1	5.1	5.1	5.1	0.04
21.9.94	0-8	5.5	5.4	5.2	5.3	5.3	0.05
Ca							
9.5.75	0-15	-	-	-	-	3.1	
8.7.80	0-8	-	-	-	-	4.6	
19.6.81	0-8	4.7	4.2	4.6	4.1	4.4	0.36
1.6.82	0-8	4.6	-	4.8	4.4	4.6	-
13.7.83	0-8	4.8	4.6	4.1	4.4	4.5	0.33
31.7.85	0-8	5.3	5.3	5.4	5.2	5.3	0.27
17.6.90	0-8	4.9	5.1	4.5	4.6	4.8	0.28
3.8.92	0-8	4.9	4.9	4.4	4.8	4.8	0.29
21.9.94	0-8	4.5	4.4	4.1	4.4	4.4	0.36
P							
9.5.75	0-15	-	-	-	-	2.5 (Truog)*	-
8.7.80	0-8	-	-	-	-	12.9 (Olsen)*	-
19.6.81	0-8	5.0	4.6	3.5	4.0	4.3 (Olsen)	0.54
1.6.82	0-8	9.0	-	8.4	7.9	8.4 (Olsen)	-
13.7.83	0-8	8.9	9.4	8.2	10.1	9.2 (Olsen)	0.93
31.7.85	0-8	14.9	12.5	13.7	14.8	14.0 (Olsen)	1.32
17.6.90	0-8	15.9	15.8	17.6	16.9	16.6 (Olsen)	1.99
3.8.92	0-8	12.2	11.5	12.4	13.6	12.4 (Olsen)	1.20
21.9.94	0-8	14.8	13.6	14.4	16.5	14.8 (Olsen)	1.49

* In 1975 and 1980 samples were taken in paddocks 1 to 8 and the results given are the mean of these, as samples were bulked for each paddock irrespective of tree density. A tree density comparison is therefore not possible. The method of P analysis changed from the Truog to the Olsen test in March 1976.

Date	Depth (cms)	Control	100	200	400	Mean	SED
K							
9.5.75	0-15	-	-	-	-	5.0	-
8.7.80	0-8	-	-	-	-	7.6	-
19.6.81	0-8	7.4	6.9	6.2	7.4	7.0	1.00
1.6.82	0-8	8.6	7.1		7.4	7.7	-
13.7.83	0-8	8.4	6.9	6.7	6.2	7.1	0.68
31.7.85	0-8	7.4	6.8	6.6	6.6	6.8	
17.6.90	0-8	7.0	6.8	5.6	5.8	6.3	0.62
3.8.92	0-8	7.7	6.8	5.6	4.8	6.2	0.69
21.9.94	0-8	8.6	10.5	5.9	5.4	7.6	1.59
S							
9.5.75	0-15	-	-	-	-	-	-
8.7.80	0-8	-	-	-	-	-	-
19.6.81	0-8	-	-	-	-	-	-
1.6.82	0-8	-	-	-	-	-	-
13.7.83	0-8	-	-	-	-	-	-
31.7.85	0-8	24.3	19.1	16.1	20.9	20.1	2.66
17.6.90	0-8	11.8	13.3	13.4	15.8	13.6	1.06
3.8.92	0-8	8.5	9.8	8.6	9.4	9.1	1.06
21.9.94	0-8	5.4	6.5	8.7	10.6	7.8	1.21
Mg							
9.5.75	0-15	-	-	-	-	-	-
8.7.80	0-8	-	-	-	-	46.6	-
19.6.81	0-8	35.8	32.6	35.3	33.1	34.2	-
1.6.82	0-8	40.2	37.1	-	34.6	37.3	-
13.7.83	0-8	35.9	33.8	30.3	31.5	32.9	2.15
31.7.85	0-8	36.7	36.3	34.7	35.9	35.9	2.21
17.6.90	0-8	34.2	34.7	30.5	30.8	32.5	2.37
3.8.92	0-8	36.0	34.1	30.9	31.8	33.2	2.15
21.9.94	0-8	34.4	37.2	33.6	32.9	34.7	2.60

Date	Depth (cms)	Control	100	200	400	Mean	SED
Na							
9.5.75	0-15	-	-	-	-	-	-
8.7.80	0-8	-	-	-	-	-	-
19.6.81	0-8	-	-	-	-	-	-
1.6.82	0-8	6.1	6.3	-	5.8	6.0	-
13.7.83	0.8	-	-	-	-	-	-
31.7.85	0-8	-	-	-	-	-	-
17.6.90	0-8	4.8	5.1	4.9	4.8	4.9	0.45
3.8.92	0-8	4.8	5.5	5.5	5.9	5.4	0.39
21.9.94	0-8	4.6	6.9	6.2	6.1	6.0	0.58

TABLE 23 — Soil chemical analyses for % C and % N (0-8 cms) Akatore — Control Plots Only

Paddock No.	Year	% N	% C	C/N
1(S)	1975*	0.19	2.85	14.95
	1990*	0.33	4.25	12.88
2(C)	1975	0.21	3.10	15.35
	1990	0.31	5.05	16.29
3(S)	1975	0.16	2.45	15.80
	1990	0.41	6.15	15.00
7(C)	1975	0.18	2.80	16.00
	1990	0.31	4.55	14.68
5(C)	1975	0.12	1.90	15.90
	1990	0.27	4.15	15.37
7(S)	1975	0.16	2.65	16.95
	1990	0.35	6.00	17.14
8(C)	1975	0.15	2.15	14.80
	1990	0.31	4.80	15.48

* 1975 - Sampling was made into unimproved tussock before tree planting
* 1990 - Sampling was made into topdressed control (nil tree) plots

Means 1990	% N	% C	C/N
Sheep	0.31	4.90	15.81
Cattle	0.31	4.87	15.71
Grand Mean	0.31	4.88	15.74
Means 1975			
Sheep	0.15	2.46	16.40
Cattle	0.17	2.49	14.65
Grand Mean	0.16	2.48	15.50
Ratio 1990/1975	1.94	1.97	1.02

TABLE 24 — Soil chemical analyses (0-8 cms) for 17.6.90. Akatore

Date	Control	100	200	400	Mean	SED	
pH	5.2	5.2	5.2	5.1	5.2	0.04	NS
Ca	4.9	5.1	4.5	4.6	4.8	0.28	NS
P	15.9	15.8	17.6	16.9	16.6	1.99	NS
K	7.0	6.8	5.6	5.8	6.3	0.62	NS
S	11.8	13.3	13.4	15.8*	13.6	1.06	*Just
Mg	34.2	34.7	30.5	30.8	32.5	2.37	NS
Na	4.8	5.1	4.9	4.8	4.9	0.45	NS
% C	4.9	5.1	4.9	4.7	4.9	0.38	NS
% N	0.32	0.33	0.31	0.29	0.31	0.023	NS

	Sheep	Cattle	Mean	SED	
pH	5.18	5.17	5.2	0.01	NS
Ca	4.88	4.69	4.8	0.39	NS
P	18.22	14.87	16.6	0.59	*
K	6.44	6.13	6.3	0.52	NS
S	14.22	12.41	13.6	0.44	*
Mg	32.53	32.53	32.5	2.12	NS
Na	4.53	5.31	4.9	0.08	*
% C	4.90	4.87	4.9	0.19	NS
% N	0.31	0.31	0.31	0.11	NS

5% significant = *

TABLE 24a — Soil chemical analysis (0-8 cms) for 3.8.92 and 14.9.92

0	100	200	400	Mean	SED	
pH	5.11	5.10	5.07	5.11	5.10	0.04
Ca	4.94	4.88	4.44	4.75	4.75	0.29
K	7.69	6.75	5.63	4.81	6.22	0.69
P	12.19	11.50	12.44	13.62	12.44	1.20
Mg	36.0	34.06	30.91	31.81	33.20	2.15
Na	4.81	5.50	5.50	5.94	5.44	0.39
S	8.50	9.75	8.62	9.37	9.06	1.06

TABLE 24b — Soil chemical analysis (0-8 cms) 19.6.81 and 21 September 1994

Note: Replicates in 1994 for each paddock have been bulked within each tree density. There are therefore 32 samples in total, i.e. (0x8); (100x8); (200x8); (400x8)

		0-8 cms					
Tree density (sph)		**0**	**100**	**200**	**400**	**Mean**	**SED**
1981	pH	5.4	5.4	5.4	5.3	5.4	0.06
1994		5.5	5.4	5.2	5.2	5.4	0.05
1981	Ca	4.7	4.2	4.6	4.1	4.4	0.36
1994		4.5	4.6	4.1	4.4	4.4	0.36
1981	K	7.4	6.9	6.2	7.7	7.0	1.00
1994		8.6	10.5	5.9	5.4	7.6	1.59
1981	P	5.0	4.6	3.5	4.0	4.3	0.54
1994		14.8	13.6	14.3	16.5	14.8	1.48
1981	Mg	35.8	32.6	35.3	33.1	34.2	-
1994		34.4	37.2	33.6	32.9	34.5	2.59
1982	Na*	6.1	6.3	-	5.8	6.0	-
1994		4.6	6.9	6.2	6.1	6.0	0.58
1985	S*	24.3	19.1	16.1	20.9	20.1	2.66
1994		5.4	6.5	8.7	10.6	7.8	1.21

* No Na analysis prior to 1982

* No S analysis prior to 1985

APPENDIX 1

Appendix 1 contains more detail of slash counts (as % available pasture) and of tree measurements than is contained in Section 10.

TABLE 1 - Slash assessments: % Available pasture for all paddocks and tree densities 1982-1995

1975 Planting

Paddock 1	600	600	600	600	1,200	1,200
	200	200	400	400	600	600
	100	100	200	200	400	400
S						
23.2.82	88	91	94	97	74	82
21.3.83	93	93	96	100	92	92
6.10.83	83	100	97	93	86	87
6.10.84	78	78	77	74	52	72
28.8.85	90	88	92	86	72	84
9.12.85	90	89	90	91	81	88
11.9.87	84	78	84	82	60	66
9.6.88	85	88	87	80	54	59
30.4.90	86	91	93	94	25	58
1.7.91	94	97	90	85	63	76
11.8.95	ND	ND	ND	ND	ND	ND
Paddock 2						
C						
23.2.82	89	88	84	100	73	73
21.3.83	90	94	94	100	73	88
6.10.83	94	94	95	99	80	89
6.10.84	71	87	87	78	43	56
28.8.85	79	79	92	93	79	83
11.9.87	83	86	76	93	83	77
9.6.88	92	91	73	95	84	82
30.4.90	83	95	43	86	40	58
1.7.91	93	94	82	83	82	80
11.8.95	ND	ND	ND	ND	ND	ND

TABLE 1 - Slash assessments: % Available pasture for all paddocks and tree densities 1982-1995 (cont'd)

Paddock 3						
S						
23.2.82	84	94	96	89	94	66
21.3.83	95	95	97	95	96	93
6.10.83	82	87	92	93	81	84
6.10.84	85	74	83	85	72	81
28.8.85	85	93	79	87	75	81
11.9.87	89	84	82	79	73	70
9.6.88	88	92	77	88	67	82
30.4.90	87	89	81	85	81	55
1.7.91	90	97	89	79	70	92(?)
11.8.95	94	98	96	92	81	86
Paddock 4						
C						
23.2.82	93	84	76	91	77	70
21.3.83	97	93	94	86	87	92
6.10.84	90	95	81	90	87	88
6.10.84	75	74	87	86	74	77
28.8.85	87	88	83	90	84	79
11.9.87	79	89	73	72	79	74
9.6.88	77	95	85	93	75	73
30.4.90	84	98	78	94	69	43
1.7.91	96	94	89	88	84	80
11.8.95	96	96	94	94	92	85

APPENDIX 1 (cont'd)

TABLE 2 - Slash assessments: % available pasture for all paddocks and tree densities 1982-1995

1976 Planting

Paddock 5	600	600	600	600	1,200	1,200
	200	200	400	400	400	400
	100	100	200	200		
C						
23.2.82	-	-	-	-	-	-
21.3.83	-	-	-	-	-	-
6.10.83	75	86	75	84	60	65
6.10.84	69	49	71	78	43	64
28.8.85	75	76	85	84	79	77
11.9.87	75	83	70	78	70	71
9.6.88	81	87	73	78	71	67
30.4.90	94	69	84	88	74	75
1.7.91	94	84	94	86	74	62
11.8.95	ND	ND	ND	ND	ND	ND
Paddock 6						
S						
23.2.82	-	-	-	-	-	-
21.3.83	-	-	-	-	-	-
6.10.83	69	72	76	83	63	51
6.10.84	64	62	75	84	50	46
28.8.85	72	78	90	81	68	75
11.9.87	91	74	80	72	52	54
9.6.88	85	79	71	73	51	52
30.4.90	93	81	88	79	62	61
1.7.91	96	92	96	90	36	38
11.8.95	ND	ND	ND	ND	ND	ND

TABLE 2 - Slash assessments: % available pasture for all paddocks and tree densities 1982-1995 (cont'd)

Paddock 7						
S						
23.2.82	-	-	-	-	-	-
21.3.83	-	-	-	-	-	-
6.10.83	77	79	74	78	45	54
6.10.84	71	77	76	87	69	71
28.8.85	80	78	90	83	82	78
11.9.87	86	82	85	75	73	69
9.6.88	69?	70?	81	76	77	76
30.4.90	93	86	90	87	52	91?
1.7.91	96	96	92	84	54	56
11.8.95	98	98	97	94	73	79
Paddock 8						
C						
6.10.83	59	77	84	78	41	59
6.10.84	66	76	86	88	60	68
28.8.85	84	82	86	88	78	77
9.12.85	87	89	91	90	81	80
11.9.87	77	89	88	89	73	78
9.6.88	78	83	79	80	57	65
30.4.90	88	92	62?	93	74	45
1.7.91	94	96	96	90	84	84
11.8.95	96	98	98	95	88	88

APPENDIX 1 (Cont'd)

TABLE 3 — Tree diameter breast height (DBH) in cms
MAF project FD110 - MOF project 474: Akatore

1975		**Yrs**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1995**
Trees	**Plot**	**Age**	**6.5**	**7.3**	**8.0**	**9.0**	**10.0**	**11.0**	**12.0**	**ND**	**ND**	**15.0**	**20.1**
	1	(200)	7.0	9.5	15.3	14.1	16.2	18.9	21.6	"	"	31.0	46.3
	2	(400)	9.6	12.8	15.0	17.9	20.5	22.9	25.2	"	"	33.2	43.7
	3	(200)	9.7	13.0	15.3	18.5	21.6	24.2	27.1	"	"	36.1	48.4
	4	(100)	9.1	12.9	15.2	18.5	23.1	26.4	29.2	"	"	39.3	57.5
	5	(200)	6.0	8.6	10.7	13.4	15.4	18.7	21.0	"	"	31.1	46.3
	6	(400)	7.8	10.2	11.9	14.2	18.7	21.2	23.0	"	"	29.4	37.5
	7	(100)	6.0	8.6	10.0	13.0	17.0	19.5	21.8	"	"	31.4	48.8
	8	(100)	8.6	11.3	13.6	16.8	18.6	21.1	23.4	"	"	33.3	48.2
	9	Control		8.2	10.6	15.5	17.1	19.5	21.4			29.0	42.6
1976		**Yrs**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1995**
Trees	**Plot**	**Age**	**ND**	**ND**	**7.3**	**8.0**	**9.0**	**10.0**	**11.0**	**ND**	**ND**	**14.0**	**19.1**
	10	(200)	"	"	9.1	11.1	15.3	18.5	21.2	"	"	31.2	44.8
	11	(400)	"	"	13.0	15.6	18.2	20.8	23.0	"	"	30.6	40.8
	12	(200)	"	"	12.5	15.3	17.6	20.6	23.0	"	"	31.0	47.5
	13	(100)	"	"	13.4	16.3	17.9	22.2	24.2	"	"	34.8	52.1
	14	(100)	"	"	14.2	17.5	20.5	23.8	26.2	"	"	37.5	54.0
	15	(400)	"	"	11.5	14.3	17.1	19.9	21.9	"	"	30.1	40.3
	16	(200)	"	"	12.3	15.0	18.2	20.0	21.7	"	"	32.0	45.3
	17	(100)	"	"	8.6	11.2	14.0	17.6	20.3	"	"	30.5	46.1
	Means												
1975	100		7.9	10.9	12.9	16.1	19.6	22.3	24.8	"	"	34.7	51.5
	200		7.6	10.4	13.8	15.3	17.7	20.6	23.2	"	"	32.7	46.9
	400		8.7	11.5	13.5	16.1	19.6	22.1	24.1	"	"	31.3	40.6
1976	100		-	-	11.0	13.8	16.7	20.3	22.9	"	"	33.1	50.7
	200		-	-	11.3	13.8	17.0	19.7	22.0	"	"	30.8	45.9
	400		-	-	12.3	15.0	17.7	20.4	22.5	"	"	30.4	40.6

APPENDIX 1 (cont'd)

TABLE 4 — Tree height in metres. MAF Project FD110, MOF Project 474: Akatore

1975		**Yrs**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1995**
Trees	**Plot**	**Age**	**6.5**	**7.3**	**8.0**	**9.0**	**10.0**	**11.0**	**12.0**	**13.0**	**14.0**	**15.0**	**20.1**
	1	(200)	4.2	4.9	5.7	7.0	7.9	9.4	10.5	ND	ND	14.4	21.7
	2	(400)	5.5	6.2	7.2	9.8	10.9	11.9	13.5	ND	ND	17.0	24.6
	3	(200)	5.9	6.9	8.1	9.7	10.7	12.0	13.8	ND	ND	17.0	24.1
	7	(100)	5.9	6.7	8.5	10.4	10.6	11.5	13.0	ND	ND	16.3	21.7
	5	(200)	3.8	4.2	5.6	6.7	8.1	9.6	11.0	ND	ND	15.4	21.5
	6	(400)	5.5	6.4	7.6	9.5	10.8	11.8	13.2	ND	ND	17.1	23.3
	7	(100)	4.2	4.6	5.4	6.8	7.2	8.6	9.5	ND	ND	12.7	18.9
	8	(100)	4.6	5.1	6.0	7.4	8.4	9.5	10.9	ND	ND	14.3	20.7
9 Control			ND	5.2	6.0	7.1	7.9	9.2	10.9	ND	ND	13.6	20.7
1976		**Yrs**	**1981**	**1982**	**1983**	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1995**
Trees	**Plot**	**Age**	**ND**	**ND**	**7.3**	**8.0**	**9.0**	**10.0**	**11.0**	**ND**	**ND**	**14.0**	**19.1**
	10	(200)	"	"	4.9	6.0	7.1	8.4	9.6	ND	ND	14.0	20.7
	11	(400)	"	"	7.0	8.5	9.8	10.6	11.9	ND	ND	16.1	22.9
	12	(200)	"	"	5.7	6.9	7.8	8.8	10.4	ND	ND	13.8	20.9
	13	(100)	"	"	6.4	8.1	9.2	10.3	11.3	ND	ND	15.0	21.6
	14	(100)	"	"	6.8	8.0	8.8	10.1	11.5	ND	ND	15.4	21.3
	15	(400)	"	"	6.5	8.5	9.9	11.1	12.7	ND	ND	16.4	23.8
	16	(200)	"	"	7.1	8.6	9.9	11.0	12.9	ND	ND	16.1	23.3
	17	(100)	"	"	4.3	5.6	6.0	7.9	9.0	ND	ND	12.5	18.8
Means													
1975		100	4.9	5.5	6.6	8.1	8.7	9.9	11.1	"	"	14.4	20.4
		200	4.6	5.3	6.6	7.8	8.9	10.3	11.8	"	"	15.6	22.4
		400	5.5	6.3	7.4	9.6	11.8	11.8	13.4	"	"	17.0	24.0
1976		100	ND	ND	5.8	7.2	8.0	9.4	10.6	"	"	14.3	20.6
		200	"	"	5.9	7.2	8.3	9.4	11.0	"	"	14.6	21.6
		400	"	"	6.8	8.5	9.8	10.8	12.3	"	"	16.1	23.4

APPENDIX 1 (cont'd)

TABLE 5 - Mean % available pasture. 600-200-100 sph. Akatore 1980-1995

1975 Tree Plantings

1980-81				**1985-86**			
June 80 - July 80	0.97 x 2	=	1.94	June 85 - Aug 85	0.78 x 3	=	2.34
Aug 80 - May 81	0.89 x 10	=	8.90	Sept 85 - May 86	0.86 x 9	=	7.74
Weighted total		=	10.84	Weighted total		=	10.08
Mean DM available		=	0.90	Mean DM available		=	0.84
1981-82				**1986-87**			
June 81 - May 82	0.89 x 12	=	10.68	June 86 - May 87	0.86 x 12	=	10.32
Weighted total		=	10.68	Weighted total		=	10.32
Mean DM available		=	0.89	Mean DM available		=	0.86
1982-83				**1987-88**			
June 82 - Sept 82	0.89 x 4	=	3.56	June 87 - Aug 87	0.86 x 3	=	2.58
Oct 82 - Mar 83	0.89 x 6	=	5.34	Sept 87 - May 88	0.85 x 9	=	7.65
April 83 - May 83	0.94 x 2	=	1.88	Weighted total		=	10.23
Weighted total		=	10.78	Mean DM available		=	0.85
Mean DM available		=	0.90				
1983-84				**1988-89**			
June 83 - March 84	0.91 x 10	=	9.10	June 88 - May 89	0.89 x 12	=	10.68
April 84 - May 84	0.78 x 2	=	1.56	Weighted total		=	10.68
Weighted total		=	10.66	Mean DM available		=	0.89
Mean DM available		=	0.89				
1984-85				**1989-90**			
June 84 - Sept 84	0.78 x 4	=	3.12	Jun 89 - April 90	0.89 x 11	=	9.79
Oct 84 - May 85	0.78 x 8	=	6.24	- May 90	0.89 x 1	=	0.89
Weighted total		=	9.36	Weighted total		=	10.68
Mean DM available		=	0.78	Mean DM available		=	0.89
1990-91				**1993-1995**			
Mean DM available		=	0.94	Mean DM available		=	0.96

APPENDIX 1 (cont'd)

TABLE 6 - Mean % available pasture 600-400-200 sph Akatore 1980-95

1975 Tree Plantings

1980-81				**1985-86**			
June 80 - July 80	1.00 x 2	=	2.00	June 85 - Aug 85	0.83 x 3	=	2.49
Aug 80 - May 81	0.9 x 10	=	9.10	Sept 85 - Mar 86	0.88 x 7	=	6.16
Weighted total		=	11.10	April 86 - May 86	0.80 x 2	=	1.60
Mean DM available		=	0.93	Weighted total		=	10.25
				Mean DM available		=	0.85
1981-82				**1986-87**			
June 81 - May 82	0.91 x 12	=	10.92	June 86 - May 87	0.50 x 12	=	9.60
Weighted total		=	10.92	Weighted total		=	9.60
Mean DM available		=	0.91	Mean DM available		=	0.80
1982-83				**1987-88**			
June 82 - Sept 82	0.91 x 4	=	3.64	June 87 - Aug 87	0.80 x 3	=	2.40
Oct 82 - Mar 83	0.91 x 6	=	5.46	Sept 87 - May 88	0.80 x 9	=	7.20
April 83 - May 83	0.95 x 2	=	1.90	Weighted total		=	9.60
Weighted total		=	11.00	Mean DM available		=	0.80
Mean DM available		=	0.92				
1983-84				**1988-89**			
June 83 - March 84	0.93 x 10	=	9.30	June 88 - May 89	0.85 x 12	=	10.20
April - May 84	0.83 x 2	=	1.66	Weighted total		=	10.20
Weighted total		=	10.96	Mean DM available		=	0.85
Mean DM available		=	0.91				
1984-85				**1989-90**			
June 84 - Sept 84	0.83 x 4	=	3.32	June 80 - April 90			
Oct 84 - May 85	0.83 x 8	=	6.64	- May 1990	0.85 x 11	=	9.35
Weighted total		=	9.96	Weighted total	0.82 x 1	=	0.82
Mean DM available		=	0.83	Mean DM available		=	10.17
						=	0.85
1990-91				**1993-95**			
Mean DM available		=	0.87	Mean DM available		=	0.95

APPENDIX 1 (cont'd)

TABLE 7 — Mean % pasture available 1200-600-400 sph Akatore 1980-1995

1975 Tree Plantings

1980-81				**1985-86**			
June 80 - July 80	1.00 x 2	=	2.00	June 85 - Aug 85	0.66 x 3	=	1.98
Aug 80 - May 81	0.76 x 10	=	7.60	Sept 85 - March 86	0.80 x 7	=	5.60
Weighted total		=		April 86 - May 86	0.73 x 2	=	1.46
Mean DM available		=	0.80	Weighted total		=	9.04
				Mean DM available		=	0.75
1981-82				**1986-87**			
June 81 - May 84	0.76 x 12	=	9.12	June 86 - May 87	0.73 x 12	=	8.76
Weighted total		=	9.12	Weighted total		=	8.76
Mean DM available		=	0.76	Mean DM available		=	0.73
1982-83				**1987-88**			
June 82 - Sept 82	0.76 x 4	=	3.04	June 87 - Aug 87	0.73 x 3	=	2.19
Oct 82 - Mar 83	0.76 x 6	=	4.56	Sept 87 - May 88	0.73 x 9	=	6.57
April 83 - May 83	0.90 x 2	=	1.80	Weighted total		=	8.76
Weighted total		=	9.40	Mean DM available		=	0.73
Mean DM available		=	0.78				
1983-84				**1988-89**			
June 83 - March 84	0.86 x 10	=	8.60	June 88 - May 89	0.72 x 12	=	8.64
April 84 - May 84	0.66 x 2	=	1.32	Weighted total		=	8.64
Weighted total		=	9.92	Mean DM available		=	0.72
Mean DM available		=	0.83				
1984-85				**1989-90**			
June 84 - Sept 84	0.66 x 4	=	2.64	June 89 - April 90	0.72 x 11	=	7.92
Oct 84 - May 85	0.66 x 8	=	5.28	- May 90	0.54 x 1	=	0.54
Weighted total		=	7.92	Weighted total		=	8.64
Mean DM available		=	0.66	Mean DM available		=	0.71
1990-91				**1993-95**			
Mean DM available		=	0.77	Mean DM available		=	0.84

APPENDIX 1 (cont'd)

TABLE 8 - Mean % pasture available 600-200-100 sph Akatore 1980-1995

1976 Tree Plantings

1980-81				**1985-86**			
June 80 - May 81	0.97 x 1	=	9.70	June 85 - Aug 85	0.66 x 3	=	1.98
Weighted total		=	9.70	Sept 85 - May 86	0.79 x 9	=	7.11
Mean DM available		=	0.97	Weighted total		=	9.09
				Mean DM available		=	0.76
1981-82				**1986-87**			
June 81 - May 82	0.97 x 1	=	9.70	June 86 - May 87	0.79 x 12	=	9.48
Weighted total		=	9.70	Weighted total	x	=	9.48
Mean DM available		=	0.97	Mean DM available		=	0.79
1982-83				**1987-88**			
June 82 - May 83	0.97 x 1	=	9.70	June 87 - Aug 87	0.79 x 3	=	2.37
Weighted total		=	9.70	Sept 87 - May 88	0.82 x 9	=	7.38
Mean DM available		=	0.97	Weighted total		=	9.75
				Mean DM available		=	0.81
1983-84				**1988-89**			
June 83 - Sept 83	0.97 x 4	=	3.88	June 88 - May 89	0.83 x 12	=	9.96
Oct 84 - May 84	0.72 x 8	=	5.76	Weighted total		=	9.96
Weighted total		=	9.64	Mean DM available		=	0.83
Mean DM available		=	0.80				
1984-85				**1989-90**			
June 84 - Sept 84	0.72 x 4	=	2.88	June 89 - April 90	0.83 x 11	=	9.13
Oct 84 - May 85	0.66 x 8	=	5.28	- May 90	0.87 x 1	=	0.87
Weighted total		=	8.16	Weighted total		=	10.00
Mean DM available		=	0.68	Mean DM available		=	0.83
1990-91				**1993-95**			
Mean DM available		=	0.96	Mean DM available		=	0.96

APPENDIX 1 (cont'd)

TABLE 9 — Mean % pasture available 600-400-200 SPh Akatore 1989-1995

1976 Tree Plantings

1980-81				**1985-86**			
June 80 - May 81	0.97 x 1	=	9.70	June 85 - Aug 85	0.82 x 3	=	2.46
Weighted total		=	9.70	Sept 85 - May 86	0.86 x 9	=	7.74
Mean DM available		=	0.97	Weighted total		=	10.20
				Mean DM available		=	0.85
1981-82				**1986-87**			
June 81 - May 82	0.97 x 1	=	9.70	June 86 - May 87	0.86 x 12	=	10.32
Weighted total		=	9.70	Weighted total		=	10.32
Mean DM available		=	0.97	Mean DM available		=	0.86
1982-83				**1987-88**			
June 82 - May 83	0.97 x 1	=	9.70	June 87 - Aug 87	0.86 x 3	=	2.58
Weighted total		=	9.70	Sept 87 - May 88	0.82 x 9	=	7.38
Mean DM available		=	0.97	Weighted total		=	9.96
				Mean DM available		=	0.83
1983-84				**1988-89**			
June 83 - Sept 83	0.97 x 4	=	3.88	June 88 - May 89	0.77 x 12	=	9.24
Oct 83 - May 84	0.80 x 8	=	6.40	Weighted total		=	9.24
Weighted total		=	10.28	Mean DM available		=	0.77
Mean DM available		=	0.86				
1984-85				**1989-90**			
June 84 - Sept 84	0.80 x 4	=	3.20	June 89 - April 90	0.77 x 11	=	8.47
Oct 84 - May 85	0.82 x 8	=	6.56	- May 1990	0.84 x 1	=	0.84
Weighted total		=	9.76	Weighted total		=	9.31
Mean Dm available		=	0.81	Mean DM available		=	0.78
1990-91				**1993-95**			
Mean DM available		=	0.91	Mean DM available		=	0.95

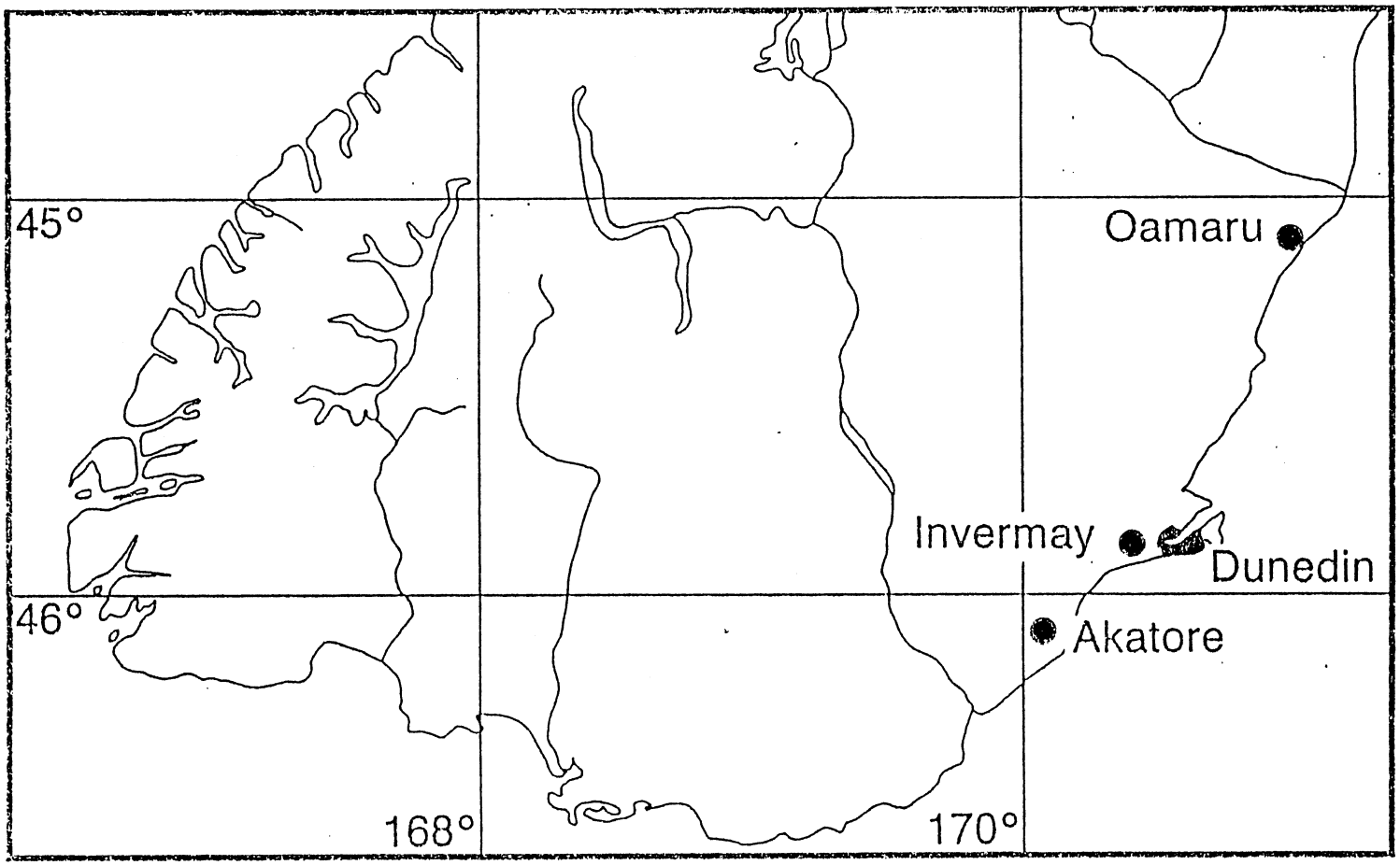
APPENDIX 1 (cont'd)

TABLE 10 — Mean % pasture available 1,200-600-400 SPh Akatore 1989-1995

1976 Tree Plantings

1980-81				**1985-86**			
June 80 - May 81	0.97 x 1	=	9.70	June 85 - Aug 85	0.57 x 3	=	1.71
Weighted total		=	9.70	Sept 85 - May 86	0.76 x 9	=	6.84
Mean DM available		=	0.97	Weighted total		=	8.55
				Mean DM available		=	0.71
1981-82				**1986-87**			
June 81 - May 82	0.97 x 1	=	9.70	June - May 87	0.76 x 12	=	9.12
Weighted total		=	9.70	Weighted total		=	9.12
Mean DM available		=	0.97	Mean DM available		=	0.76
1982-83				**1987-88**			
June 82 - May 83	0.97 x 1	=	9.70	June 87 - Aug 87	0.76 x 3	=	2.28
Weighted total		=	9.70	Sept 87 - May 88	0.69 x 9	=	6.21
Mean DM available		=	0.97	Weighted total		=	8.49
				Mean DM available		=	0.71
1983-84				**1988-89**			
June 83 - Sept 84	0.97 x 4	=	3.88	June 88 - May 89	0.61 x 12	=	7.32
Oct 83 - May 84	0.55 x 8	=	4.40	Weighted total		=	7.32
Weighted total		=	8.28	Mean DM available		=	0.61
Mean DM available		=	0.69				
1984-85				**1989/90**			
June 84 - Sept 84	0.55 x 4	=	2.20	June 89 - April 90	0.61 x 11	=	6.71
Oct 84 - May 85	0.57 x 8	=	4.56	- May 90	0.67 x 1	=	0.67
Weighted total		=	6.76	Weighted total		=	7.38
Mean DM available		=	0.56	Mean DM available		=	0.62
1990-91				**1993-95**			
Mean DM available		=	0.69	Mean DM available		=	0.84

Figure 1. **Akatore Agroforestry Trial Location Map Southern South Island.**



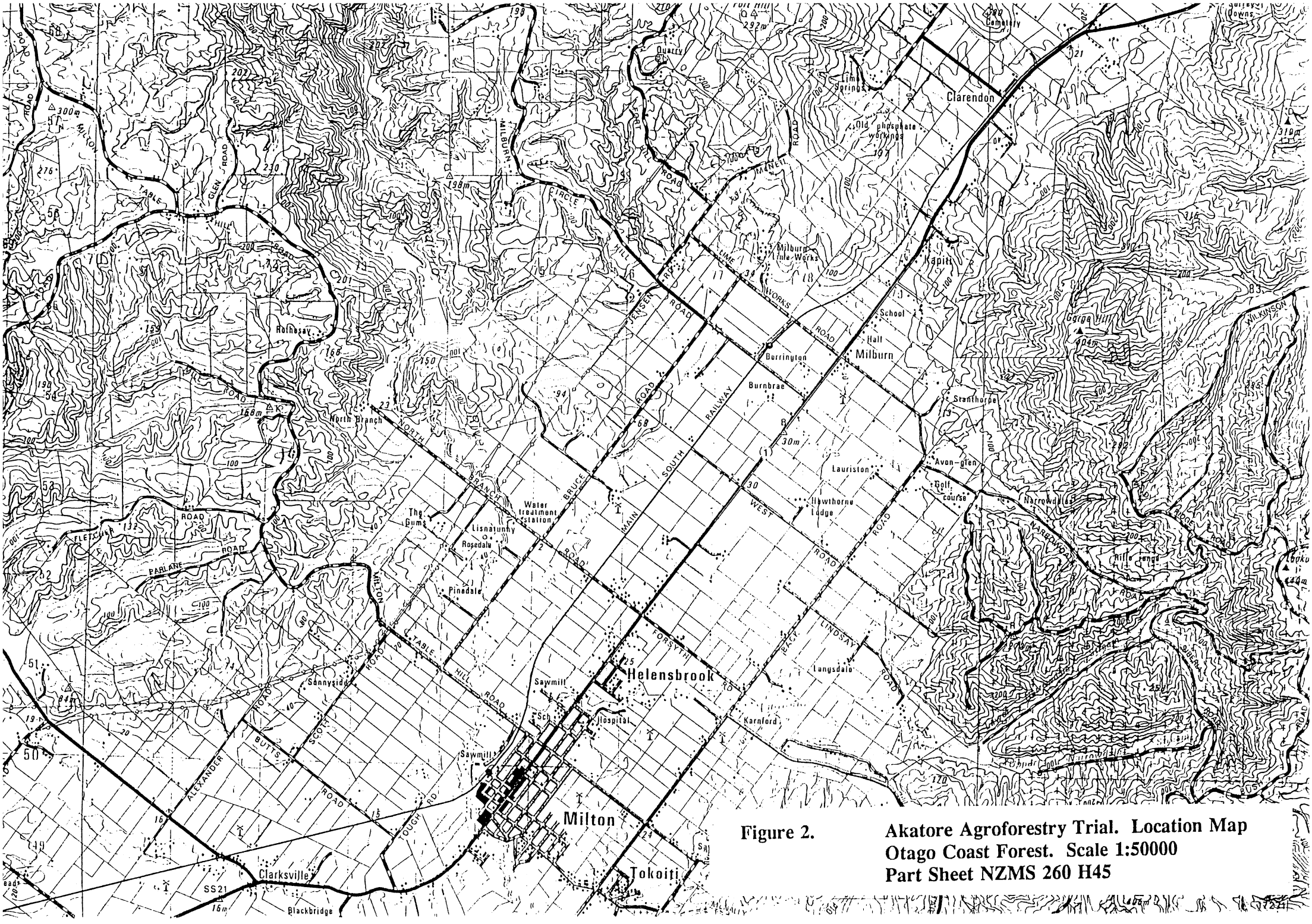


Figure 2. **Akatore Agroforestry Trial. Location Map**
Otago Coast Forest. Scale 1:50000
Part Sheet NZMS 260 H45

Figure 3. **Akatore Agroforestry Trial. Location Map. Compartments showing trial in 157 Otago Coast Forest. Scale 1:50000**

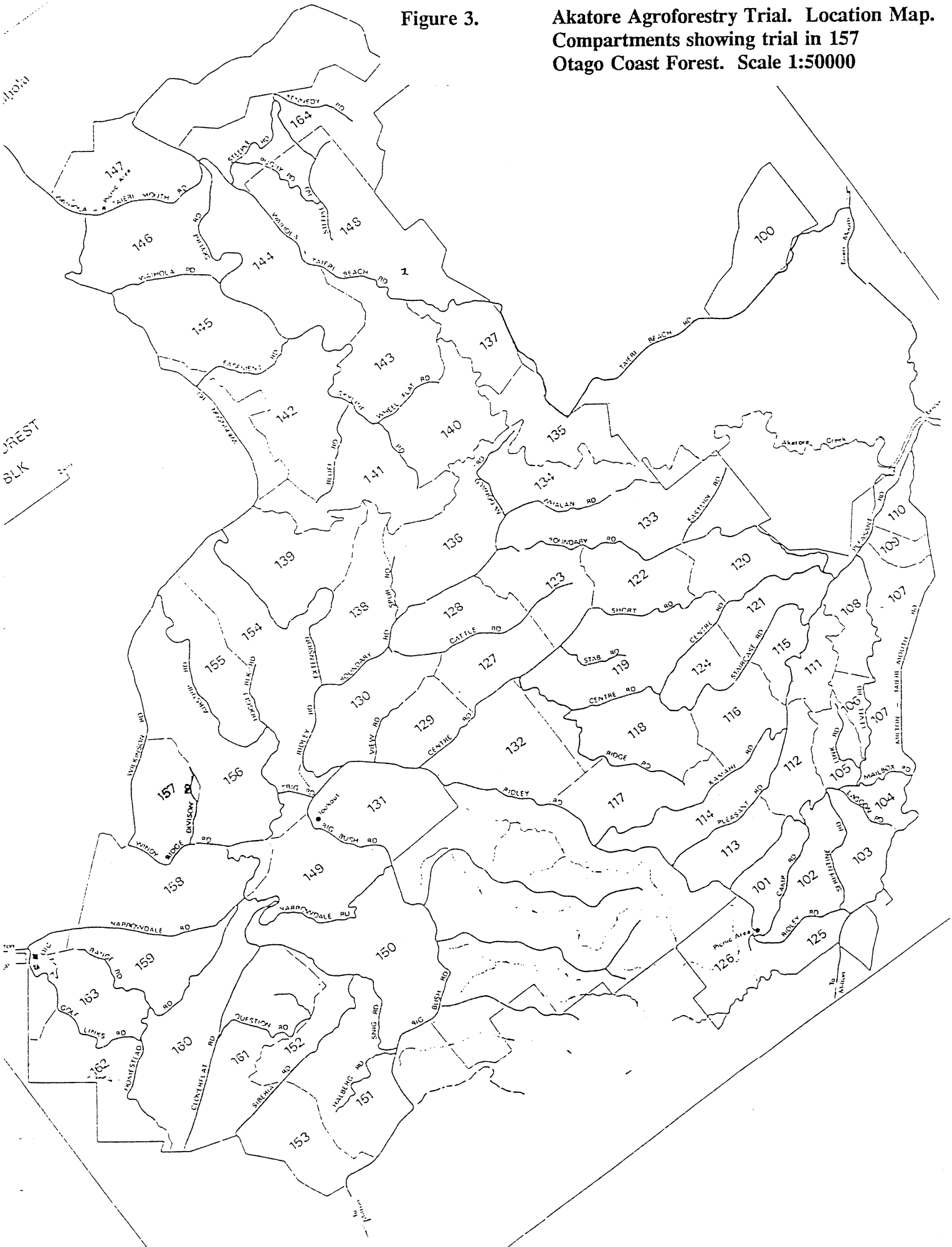
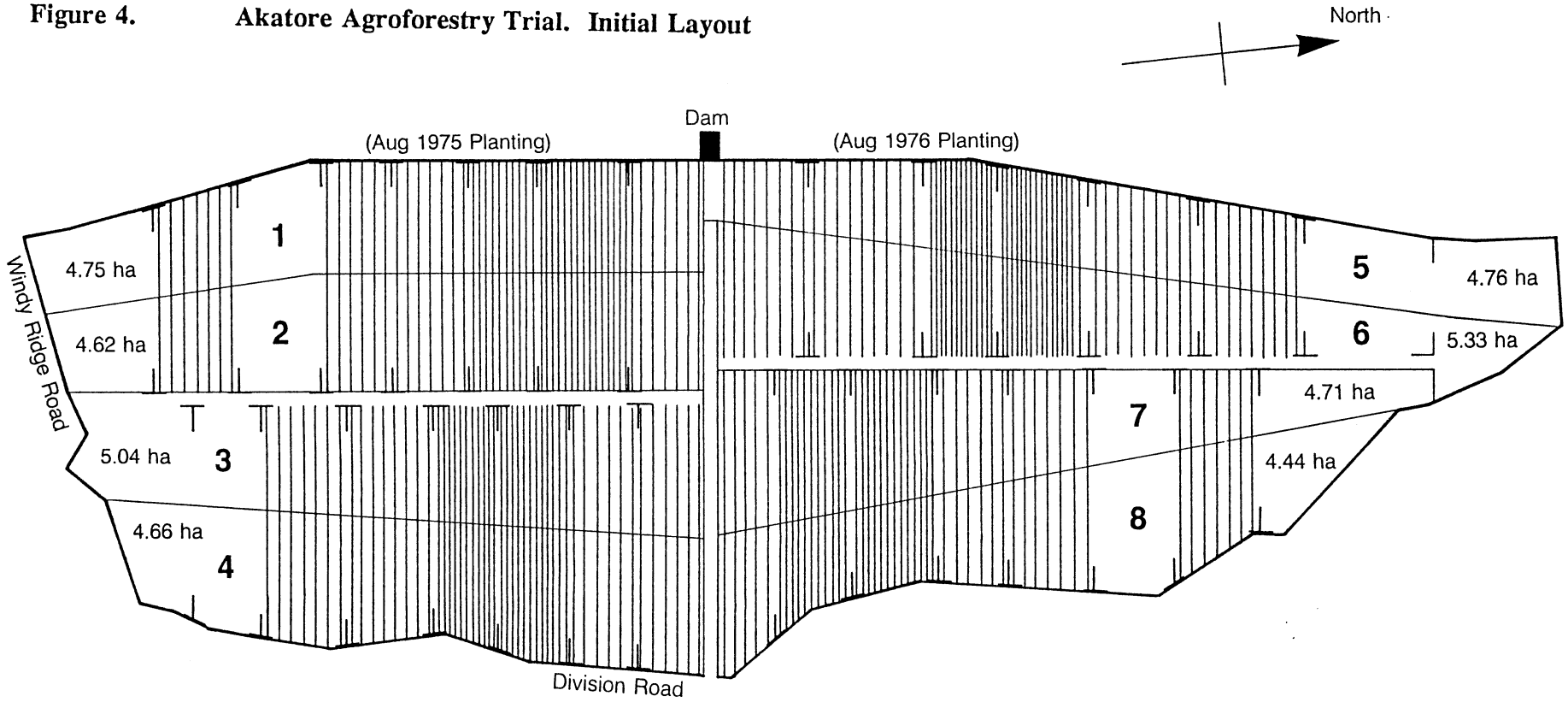


Figure 4. **Akatore Agroforestry Trial. Initial Layout**



Initial Density 600 sph 10 x 1.6m

Initial Density 1200 sph 5 x 1.6m

Density Markers

Akatore Forest Grazing Trial

MAF Project FD 110

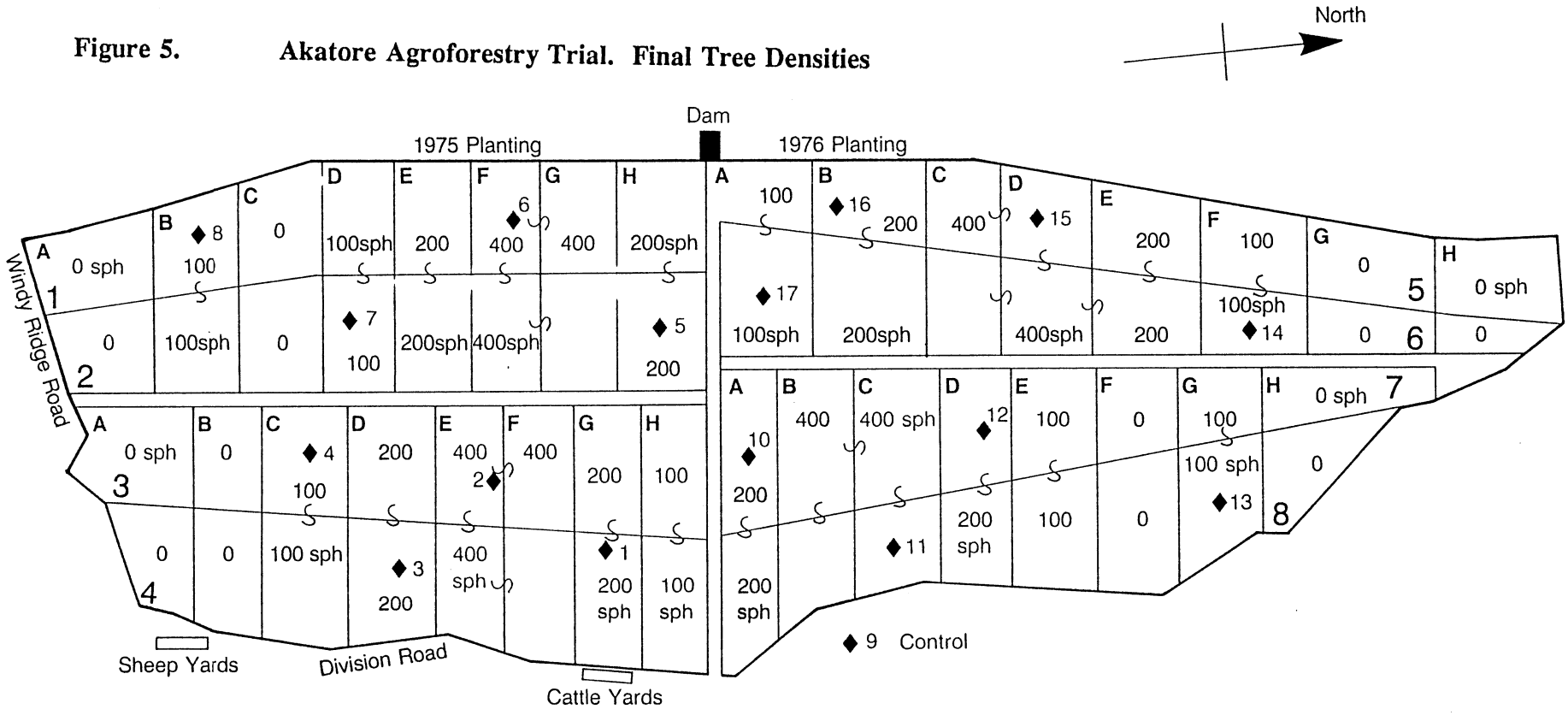
MOF Project S474

Density Subdivisions A B C D E F G H

Paddock Numbers 1975 Planting 1,2,3,4

1976 Planting 5,6,7,8

Figure 5. **Akatore Agroforestry Trial. Final Tree Densities**



Akatore Forest Grazing Trial

MAF Project FD 110

MOF Project S474

Density Subdivisions A B C D E F G H

Paddock Numbers 1975 Planting 1,2,3,4

1976 Planting 5,6,7,8

Figure 6a. Akatore Agroforestry Trial. 18 July 1974.
Scale 1:6200

Figure 6b. Akatore Agroforestry Trial. 8 May 1975.
Scale 1:9100

Figure 6c. Akatore Agroforestry Trial. 25 February 1980.
Scale 1:10000

Figure 6d. Akatore Agroforestry Trial. 9 February 1981.
Scale 1:10000

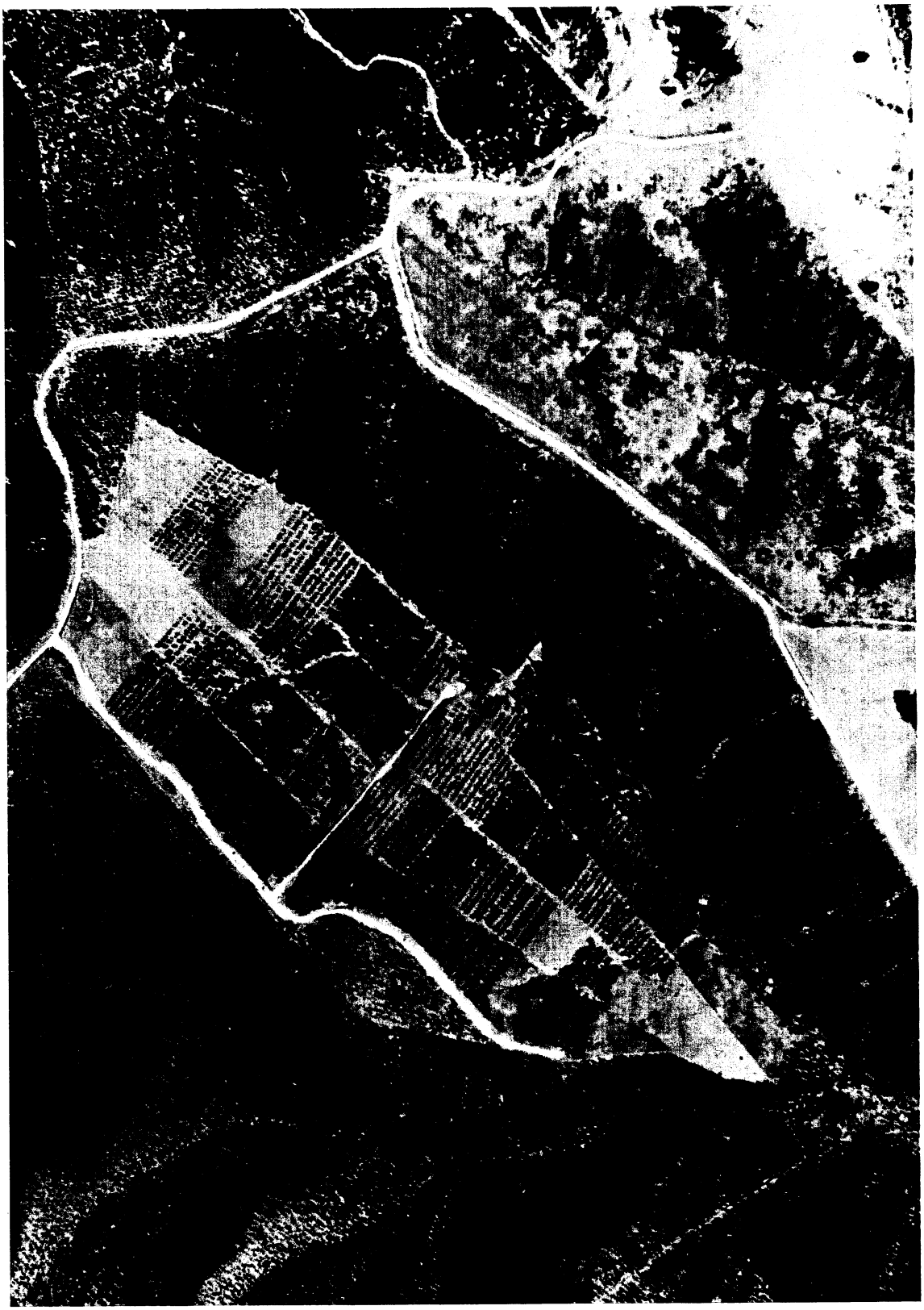


Figure 6e. Akatore Agroforestry Trial. October 1983.
Scale 1:10000

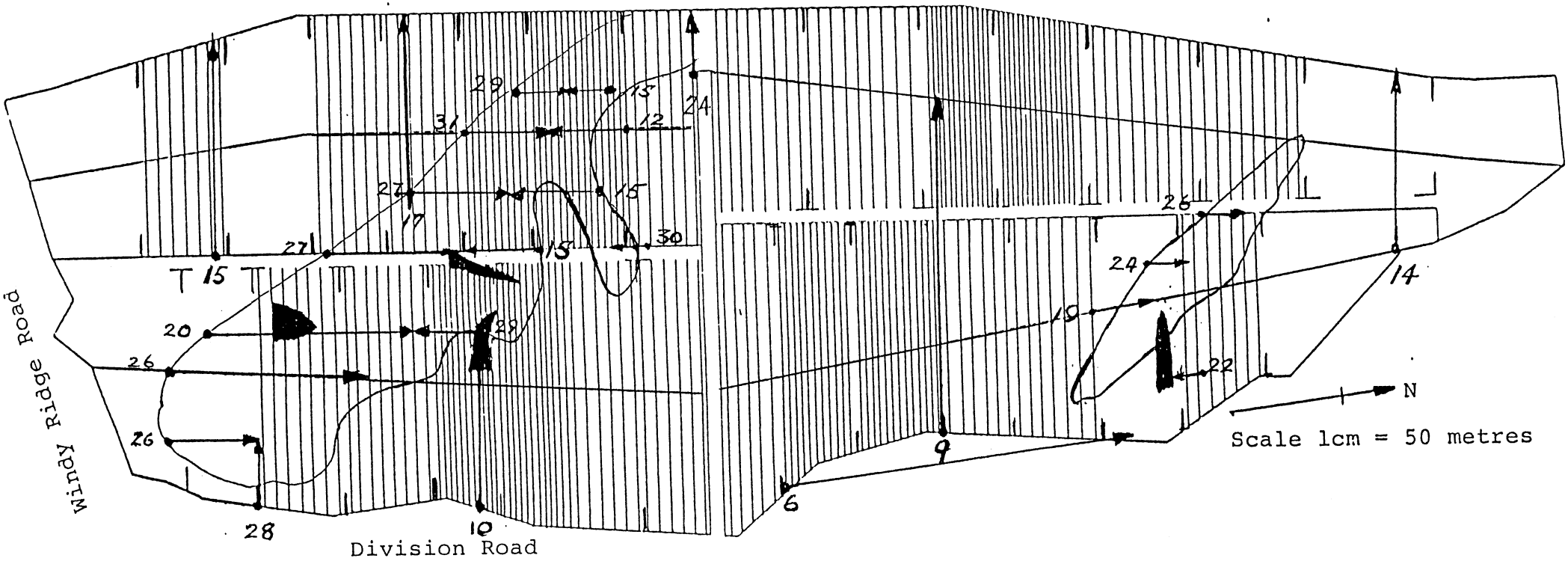
Figure 6f. Akatore Agroforestry Trial. June 1989.
Scale 1:8700

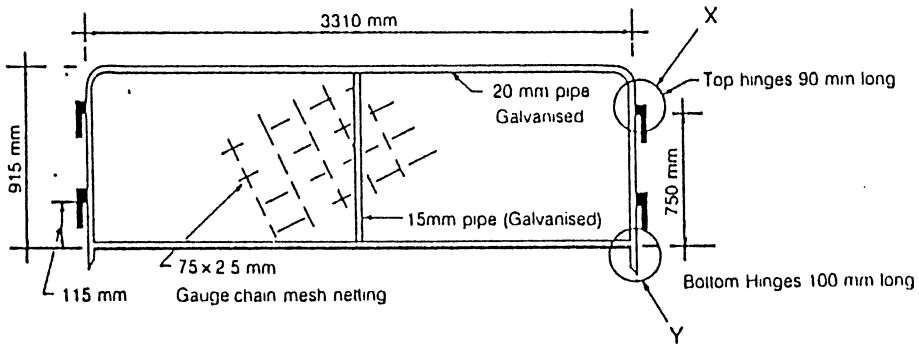
FIGURE 7

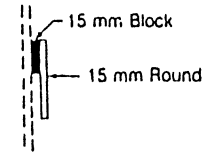
AKATORE FOREST GRAZING TRIAL FD110

MAJOR SLIP AND BRACKEN FERN AREAS

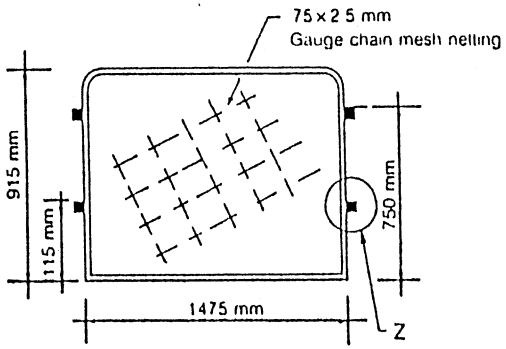
SEPTEMBER 1981

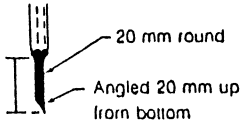




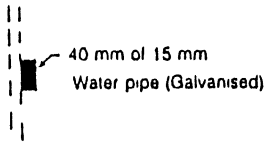


DETAIL X





DETAIL Y



DETAIL Z

PASTURE FRAME FOR FIELD RESEARCH

RATE OF GROWTH TRIALS

INVERMAY AGRICULTURAL RESEARCH CENTRE

Figure 8. Construction details of pasture frame used for rate of growth trials.