STOCK AND PASTURE MANAGEMENT FOR ESTABLISHMENT OF RADIATA PINE IN FARMLAND

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Abstract

The success of grazing within 3 years of planting radiata pine seedlings in pasture is affected by early tree growth rate, class of livestock used, type of pasture available, season, and topography. This early grazing should be with sheep, restricted to autumn and winter in the first 2 years after planting, and must always be associated with cautious stock management. Trials in the central North Island have shown that, during the 3 years after planting, 20, 40, and 80%, respectively, of the full grazing potential can be achieved, with adequate development of the tree crop.

Inter-row cropping of hay or silage has been demonstrated with a production loss (in area) of about 8% during the first 3 years after planting.

INTRODUCTION

THE CONCEPT of using the same area of land for the production of bath grass and trees is designed to obtain greater profitability. This could have direct application for large areas of land which at present are giving poor returns from farming. In such cases additioaal grazing losses due to the presence of tree's would be more than offset by the returns from the timber crop. Limitations in the use of pasture planted, in trees are likely to be greatest soon after planting when seedlings are most susceptible to damage by stock and only restricted grazing is allowable. Pasture growth is likely to be limited toward the end of the rotation when increasing canopy cover reduces available light and limits pasture growth.

Since the concept is relatively new, most of the experience and research to date have been associated with the early years of the stand and this paper will deal with this aspect.

Planting recommendations (Knowles *et* cl., 1973) include selection of an area of established pasture so as to reduce subsequent weed problems, hard grazing before planting, and spraying of planting! sites with a paraquat-simazine mixture 2 weeks before planting to, prevent grass competing with trees. Planting should be done in late winter or early spring to allow maximum winter utilization of feed. About 800 seedlings/ha should. be sufficient to provide 200 for the final crop and therefore the initial planting should be at about 2 m intervals in rows 7 m apart.

Once the trees are planted, the farmer has the option of either keeping livestock out of the area until trees are safe from browsing damage, or trying to obtain some grazing. There are several factors that will influence the success of any attempted grazing and the effects of class of livestock, pasture type, topography, and season all appear to be closely inter-related.

RESULTS

CLASS OF LIVESTOCK

There are still different opinions about the type and breed of animal that can be used safely. The initial choice is between sheep and cattle. Olsen (1973) reported successful grazing by weaner Angus, Hereford, and dairy beef animals amongst large stands of very young trees, whilst older animals were successfully used in stands aged 3 years and older. Trial observations suggest that weaned cattle can be grazed successfully 2 years after planting, but considerable care is needed. Dairy breeds are generally less satisfactory than Hereford or Angus. "Preconditioning" of mature cattle by grazing among older trees before introduction to 3-year-old stands appears to be beneficial.

There have also been widely divergent reports on the results of grazing with the various breeds and classes of sheep, although they have been generally more reliable than cattle in grazing pasture without inflicting severe tree damage. Consequently, mainly sheep have been used in experiments to date.

Some information on differences between livestock Classes and breeds was obtained from a trial on flat land at Rukuhia. Stock were grazed at 25 EE/ha in 0.83 ha paddocks each containing 400 newly planted trees. Stock numbers were adjusted according to available pasture so that grazing pressure in all treatments was equal, Damage was recorded on 200 trees per paddock and all treatments were unreplicated in most cases.

Three breeds of hoggets (Border Leicester/Romney, Romncy, and Perendale) were compared with "tree preconditioned" dry Romney ewes in spring and autumn, and also with Friesian calves in autumn.

As a group hoggets caused a higher incidence of browsing damage than ewes, especially in spring, but this was due to some extent to: the greater number of animals present (Table 1). Incidence of tree damage by Perendales was similar to that caused by other hoggets, except in autumn, but both Perendales and Border Leicester/Romney hoggets showed a low severity ratio (Table 2) compared with other classes of livestock. Friesian calves showed a particularly severe browsing pattern, causing more damage in 9 days than other stock caused in 16 days.

TABLE 1: FREQUENCY OF BROWSING DAMAGE TO YOUNG RADIATA PINE BY DIFFERENT LIVESTOCK CLASSES

		Hoggets			
	Dry Romney Ewes	*Border Leicester/ Romney*	*Romney*	*Perendale*	*Friesian Calves*
Spring 1973 (19 days) :					
Stock number	19	33	37	28	
% trees browsed daily	4.1	12.0	10.4	14.0	
% trees browsed daily per animal	0.21	0.36	0.28	0.52	
Spring 1974 (18 days) :					
Stock number	25				
% trees browsed daily	7.9				
% trees browsed daily per animal	0.31				
Autumn 1974 (20 days):					
Stock number	18	33	'38	37	7
% trees browsed daily	2.1	3.1	4.6	0.9	11.1*
% trees browsed daily per animal	0.11	0.09	0.12	0.03	1.58
Autumn 1975 (25 days):					
Stock number	22		33		
% trees browsed daily	3.7		1.2		
% trees browsed daily per animal	0.17		0.04		

"9 days grazing only.

Note: Data derived from several grazing periods, and therefore total incidence of browsing may exceed 100%.

TABLE 2: INCIDENCE OF SEVERE BROWSING DAMAGE BY DIFFERENT LIVE STOCK CLASSES

	Spring 1973 (3 days)			*Autumn 1974 (16 days)*		
	% Trees Browsed	*% Trees Severely Browsed*	*Severity* Ratio*	*% Trees Browsed*	*% Trees Severely Browsed*	*Severity Ratio*
Dry Romney ewes	22.5	7.3	0.32	25.9	3.5	0.14
Border Leicester/Romney hoggets	42.0	4.0	0.09	62.0	5.0	0.08
Romney hoggets	44.0	13.5	0.31	91.5	50.3	0.55
Perendale hoggets	26.5	0.5	0.02	13.5	1.0	0.07
Friesian calves†				99.5	57.0	0.57

*Severity ratio = (% trees severely browsed) / (% all trees browsed) (range 0.00-1.00).
†9 days' grazing only.

TABLE 3: EFFECT OF GRAZING DURATION ON SEVERITY OF DAMAGE IN AUTUMN 1975

	13 Days Grazing	*25 Days Grazing*	*39 Days Grazing*		
Stock Class	*Severity Ratio*	*Severity Ratio*	*Severity Ratio*	*Av. Tree Ht in cm**	*Pasture Type*
Dry Romney ewes	0.18	0.52	0.99	43	Spring-grazed, legume dominant
Dry Romney ewes	0.12	0.20	0.39	81	Spring-spelled, high legume content
Dry Romney ewes	0.11	0.16	0.32	86	Spring-spelled, legume dominant
Romney hogget	0.02	0.03	0.88	55	Spring-grazed, high legume content
Romney hoggets	0.06	0.15	0.97	46	Spring-grazed, high legume content

*At the beginning of the grazing period.

TABLE 4: BROWSING DAMAGE IN RELATION TO PASTURE CONDITION IN SPRING
(Percentage of *trees* browsed after 3 days)

	Dry		*Hoggets*		
	Romney ***Ewes***	*BL/Romney*	***Romney***	***Perendule***	*Pasture* ***Condition***
Stock number	19	33	37	28	
Date:					
Sep. 1973	22.5	42.0	44.0	26.5	Short, fresh regrowth
Oct. 1973	6.7	61.0	30.9	43.5	Rank, pre-silage — Grass dominant
Nov. 1973	8.8	67.0	41.5	50.5	Short, post silage cut — very few legumes
Nov. 1973	29.2	23.5	63.0	50.5	Semi-rank
Stock number	25				
Nov. 1974	39.0				Short, high legume content (34.0%)
	16.8				Short, medium *legume* content (23.2%)
	38.1				Short, low legume content (6.9%)

Trees were newly planted radiata pine with average heights of 29 cm (1973) and 45cm (1974).

TABLE 5: BROWSING DAMAGE IN RELATION TO PASTURE CONDITION IN AUTUMN
(Percentage of trees browsed after 3 days)

	Dry ***Romney*** ***Ewes***	*BL/Romney*	*Hoggets* ***Romney***	***Perendale***	*Friesian* ***Calves***	***Pasture Condition***
Stock number	18	33	38	37	7	
Apr. 1974	7.5	27.1	27.5	0.8	20.0	Spring-grazed, low legume content
Stock number	22		33			
Mar. 1975	7.0		7.0			Spring-grazed, high legume content (40.0%)
			4.5			Spring-grazed, high legume content (30.8%)
	9.5					Spring-spelled, rank, high legume content (31.5%)
	11.5					Spring-spelled, rank, med. legume content (20.7%)

Trees were radiata pine planted out during the preceding spring.

The proportion of severe browsing damage by sheep tended to increase with length of grazing period (Table 3), most likely as a result of rebrowsing previously damaged trees rather' than because of a change in browsing behaviour.

Total damage after 3 days was found to be a useful indication of relative rates of damage by different classes of livestock; that is, the relative order of damage for the whole of any grazing period did not vary greatly from that incurred in the initial 3 days.

PASTURE TYPE AND CONDITION

Pasture composition has some effect on the amount of tree damage likely to occur. This has been illustwted by seasonal differences in the rate of damage by all stock classes (Table 1). However, variation in pasture condition *(i.e.,* rankness and clover content) in spring appears to have relatively little effect (Table 4).

The lower amount of damage in autumn compared with spring appears to be associated with the mixture of clover and roughage in the sward during autumn. The supplementation of the dry pasture, accumulated as a result of summer spelling, with fresh regrowth of relatively palatable clover appeared to divert much attention from the trees. This was particularly evident from the

TABLE 6: EFFECT OF EARLY GRAZING ON TREE GROWTH AFTER PLANTING

	Tree Age (yr)	*Increase in Tree Height (cm) after Planting*			
		Mamaku	*Matahina*	*Reporoa*	*Whatawhata*
Unbrowsed leaders	1	26	53	39	28
	2	80	138	80	104
Leaders browsed first spring only	1	22	43	30	18
	2	76 (5%)*	129 (6%)	64 (20%)†	91 (13%)†
Leaders browsed first spring and autumn	1	16	31	17	14
	2	44 (45%)	81 (41%)	39 (51%)	66 (37%)
Leaders browsed first [spring, autumn, and second spring	1	8	26	13	13
	2	25 (69%)	58 (58%)	26 (68%)	48 (54%)

*% growth 'loss at age 2 compared with unbrowsed.
†Includes some summer damage.

TABLE 7: GRAZING RETURNS DURING ESTABLISHMENT

	Locality							
	Mamaku		*Matahina*		*Whatawhata*		*Rukuhia*	
Early tree growth*	80/140/220		95/180/320		90/170/300		go/-/-	
Carrying capacity without trees (EE/ha)	11.0		12.0		11.0		12.5	
Grazing returns: (% of that without trees)	Actual	Autumn-Winter only	Actual	Autumn-Winter only	Actual	Autumn-Winter only	Actual	Autumn-Winter only
Year 0-l	10.8	5.4	35.0	26.7	48.2	26.4	21.6	21.6
Year 1-2	44.5	36.4	59.2	51.7	55.5	30.9		
Year 2-3	67.3		78.3		83.6			

*Early growth (tree heights in cm) for the 1st, 2nd, and 3rd years after planting, and not influenced by browsing damage.

results with Romney hoggets, which caused much less damage on clover-dominant pasture in 'autumn 1975 than on pasture containing very little clover in autumn 1974 (Table 5).

TOPOGRAPHY

On steep hill country at Whatawhata the effect of topography was dramatically expressed in the pattern of damage by sheep to newly planted radiata pine seedlings. Sites used by sheep to camp — *i.e.,* ridge crests and any sizable flatter areas within a paddock — received very high grazing pressure with severe browsing damage to trees. In uniformly steep paddocks, damage tended to be more widely spread but generally less severe. In such paddocks it was possible to achieve better pasture control than in those of more variable topography. Stock had to be removed from the latter before serious tree damage occurred on flatter sites, the steeper areas remaining virtually ungrazed.

EFFECTS OF BROWSING ON SEEDLING GROWTH

The effect of browsing on seedling growth is largely insignificant if the: terminal leader remains intact and if laterals are not completely stripped of needles. Recovery from light terminal leader damage is surprisingly good but requires a subsequent browse-free growing period if growth is not to be significantly restricted. Table 6 shows the effect on tree growth of browsing by sheep at four sites in the central North Island. All sites were carefully supervised and overall damage in each season should therefore be regarded as only moderate. The damaging effect of browsing in the first spring was slight but became significant when continued after the trees had a flush of growth, as at the Reporoa and Whatawhata sites.

Similarly, further damage in autumn, at the end of the active growing period, seriously reduced tree height at the end of the first year. Additional damage in the second spring had a further significant effect on, growth and, as a result, those tree's that had been browsed during all seasons produced less. than half the growth of trees that had been completely unbrowsed during their first 2 years.

Consequently, the "control" areas could be grazed 2 years after planting without any likelihood of serious tree damage, whereas it would take another year before pasture in areas with more seriously damaged trees could be grazed without the need for careful management.

TABLE 8: GROWTH AND INCIDENCE OF BROWSING ON SIX SEEDLING CLASSES OF *P. RADIATA*

Growth *Rates — free heights in cm*

Rukuhia (12.5 EE/ha) *			*Control (Rukuhia)*			*Tikitere (11 EE/ha)* *		
Tree-Stock	*Initial Ht*	*Ht at 9 mth*	*Ht Change*	*Initial Ht*	*Ht at 9 mth*	*Ht Change*	*Initial Ht*	*Ht at 9 mth*	Ht *Change*
1/0	35	23	— 13	34	105	+ 71	34	55	+ 21
1½/0	45	35	— 10	46	115	+ 69	45	64	+ 19
1½/0	58	51	- 7	62	120	+ 58	58	84	+ 26
2/0	86	88	+ 2	86	139	+ 53	94	126	+ 32
2/0	115	130	+ 15	115	158	+ 43	122	155	+ 33
2/0	128	142	+ 14	141	181	+ 40		Not Planted	-

Percentage *of seedlings with browsed terminal leaders and debarking*

	Rukuhia			*Tikitere*		
	At *3 mth*	*At 9 mth†*	*Debarked at 9 mth*	*At 3 mth*	*At 9 mth‡*	*Debarked at 9 mth*
1/0	98	100	N/A	98	85	1
1½/0	99	100	N/A	56	80	1
1½/0	97	100	4	97	46	1
2/0	53	100	6	20	14	8
2/0	12	86	21	2	6	17
2/0	20	93	24		Not planted	

*Actual annual return.
†Accumulative due to severity of damage.
‡New damage after recovery from previous browsing.

GRAZING RETURNS DURING ESTABLISHMENT

Even though careful management is practised in the first 2 years, trees are likely to suffer some damage. This will subsequently require removal of stock and will therefore, impose a limited grazing regime on the planted area. Table 7 shows the grazing returns from four different trials. Except at Rukuhia, the grazing imposed was for longer periods than recommended and therefore more realistic returns in the fist 2 years are the figures from grazings in autumn and winter only. These show that during the 2 years after planting a significant proportion of the potential grazing can be obtained. However, this will require close stock supervision and regular tree inspection to keep browsing damage to a minimum.

It would appear that approximately 20, 40, and 80% of the potential grazing could be obtained, respectively, in the 3 years after planting. At the high altitude Mamaku site on compacted soil, unrestricted grazing was still not possible in the third year, since in spring many tree leaders were less than 1.5 m high and within reach of sheep. Such areas with poor tree growth could still require restricted grazing after year 3.

PROTECTION OF TREES FROM LIVESTOCK

Trials have been conducted recently to test ways of protecting trees from livestock. These' have involved various mechanical guards which, although successful, are costly. To be satisfactory the guard must give protection until the tree is about 1½ m tall, and to be economic each guaad should cost not more than 0.07% of the net full potential annual grazing return per hectare. This is calculated on the basis that 750 seedlings/ha will be planted and that, without protection in the first 3 years, an average of 50% of potential grazing will be lost. Naturally, the retention of good pasture' quality will have to be considered also.

Another approach has been to use taller seedlings than normal in an attempt to eliminate or reduce the period of vulnerability to livestock. Trees ranging in height from 35 to 130 cm were planted and the pasture was grazed normally by sheep of various ages and breeds. In spring all trees up to 58 cm high were severely damaged, but with increase in height there was a decline in the number of terminal leaders browsed (Table 8) . However, in summer, with a high grazing pressure applied (Rukuhia site), all trees received a high proportion of damage, including significant debarking of the tall trees. With a lower summer-

grazing pressure (Tikitere site), overall damage was less and the terminal growth of trees taller than 94 cm was only lightly browsed. This lesser amount of damage was reflected in the net tree growth after 9 months, but shows that even seedlings about 130 cm high can be damaged badly enough to restrict growth.

The greater growth increment of the smaller trees in the control area is a reflection of their more rapid establishment due to a better balanced root/shoot ratio at planting. The "riding down" of the taller seedlings in order to browse the terminal leader and the debarking of the stems (coupled with the usual problem of tree instability in large-scale operations), make it impracticable to use taller seedlings to gain full grazing returns.

TABLE 9: AGRICULTURAL RETURNS FROM INTER-ROW HARVESTING TRIALS

TRIAL 1 1971 Plantation 1000 stems/ha (tree rows 5.5 m apart)	
Year 1 (1971-2)	***Per ha***
Crop 1-Hay in December	150 bales
Crop 2-Silage in April	17 tonnes*
Grazing-Ewes during July-August	4.5 EE
Year 2 (1972-3)	
Crop 1—Silage in November	19 tonnes
Crop 2-Hay in February	128 bales
Grazing-Lambs and ewes	7.9 EE
Year 3 (1973-4)	
Crop-Silage in November	20 tonnes
Grazing-Hoggets and ewes	6.7 EE
Mean annual return: 18 tonnes of silage/ha 83 bales of hay/ha 6.4 EE/ha	
TRIAL 2 1972 Plantation 750 stems/ha (tree rows 7.3 m apart)	
Year 1 (1972-3)	
Crop 1—Silage in December	19 'tonnes
Crop 2-Hay in February	128 bales
Grazing-Lambs in May, June, July	0.7 EE
Year 2 (19734	
Crop 1—Silage in November	19 tonnes
Grazing-Lambs in March, April, ewes in May	6.4 EE
Mean annual return: 19 tonnes of silage/ha 64 tonnes of hay/ha 3.6 EE.	

"All returns from silage were estimated.

HAY OR SILAGE CROPPING

Where contour permits, hay or silage may be obtained from planted areas. This will provide spring and summer pasture control while ensuring optimum conditions for tree growth. Stock can still be used for limited autumn and winter grazing.

Even if variable topography permits only a part of the total area to be mown, this has been found to be beneficial in increasing the overall pasture utilization by stock.

If hay or silage is to be 'harvested, special row alignment should be considered to allow for machinery access, and maintenance topdressing must be continued to compensate for nutrient removal. The returns from two inter-row harvesting trials are shown in Table 9. In both triads some grazing by sheep in autumn and winter was also used to aid maintenance of the sward. Unmown areas within the tree rows amounted to 9 and 8% of the total area for Trials 1 and 2, respectively, during the first year after planting. This was reduced by about 1% during yeaw 2 and 3 as tree rows became more easily identified.

TABLE 10: PASTURE COMPOSITION (% DRY WEIGHT) IN EARLY SPRING, WHATAWHATA, ON NORTH AND SOUTH FACING ASPECTS

	Year 1 (1972)		*Year 2 (1973)*		*Year 3 (1974)*	
	Grazed		*Grazed*		Grazed	
Aspect	*North*	*South*	*North*	*South*	*North*	*South*
Grasses	61	68	**66**	**67**	60	**64**
Legumes	**23**	**24**	**17**	**21**	**12**	**17**
Weeds	11	**4**	10	9	**22**	**13**
Litter	**5**	**4**	**7**	**3**	**6**	*6*
	Spelled		*Spelled/Grazed*		*Grazed*	
Grasses			**57**	**63**	**58**	**63**
Legumes			9	**7**	**13**	**14**
Weeds			**6**	**3**	**14**	*8*
Litter			**28**	**27**	**15**	*15*

Hay production ranged between 130 and 140 bales/ha, and estimated silage crops between 17 and 20 tonnes/ha. The marked decline in. production during the 1973-4 season in each trial was due largely to a prolonged summer drought. Although' the clover content of the pasture in both areas declined during the first and second years of the trial, the greater subsequent grazing pressure largely restored pasture quality.

EFFECT OF SPELLING ON PASTURE COMPOSITION

Spelling of pasture from grazing caused an accumulation of standing dry matter which resulted in an increase in litter and a decrease in legume and weed content of the sward. This was illustrated by measurements at Whatawhata (Table 10) on pasture spelled for a year, grazed for a short time: in early spring, and then spelled again for a further 6 months. However, these results also showed that, when grazing had been resumed for a year, the legume level was largely restored, even though considerable litter was still present. The gradual decline: in legume content of the continuously grazad areas, particularly on north-facing aspects, could be attributed to the series of dry autumn periods, particularly that in 1974. Spelling of clover-dominant swards allows the accumulation of a significant amount of seed in the soil, which may help ensure a high clover content in the pasture for several subsequent years.

Spelling of pasture helped reduce the flat-weed content as well as the clover. On the other hand, it is possible that taller weeds such as bracken (*Pteridium aquilinum* var. *esculentum*) may flourish with spelling from grazing, so it is desirable to start with a fairly weed-free sward. At Matahina and Mamaku the spelling caused a rapid decline of the ryegrass content, but clover content was restored once the grazing became more regular.

CONCLUSIONS AND RECOMMENDATIONS

The grazing of pasture containing newly planted radieta pine seedlings should be restricted to 'autumn and winter in the first 2 years after planting and, to avoid unacceptable damage to trees, must always be associated with careful livestock management. If care is taken and a medium-to-high legume content is present, it is likely that.45 to 50% of full pasture utilization can be obtained in the first 3-year period after planting without seriously retarding the trees. Slightly higher returns can be expected where tree growth is relatively fast — e.g., at Matahina, and lower returns at sites like Mamaku. However, if regular inspection of the planted area is not possible, or if the grazing area is not so urgently needed, the pasture can be spelled completely for 18 months. The subsequent renovation of spelled pasture may be best achieved by grazing with mature sheep in large numbers for short periods. Nearly full utilization should be possible once pasture quality is restored. This will be largely achieved after a year

under full grazing, and the mean annual grazing return over 3 years would then be about 30% of that from unrestricted grazing.

On steep hill country the effect of variable topography on severity of browsing damage accentuates the need for even more stringent limitations on early grazing in order to avoid incurring serious variability within the final tree crop;

While neither the exact factors stimulating stock to graze trees nor the proportion of total stock that cause this damage are known, it is evident that the influence of season on pasture composition and palatability is an important factor. A high proportion of clover in the sward, while not having a marked influence in spring, doles seem effective in autumn in reducing total damage, especially by hoggets. However, while such grazing is less risky in autumn than in spring, the effect of damage on tree growth is greater and so a cautious approach to livestock management should be adopted regardless of season during the first 3 years.

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