PROGRESS IN EVALUATING FOREST FARMING

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Abstract

The Tikitere forest farming research area was established in 1973 to determine the feasibility of integrating farming and forestry. This paper reports on progress in evaluating the effects of tree density and spatial arrangement on numbers and performance of livestock, and availability and productivity of pasture.

Only 5 years after planting *Pinus radiata* (D. Don) into pasture there were large reductions in carrying capacity with increasing tree density, and it is apparent that a tree management regime leading to a final crop of 400 sph is unsuitable for combining with intensive livestock production. Individual livestock performance as measured by both liveweight change and wool production was poorer under trees, and a number of possible explanations are given, Availability of pasture for livestock was affected both by a reduction in dry matter production with increasing tree density and by the covering of ground with thinning and pruning debris. The effects of the latter on managing livestock under trees are discussed.

INTRODUCTION

THE planting of widespaced trees into agricultural land is seen as a means of improving the returns from areas where previously the main products were wool and meat (Knowles, 1972). The Tikitere research area was established in 1973 as a joint project between the Ministry of Agriculture and Fisheries and the Forest Research Institute. Its objective is to provide data on the effects of grazing livestock in forests, in order to assess the profitability of the concept.

Pinus radiata (D. Don) was planted at five densities for thinning down to 50, 100 (widespaced and as twin rows), 200, and 400 stems per hectare (sph), with clear areas as pasture controls (Table 1). Each treatment was planted at five times the final crop density in order to provide sufficient selection to satisfy the forest management objective of producing high-quality sawlogs. The 400 sph treatment represented a smother tree density, with the final crop on this treatment being between 30 and 100% higher than current forestry practice in sawlog regimes.

Each treatment is replicated four times, with each being represented on flat, easy, medium, and steep contours. Each plot consists of 2 ha surrounded by a buffer strip of 28 m planted at the

TABLE 1: TREE SPACING AND DENSITY AT THE TIKITERE FOREST FARMING RESEARCH AREA

Tree Density at Planting (stems/ha)	*Final Tree Spacing (m)*		*Final Tree Density (stems/ha)*
	Between Rows	*Within Rows*	
250	14	14	50
500	7	14	loo
1000	7	7	200
2 000	3.5	7	400
500	28	3.5	100 (twin rows)

same tree density as the plot. Emphasis in the first 3 years after planting was placed on establishing the trees. This involved relatively light grazing over the whole period. Various classes of sheep and cattle were used. Management requirements to establish ***P. radiafa*** in grazed pastures have been defined by Beveridge et ***al.*** (1973) and Gillingham *ef al.* (1976).

Comprehensive pasture and animal performance measurements began in 1977, and this paper outlines the main agricultural trends and experience to date.

METHODS

LIVESTOCK PRODUCTION

During 1977, wether lambs were grazed at two stocking rates (9 and 12 ewe equivalents/ha) on each treatment to determine the carrying capacity of- the area. The results indicated that pasture without trees could winter 11.75 EE/ha.

From 1978, the objective was to establish the effect of the trees on livestock carrying capacity and performance. Grazing policy was to utilize pasture to an equivalent residual dry matter in all plots. The initial carrying capacity of each plot was determined from' the dry matter production during 1977, allowing for loss of pasture from pruning and thinning debris, and known characteristics of individual plots. Each plot consisted of two paddocks grazed by two-tooth wethers on a 3-week rotation in autumn, winter, and summer, with a 2-week rotation in spring. Sheep were randomly allocated to each plot at the start of the trial. Most of these sheep remained on the same plot for 12 months. Visual pasture assessments were made at 2-week intervals to determine minor adjustments to the stocking rate. This was necessary to maintain equal grazing intensity on all plots.

TABLE 2: THE EFFECT OF 5-YEAR-OLD *PINUS RADIATA* ON SHEEP CARRYING CAPACITY AND PERFORMANCE

Final Tree Density (sph)	*Carrying Capacity (relative to open pasture)*	*Liveweight Changes (g/sheep/day) Jan.-Jun.*	*Jun.-Sep.*	*Sep.-Feb.*	*Whole Period*	*Wool Production and Quality Yield/Sheep" (kg)*	*Yield/ha" (kg)*	*Character[b]*	*Colouf*	*(% > 1) Break*
0 (open pasture)	100	-1	18	93	38	3.5	48.7	4.7	1.9	1
50	96	-32	26	85	26	3.1	40.6	4.5	2.3	5
100	89	-31	-1	104	25	2.1	33.6	4.3	2.1	7
200	67	-41	6	85	17	2.9	24.9	1.3	1.9	3
400	30	-75	59	89	16	2.7	34.6	4.3	2.6	5
100 (twin rows)	91	-40	-11[c]	98	17					
LSD 5%	16	21	33	25	9	0.3	7.1	0.5	0.6	n.s.[d]

*Applies to basic mob only; [b] Wool character — 1 poor, 5 good; [c] Wool colour — 1 poor, 4 good; [d] n.s. — difference not significant: [e] Sheep removed 9.6.78, replaced 11.7.78.

During spring, additional sheep were added to each mob to control the extra pasture growth. Liveweights of the basic mobs were recorded on a 4-weekly basis (after fasting for 24 hours to minimize differences in gut fill), while the additional sheep used to control surpluses in spring were only weighed on and off their plots. Wool production and quality characteristics from the basic mobs were determined over a g-month period (April-January).

PASTURE PRODUCTION

Pasture dry matter production was measured on a year-round basis by the "Rate of Growth" technique (Radcliffe, 1974), using four 3.3 x 1.5 m grazing exclosure frames/plot cut at 4-week intervals. Care was taken when placing cages to avoid areas of thinning and pruning debris.

THINNING AND PRUNING DEBRIS

The thinning and pruning schedule is as follows:

1. At tree height 4 m, thin to 250% of final crop and prune the remainder to 1.5 m (January 1976).
2. At tree height 5.5 m, thin to 200% and prune to 2.4 m (July-August 1977).
3. At tree height 8 m, thin to 150% and prune to 4 m (1979),
4. At tree height 11 m, thin to final crop stocking and prune to 6 m (1980-l).

All slash (thinning and pruning debris) was left where it fell. The effects of thinning on slash cover were minimized by felling alternate rows into one another. The proportion of pasture covered was determined each 3 months by recording the identity of ground cover at 1 m intervals on four x 50 m line transects/plot.

RESULTS

LIVESTOCK PRODUCTION (Table 2)

Reductions in carrying capacity were relatively small in the 50 and 100 sph treatments, but at 200 and 400 sph only 67 and 30%, respectively, of stock were carried relative to open pasture. Individual sheep performance (liveweight gain) followed a similar pattern. The greatest effects occurred in the January to May period, coinciding with a prolonged drought and low pasture growth. The effect was greatest in the 400 sph treatment, where all stock were removed in midwinter because of emaciation, and replaced with new animals. In the September to February period,

the main effect on individual growth rates occurred at 400 sph. There were no other treatment effects on liveweight gain during this period.

The average wool weight per sheep on the open pasture control was 0.6 kg greater than that under the trees, with the least effect in the 50 sph treatment. On a per-hectare basis, wool prduction decreased uniformly as tree density increased, but at a greater rate than carrying capacity. Of the wool quality indices, character-scored high on all groups, with no treatment effects. There was slightly less discoloration in the 100 sph (twin rows), but no effect on the incidence of break.

STOCK DAMAGE TO TREES

Browsing damage to young trees in the first 3 years through removal of the growing tips was largely avoided by using low grazing pressures. However, between years 3 and 5 ½, trees were damaged by both sheep and cattle consuming strips of bark. Debarking was most prevalent in spring, especially during cold/wet periods. If damage was serious, livestock were removed from under the trees for short periods.

PASTURE PRODUCTION

Pasture dry matter yields from January 1978 to February 1979 are given in Table 3. A prolonged drought in the early months of 1978 resulted in low pasture growth. The only effect of the trees during this period occurred at the highest tree density. However, between June 1978 and February 1979 pasture production was lower with increasing tree density. When considered over the whole year there was a similar trend.

TABLE 3: THE EFFECT OF 5-YEAR-OLD *PINUS RADIATA* ON PASTURE PRODUCTION (kg DM/ha)

Final Tree Density (sph)	*Jan.-Jun.*	Jun.-Sep.	*Sep.-Feb.*	*Whole Period*
0	1 690	1500	5 710	8 900
50	1 420	1 340	4 520	7 290
100	1 660	1290	4300	7 250
200	1 520	1 090	3 500	6 110
400	920	670	1880	3 470
100 (twin rows)	1 700	1090	4 740	7 520
LSD 5%	300	460	770	1250

TABLE 4: THE EFFECT OF THINNING AND PRUNING DEBRIS ON PASTURE AVAILABILITY AND SHEEP MUSTERING TIMES

Final Tree Density (sph)	Pasture Availability (%) After 5.5 m Pruning and Thinning[a]	After 8 m Pruning and Thinning[b]	Relative Mustering Times (Apr.-Sep. 1979)
0 (open pasture)	100	100	100
50	96	86	121
100	93	75	126
200	81	67	329
400	67	58	—[c]
100 (twin rows)	91[d]	83[b]	108
LSD (5%)	3	6	44

[a] Completed August 1977; [b] Completed August 1979; [c] Plots not stocked with sheep during this period; [d] Trees planted 1 year later than other treatments.

THINNING AND PRUNING DEBRIS

The major effect of slash was to reduce the area available for grazing (Table 4). The effects were greater both with increasing tree density and with each thinning and pruning. The slash breaks down with time. Most of the needles fall off and decay within 12 months, and only a few branches from the first thinning and pruning remained in 1979. Other effects of slash included:

1. *Reduced mobility for shepherding and livestock*

While the ability of adult sheep to forage for grass does not appear to be greatly impaired by up to 50% ground cover by slash, their mobility, especially at mustering, is reduced. With up to 30% slash cover there is little effect on mustering time (relative to open pasture), but with greater than 30% slash the time required increases substantially (Table 4). While this extra time is insignificant in small plots, on large paddocks the slash would increase the relative time required for mustering. Further, it is not easy to find missing sheep. The presence of slash in the 200 and 400 sph treatments also limits access either by four-wheeled vehicle or by motorcycle. However, access by horse is possible, and made easier after pruning to 4 m. Decaying branches on uneven ground tend to move downhill into gateways, water-troughs, and roadways, requiring clearing.

2. *Seedbed for weeds/cover for rabbits*

As the needles drop and decay, there is almost invariably suppression of the pasture underneath. This provides areas where

weeds such as nodding thistle can become easily established. The slash also provides cover for rabbits, and poisoning has been the only effective method of control.

3. Pasture conservation

The presence of slash precludes hay and silage making on all treatments except the 100 sph (twin rows), where slash is confined to a relatively small area (25 m spacing between rows).

DISCUSSION

It is axiomatic that livestock carrying capacity will be reduced by both advancing age of the tree crop and higher tree densities. The two main factors directly influencing carrying capacity are pasture availability as affected by ground cover with slash, and the effect of the trees on pasture growth of the remaining areas. The results of this experiment show that even within 5 years of planting there were large effects on carrying capacity, directly related to tree density. The relationship was almost linear, and most pronounced in spring 1978. It is apparent that a tree management regime leading to a final crop of about 400 sph is not suitable for combining with intensive livestock production.

The apparent effects on individual livestock performance are relatively more important because economic evaluations of forest-farming in New Zealand have been based on lower carrying capacities but not poorer animal performances (Jackman and Knowles, 1973; King, 1975; Boswell and Edmonds, 1978). Because the pasture measurement technique does not relate directly to animal intake, it is difficult to draw conclusions on nutritive values unless differences between treatments are very large. In the period September 1978 to February 1979, the relative net pasture production per stock unit per day was 100, 84, 82, 86 and 85 for the open pasture, 50, 100, 200, and 400 sph treatments, respectively. For the same period, liveweight gain in the 400 sph treatment averaged 50 g/sheep/day, whereas sheep on open pasture, 50, 100 and 200 sph, gained 93, 85, 104 and 85 g/day, respectively. Thus, for almost identical pasture availability in the tree treatments, daily weight gain at 400 sph was only 65% of that in the other tree treatments.

Explanation of differences in individual animal performance is not simple, as the environment provided by placing trees on pasture creates a completely different ecological circumstance from open pasture. Insolation, temperatures, and air movement are all

affected, which could influence many aspects of the soil/plant/animal system, including:

1. Reduced direct sunlight allowing build-up of gastrointestinal parasites under the trees, a deficiency of vitamin D in herbage, and changes in soluble or structural carbohydrates of herbage, with consequent effects on digestibility.
2. Ingestion of dead pine needles causing rumen compaction.
3. Direct effects of the micro&mate on livestock (shelter).
4. Competition by the trees for nutrients causing changes in the mineral balance of herbage, and changes in the botanical composition of the pasture.

Such diversity emphasizes the complexity of explaining differences in individual animal performance.

The presence of slash is a major influence in practising agriculture in association with forestry. While on land of easy contour there are machines available that will break up slash, this or physical removal was not considered in this experiment as the concept of mixed agriculture and forestry appears to have greatest applicability to hill country, where the slash' would remain on the ground. After the final thinning and pruning the effects of slash become less with time, as evidenced by another experiment with 1 l-year-old trees *at* their final density of 200 sph, where slash has reduced pasture area by only 11%. The effects of slash are not all negative, as trees that missed pruning shade a much greater area than pruned trees, with consequent greater suppression of pasture growth.

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