Production and interaction of pastures and shelterbelts in the central North Island

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Abstract

Many New Zealand farms contain shelterbelts which have generally been unmanaged, resulting in dubious shelter benefits and poor log values at harvest. The effect of a 6- and 7-row *Pinus radiata* shelterbelt on adjacent pasture production was monitored at Matea, Taupo during 1992193. Pasture production was measured at a range of distances parallel to the shelterbelts on both sides and on open pasture. A 15% increase in pasture production was recorded at 0.7 tree height distance on both sides of the shelterbelts. There was also a gradual trend of increasing dry matter production as distance from the shelterbelts increased. However, on average, the sheltered zone produced slightly less dry matter than the open pasture. Increases in soil and herbage nutrient levels close to the shelterbelt suggest nutrient transfer by animals to the sheltered zones may have occurred. Shelterbelt tree growth was assessed and projected forward to maturity. Merchantable log volume at age 28 years was predicted to be 2300 m^3/km of shelterbelt. Based on current log prices the 7-row shelterbelt was estimated at age 28 years to have a net value of $130 000/km.

Keywords: log value, nutrients, pasture production, pasture composition, *Pinus radiata*, shelter, shelterbelt, wood yields

Introduction

Shelterbelts have been planted for over 100 years, but they have generally been unmanaged (Chevasse 1982). Most New Zealand farms have shelterbelts and there is increasing interest from farmers in this system of agroforestry (Morey 1988).

Multiple-row shelterbelts are a feature of many regions throughout New Zealand, one of their objectives being a source of timber. Agricultural shelter benefits have been measured in a study by Radcliffe (1985) in Canterbury, which showed a positive pasture response to shelter. Sturrock (1972) defined the benefits of shelterbelts in terms of wind speed reduction for a wide range of designs, and farm survey data indicated that sheltered farms suffered reduced stock losses (Shelter Working Party Report 1982). Sturrock (1988) also highlighted an impressive list of functions for shelterbelts, including protection of soils, improving working conditions, increasing farm management options and conserving wildlife.

Previous pasture measurements parallel to single and double row *Pinus radiata* shelterbelts in the Rotoma and Waikato districts showed reductions in pasture yields compared with non-sheltered areas (Hawke 1992). Furthermore, at the Tikitere Agroforestry Research trial, near Rotorua, there was no evidence that pasture yields were improved under the range of final crop stockings of 100-400 stems/ha (Hawke 1991).

Although animal welfare issues have not been well researched in New Zealand, Holmes & Sykes (1984) suggested that livestock would benefit from shelter and that the provision of shade enhances their welfare. Movement of stock into the shaded and sheltered areas of a shelterbelt can result in fertility transfer (Sturrock 1977), but Radcliffe (1985) commented that this had not occurred in the Canterbury study. Research into measuring shelter effects in New Zealand have been carried out on the leeward side only of the shelterbelt (Radcliffe 1985).

Studies of shelterbelt tree and log characteristics located in the central North Island and Canterbury regions (Tombleson & Inglis 1986) showed that the middle rows resembled a close-spaced plantation while the edge trees were considerably larger and contained large branches. These studies also showed that with the exception of branch size, shelterbelt-grown trees have similar tree and log characteristics to plantation-grown trees and as such could be modelled using models developed for plantation-grown trees.

Site details and management

The two radiata pine shelterbelts were located on Kotara Land Corporation Block, Matea, 32 km south east of Taupo.

The soil type was classified as Kaingaroa Sand (DSIR 1954) and the climate described as winter cold, summer moist with an annual rainfall of 1700-1800 mm. Altitude was 690 m asl. The area has been in improved pasture for approximately 25 years and consisted of ryegrass, white clover, *poa* species, browntop, Yorkshire fog, cocksfoot and sweet vernal. Rotational grazing was with sheep and beef cattle.

The two shelterbelts (1 x 6 row and 1 x 7 row) were planted in 1982 in a north east, south west orientation. They were 1 km apart and each shelterbelt was over 600 m long on flat terrain. Both shelterbelts were approximately 15 m tall at age 10 and had been pruned to a height of 1.6 m. The fence to fence width of both shelterbelts was 21 m. Tree spacing was 2 x 3 m and 2 x 3.5 m in the 6- and 7-row shelterbelts respectively. Merchantable log volume and value for the 7-row shelterbelt was calculated using STANDPAK (Whiteside 1989) with estimates of yield and value expressed on a 1 km of shelterbelt unit area (see Appendix 1 for details). The shelterbelt had a tree stocking of 3500 stems/km.

Two pasture cages (60 cm x 30 cm) were located on trimmed spots on 3 September 1992 at the following distances on both sides of the shelterbelts: 5, 10, 20, 40, 80, 120, 160 and 200 m. The 200 m spot at 13 x tree height (h) on both sides of the shelterbelts was considered to be equivalent to an "open" pasture situation, i.e., not influenced by the shelterbelt (Sturrock 1972).

Pasture growth was measured by taking quadrat samples (47 cm x 25.4 cm) from within each cage (Piggott 1986) with electric shears on 4 occasions over a 7-month period from 3 September 1992 to 25 March 1993. Dry matter production was calculated from each pair of samples. New areas were trimmed at each cutting time and the cages placed on them. Pine needles were discarded.

On the first production cut, herbage and soil samples were taken for chemical analysis (Comforth & Sinclair 1984). Pasture samples were also taken for herbage dissection analysis at the first cut. Samples were bulked from the two shelterbelts for each side and distance, i.e., 16 samples in total for each analysis. A bayesian smoother was used to analyse the soil data. This has an infinite number of parameters, one for each x position, thus allowing the data to determine to a very great extent the form of the curve. The relationships between the parameters are described by means of mean and covariance functions. Specifying these relationships enables the parameters, and hence the curve, to be estimated (Wecker & Ansley 1983: Steinberg 1984; Upsdell 1985). For the soil data here, an asymptotic relationship was assumed.

Tree diameters, heights and stocking were assessed and projected on to age 28 years using the integrated stand modelling system STANDPAK (see Appendix 1 for details). An assumption was made that the predicted volume comprised 50% edge rows (x 2) and 50% mid rows (x 5). It was also assumed that because of the small piece size, the upper SO% of the shelterbelt trees by volume would not meet sawlog specifications and were thus categorised as pulp logs. The projected value of the shelterbelt is based on current log prices of $95 stumpage (net return) for both categories of sawlog and $18 for pulp logs.

Results

Pasture

Total dry matter production at the 10 m zone (0.7 tree height) for both sides of the shelterbelt was 15% greater than that produced at the "open" pasture zone (Figure 1). A significant ($P<0.05$) trend of increasing DM production was also shown from the 40 to 200 m distance on both sides of the shelterbelt. However, on average the sheltered zone produced slightly less DM production than the "open" pasture zone (Table 1). Pasture species composition did not vary with distance from the shelterbelt (Table 2).

Figure1 Effect of Matea shelterbelts on total dry matter production

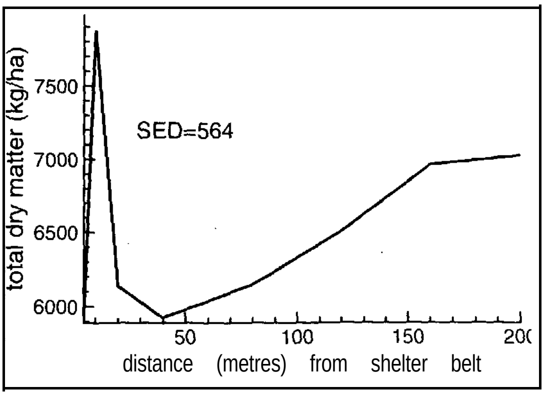


Table 1 Mean individual cut and total pasture yields (kg DM/ ha) at distances from the Matea shelterbelts

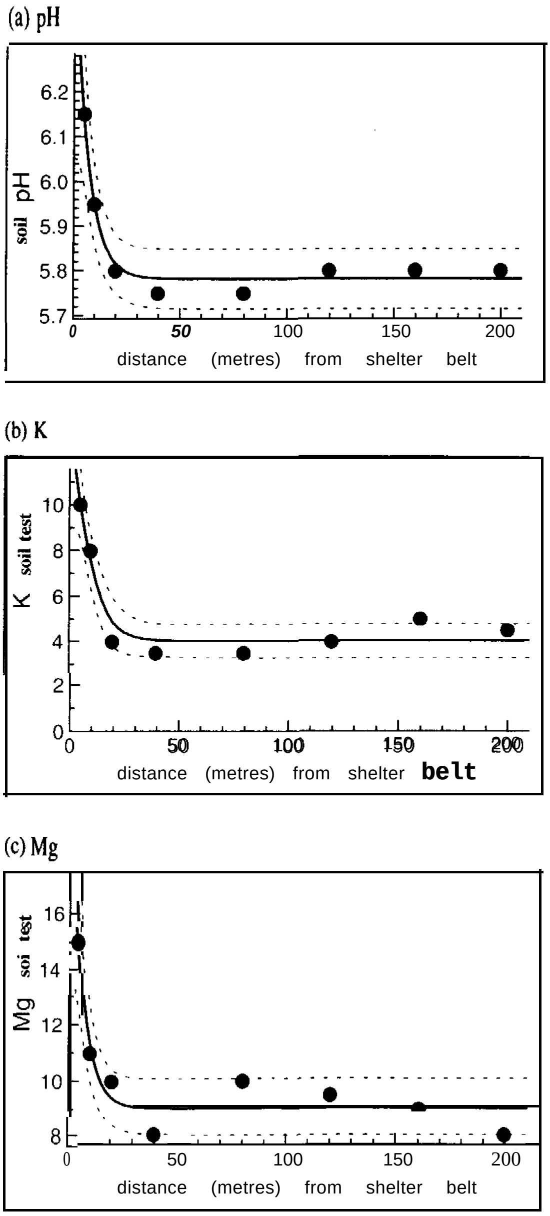
	Date of Cut				
Distance	29.10.92	16.12.92	4.2.93	25.3.93	Total
5 m	1445	2416	992	1040	5892
10 m	1721	3026	1830	1302	7679
20 m	1271	2319	1411	1139	6140
40 m	1290	2336	1292	1007	5925
80 m	1016	2251	1626	1252	6146
120 m	1340	2492	1508	1172	6511
160 m	1264	2695	1645	1366	6972
200 m	1316	2646	1769	1301	7034
S.E.D.	221	311	271	160	564

Table 2 Mean herbage composition, soil and plant nutrient status of Matea site as at 29.10.92

Herbage Composition[1]		Ryegrass	Y. Fog	Other Grasses	W. Clover	
Distance	5m	14.0	27.5	18.0	19.0	
	10m	19.5	20.0	20.5	27.0	
	20m	5.0	26.5	29.0	18.0	
	40m	6.0	28.5	28.0	18.5	
	80m	12.5	24.5	17.0	25.5	
	120m	8.5	45.5	11.0	18.5	
	160m	16.0	21.5	36.5	16.0	
	200m	12.5	41.5	13.0	24.5	
	S.E.D.	9.5	10.0	5.4	8.2	
Soil Nutrient Level[2]		**pH**	**Ca**	**K**	**P**	**Mg**	**S**
Distance	5m	6.2	4.0	10.0	19.5	15.0	19.0
	10m	6.0	3.5	8.0	24.5	11.0	26.0
	20m	5.8	4.0	4.0	19.0	10.0	22.0
	40m	5.8	3.0	3.5	23.5	8.0	17.5
	80m	5.8	3.5	3.5	29.0	10.0	16.0
	120m	5.8	3.5	4.0	31.0	9.5	15.0
	160m	5.8	3.5	5.0	25.5	9.0	19.5
	200m	5.8	3.5	4.5	26.0	8.0	18.0
	S.E.D.	0.1	0.7	1.0	7.7	1.8	5.4
Plant Nutrient Level[3]		**N**	**Ca**	**K**	**P**	**Mg**	**S**
Distance	5m	3.32	0.92	2.93	0.44	0.23	0.29
	10m	3.55	0.90	2.50	0.43	0.19	0.31
	20m	3.52	1.17	1.82	0.41	0.21	0.33
	40m	3.30	0.91	2.44	0.40	0.19	0.31
	80m	3.21	1.03	2.22	0.41	0.21	0.31
	120m	3.43	0.77	2.95	0.37	0.17	0.29
	160m	3.20	0.98	2.23	0.38	0.18	0.34
	200m	3.00	0.70	2.61	0.36	0.17	0.32
	S.E.D.	0.29	0.10	0.31	0.03	0.01	0.03

[1] % dry weight
[2] MAF Quick Test units
[3] % concentration

Figure 2 Effect of Matea shelterbelts on soil test values



Soil pH and Quicktest K and Mg levels were shown to be higher close to the shelterbelt (Table 2 and Figure 2), as were herbage concentrations, particularly P. Mg and Ca.

There were no effects of shelterbelt side on any of the pasture measurements.

Timber

At age 28 years the shelterbelt is predicted to have a mean tree diameter at breast height of 33.0 cm and a mean top height of 36.3 m. The predicted total merchantable volume is 2300 m^3/km of shelterbelt (Table 3). Because of the high final crop stocking the piece size is projected to be very small, 0.66 m^3. For the purpose of projecting log grades, the shelterbelt was divided into the following two components.

Table 3 Merchantable log volume, log grade and net returns of 7-row Matea shelterbelt

Description	Maximum Branch	Log Grade	Vol./km	Net Price ($/$m^3$)	Net Return $/km
Edge rows (2)	16 cm	Large branched sawlogs	575 m^3	$95	54,625
		Pulp logs	575 m^3	$18	10,350
Mid rows (5)	6 cm	Small branched small sawlogs	575 m^3	$95	54,625
		Pulp logs	575 m^3	$18	10,350
Totals			2,300 m^3/km		$130,000 km

Edge rows

Based on studies of mature radiata pine shelterbelts in the central North Island (Tombleson & Inglis 1986) the two edge rows were estimated to contain a mean maximum branch size of 16 cm, which yielded large branched sawlogs 10 m long. Based on current log prices they have a stumpage of $95/m^3$.

Mid rows

The five mid rows were estimated to contain a mean maximum branch size of 6 cm, which yielded small-branched, small-sized sawlogs, 10 m long with a stumpage of $95/m^3$.

Because of the small tree diameters, all logs above a height of 10 m were classified as pulp grade logs with a net return of $18/m^3$. Table 3 summarises the volume by log grades and the net returns per km of shelterbelt.

Discussion

The 6- and 7-row Matea shelterbelts may be better described as long narrow woodlots and as such act as solid barriers to the wind. Such shelterbelts (Cabom 1965) create a small zone of shelter close to the leeward side of the shelterbelt. McNaughton (1988) showed that beyond this "quiet" zone lies an extended region of increased turbulence. The pasture production profile of the Matea shelterbelt closely tits the wind profile associated with dense (versus permeable) shelterbelts. This result has been supported by Mr P. Smail (pers. comm.), a Canterbury farm forester with extensive experience of shelterbelt design and management, who believes that in such conditions, livestock congregate in the narrow sheltered zone immediately adjacent to the shelterbelt.

It may be possible that the associated deposits of dung and urine may have resulted in the substantial increase of pasture production at the 0.7 tree height zone.

The profile of pasture production associated with the Matea shelterbelt may also be compared with the study carried out by Radcliffe (1985) on a permeable shelterbelt located in Canterbury where it was found that pasture production peaked at 3 to 4 tree heights on the leeward side of the shelterbelt. Such shelterbelts are purposefully designed and managed to filter the wind, and as such there is less air turbulence on the leeward side. Shelter from wind of such shelterbelts is provided to a much greater area, hence livestock do not have to congregate close to the shelterbelt.

Both the Matea and Canterbury experiments showed depressed pasture production at the 0.3 tree height distance from the shelterbelt. Radcliffe (1985) suggested this could be due to a rain shadow effect, water use by the shelterbelt, cooler soils and appreciable tree shading. Root competition and excessive stock trampling are also possible explanations in the Matea shelterbelt study.

Mates, at an elevation of 690 m, was considered to have a cold and windy climate for this region of the North Island. The orientation of the shelterbelts gave protection from the south east and north west winds. However, results indicated that orientation had little effect on DM production. Grazing management, fertiliser application or inherent soil type variation may have had more impact on DM production in this location than the shelterbelt orientation.

For timber production the shelterbelts will produce at harvest a considerable quantity of timber. Although of modest quality and value the tree crop will provide considerable returns to the landowner. It is also noted that tree size and log values could have been more than doubled with increased tree spacing and improved management, particularly with all trees being pruned to a height of 6 m. Such an improved system would also incorporate a supplementary species to block the low draught created by the pruning. The limited data from this trial has indicated that the displacement of agriculture is more than likely to be compensated for by the considerable timber returns at harvest. The benefits of shelter for improved pasture growth have not been realised while the impact on livestock performance and animal welfare has not been measured.

A more detailed study is planned to determine whether the increased pasture production close to the shelterbelt is due to a shelter effect or nutrient transfer or a combination of these factors.

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APPENDIX I
SUMMARY OF DATA INPUTS TO STANDPAK ANALYSIS

Age: 10 years	(actual)	
Stocking:	stems per ha. 1360	
	1 kilometre of shelterbelt	= 2.577 ha
		= 3500 stems
Pruned height:	1.6 m	
Mean top height:	14.6 m	
Site index:	27.2 m	
Mean diameter at breast height:	26.5 cm	
Basal area:	71.0 m^3/ha	
	237 m^3/km	
Age: 28 years	(predicted)	
Mean top height:	36.3 m	
Basal area:	94.2 m^3/ha	
Total merchantable volume/ha:	902 m^3	
Total merchantable volume/km:	2300 m^3	