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Report No. 67 **November 1999**

FOREST & FARM PLANTATION MANAGEMENT COOPERATIVE

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EXECUTIVE SUMMARY

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In the dryland, Hawke's Bay region of the North Island, shelterbelts are seen in a diversity of planting patterns, species and silvicultural practices. At Poukawa Research Station, the existence of two mature parallel shelterbelts offered the opportunity to extend our studies on the effects of shelterbelts on adjacent pastures and soils to a dryland situation.

Results from this three-year study indicated that there were no significant improvements in pasture production across the 'sheltered' zone on either northerly or southerly aspects and that there was no higher soil moisture status close to the shelter in drying and drought conditions. Soil nutrient status indicated there was nutrient transfer by grazing animals close to the shelter, particularly on the northern aspect indicating that stock gained some comfort from camping in this location. Ryegrass yields in a 'neutral soil' study indicated that there were no direct shelter benefits on pasture production. Wind run was relatively uniform across the study area and pine needles were not evident beyond the 40m distance from the shelterbelt. Soil biota was generally greater at distances furthest from the shelterbelts.

CONTENTS

FIGURES

1.0 INTRODUCTION

Previous studies of farm shelterbelts in the Central Plateau and Wairarapa (Hawke and Tombleson, 1993 and Hawke *et al.,* 1998) have indicated that shelterbelts modified the pasture production profile in the sheltered zone through both direct and indirect effects. The primary reason for planting shelterbelts in Hawke's Bay is to reduce the effects of strong winds, especially cold southerly winter winds

In Central Hawke's Bay it has been suggested that there may be benefits from shelterbelts in retaining soil moisture and improving pasture production adjacent to the shelterbelts during the regular summer droughts.

The 'neutral soil' project, conducted at Matea in the Central Plateau, to evaluate the direct effects of shelter on pasture growth in the absence of nutrient transfer by animals, showed that in a district of summer moist conditions, there was no effect of shelter beyond 10m from the shelterbelt. It was considered that this study should be repeated in a summer dry climate such as Poukawa.

1.1 Shelterbelt Details and Trial Description.

Two north west/south east (NW/SE) orientated shelterbelts were measured at Poukawa AgResearch Research Station, 14 km south of Hastings from 1996-1999 (Figure1). The shelterbelts were planted parallel and 320 m apart in 1980 and were 21-25m in height over the measurement period. The north shelterbelt was comprised of a single row of unpruned, *Pinus radiata*, and the south shelterbelt was formed by a double row of unpruned, *Pinus radiata*. The soil type was Matipiro sandy loam (YGE) and the average annual rainfall was 770mm. Pasture between the shelterbelts consisted of 10% ryegrass (*Lolium perenne L.*), 10% legumes (*Trifolium repens and Trifolium subteranium)* and 80% other grasses. The paddock was rotationally grazed with sheep and young dairy cattle at a stocking rate of 10su/ha. One set of measurements was taken on the southerly aspect of shelterbelt 1(Table 1), and the other on the northerly aspect of shelterbelt 2.

Forest Research have permanent sample plots (PSPs) in the two shelterbelts and have measured the overall optical porosity at 23.3% and 23.6% (% air space) for shelterbelts 1 and 2 respectively (Horvath, *pers comm).*

Table 1: Shelterbelt descriptions

Shelterbelt Location	Orientation	No of rows	Between Row Spacing (m)	Within row tree spacing (m)	Between Fence Width (m)	Optical Porosity (%)
Poukawa 1	NW/SE	1	-	2.0	4.0	23.3
Poukawa 2	NW/SE	2	2.6	1.8	6.6	23.6
	Current Age					
Poukawa 1	19 years					
Poukawa 2**	19 years					

** Branches mechanically trimmed to within 1.5 m of the stem to a height of 13 m on the North side only.

1.2 Measurement Details

In - situ pasture measurement:
Two pasture exclusion cages ($0.5m^2$) were located 30m apart at each of the distances 5m, 10m, 20m, 40m, 80m and 120m from each shelterbelt representing zones at approximately 0.25h (h= tree height), 0.5h, 1h, 2h, 4h and 6h. The mid-way point at 160m (8h) represented open pasture. Pasture production was measured by the trim technique (Piggott 1986) on three occasions each year. Pasture dry matter production was calculated from each cage after separating out any pine needles present.

Soil measurements:
Soil samples (0-75mm depth) were taken in December 1996 as a bulk sample at each of 5m, 10m, 20m, 80m distances from the shelterbelt on each aspect, and at 160m, and subjected to AgResearch Quick Test Analysis.

Soil moisture content by weight was calculated from duplicate samples of bulked, 0-75mm depth cores taken at the specified range of distances during the three year trial period, at times which represented a range from moist to drought situations.

Neutral soil study:
Five replicate boxes (435mm by 250mm by 200mm deep) of a uniform, fertilised soil containing 100mm high *cv. Yatsyn* perennial ryegrass plants were implanted to ground surface level in the surrounding pasture at the same range of distances as the pasture in situ cages, and protected from grazing animals by covering with a pasture exclusion cage. A separate study was conducted each year, using fresh soil and grass seed. Ryegrass growth was measured by cutting the regrowth since the previous cut. Pine needles were separated out and the boxes were irrigated when conditions became dry.

Wind run:
Two cup anemometers were set up in separate exclosure frames at 50cm height above ground level, at 10m from each shelterbelt, and in the mid-zone area at 160m. Total windrun was recorded over the period 10/3/97 -25/2/99.

Soil biology survey:
A survey of soil fauna populations within and adjacent to the two shelterbelts was conducted on 10 & 11 October 1996. One hundred metre long transects parallel to each shelterbelt were set out at 7m, 12m and 160m distances from each shelterbelt, and also directly within each shelterbelt. At 1m intervals along the transects at 7m and 160m distance, soil cores of 0.1m diameter and 0.2 m depth were taken with a tractor operated hydraulic coring machine. For the 12m distance transect, 3 sets of 10 cores were taken at 1m intervals with a 30m intervening gap between each set. Within each shelterbelt, 30 cores were collected at 1m intervals using a 0.1m diameter hand soil corer. Soil cores were dissected for biological activity and categorised according to species.

Needle litter:
Pine needles from the neutral-soil boxes were collected at the time of each production cut, dried and weighed and their dry matter yield calculated.

2.0 RESULTS

2.1 In - Situ Pasture Production

The average, annual pasture production declined close to the shelterbelt on the southern aspect but on the northern aspect, the decline was masked by vigorous weed growth during winter and early spring in 1997/98 (Table 2 and Fig. 2). The low level of total annual pasture production in all years was due to the effects of summer-autumn droughts.

Table 2. Total and average annual pasture production (kgDM/ha) adjacent to Poukawa shelterbelts

North Aspect	96/97	97/98	98/99	Annual Av
5m	337	6868	4880	4028
10m	2549	4130	4903	3861
20m	2322	3705	6631	4219
40m	2593	3296	6407	4099
80m	3963	3002	6877	4614
120m	2436	4118	6042	4199
160m	2664	3803	5396	3954
South Aspect				
5m	2487	1420	2210	2039
10m	3462	2213	5318	3664
20m	2209	3367	6869	4148
40m	2498	4773	6588	4620
80m	2561	4647	7394	4867
120m	2307	4319	8378	5001
160m	2664	3803	5396	3954

2.2 Soil Nutrient Status

Because soil nutrient status was measured on a bulk sample at each distance the results can only be used to indicate general nutrient levels or trends. Soil P, K and S levels were all elevated close to the shelter on the northerly aspect, but only soil K was higher on the southerly aspect (Table 3).

Table 3: Soil nutrient levels adjacent to shelterbelts at Poukawa

		Soil Quick Test Units[1]				
	Distance (m)	**Ca**	**K**	**P**	**S**	**pH**
South Aspect	5	10	8	14	7	6
	10	8	3	16	5	5.8
	20	9	4	18	7	6
	80	8	5	13	6	5.7
Mid-zone	160	8	5	19	9	5.8
North Aspect	5	10	35	92	32	5.9
	10	10	5	15	8	5.5
	20	8	4	9	8	5.7
	80	9	3	9	7	5.8

[1] Cornforth and Sinclair 1982.

2.3 Soil Moisture

Soil moisture levels were similar over the range of distances during periods following recent rainfall e.g. 12/12/96 and 12/1/99 and in drought conditions e.g. 6/4/98 and 22/11/98, whereas in drying soil conditions such as 25/10/96 and 7/11/97, soil moisture levels were lower close to the shelterbelt (Table 4).

Table 4: Soil moisture levels (%SM) adjacent to Poukawa shelterbelts

		Date							
		25/10/96	**12/12/96**	**7/11/97**	**6/04/98**	**6/05/98**	**22/11/98**	**12/01/99**	**25/02/99**
Aspect	**Dist (m)**								
South	5	10.8	14	17	8.1	18.6	7.6	10.2	15.9
	10	14.3	13.8	19.9	8.9	20	9.1	9.7	18.3
	20	16.8	13.7	17.8	8.5	20.3	8.5	8.8	15.9
	40	14.9	12.3	18.9	7.3	18.4	7.4	8.1	14.7
	80	15	12.8	19.1	7.8	17.5	7.6	8.6	16.3
	120	13	13	18	7.1	18.1	7.2	8.3	16
Mid zone	160	14.3	13.8	19.2	7.6	18.3	8	8.9	20
North	5	11.4	15.2	13.9	7	14.4	8.7	9.3	13.4
	10	12.5	12.6	18.9	7.8	17.6	8.9	9.6	15
	20	13.1	11.1	16.9	8.1	17.2	8.3	9.8	14.7
	40	15.1	11.9	20.6	8.1	18.6	8.1	9.1	16.6
	80	15.4	14.4	18.5	7.5	19.1	8.6	9.9	15.3
	120	15	12.8	18.8	6.7	18	8.4	10	17.4

2.4 Neutral Soil Study

The average annual ryegrass yield was similar on each aspect with differences occurring only at the 5 and 10m distances (Table 5 and Fig. 3). Annual totals varied, reflecting rainfall patterns. The boxes were occasionally irrigated during dry periods, but this was not effective in maintaining ryegrass growth.

Table 5: Total annual and average ryegrass yields (kg DM/ha) in neutral soil boxes

North Aspect Distance (m)	**96/97**	**97/98**	**98/99**	**Annual Av.**
5	2139	4502	1731	2791
10	2604	3932	1579	2705
20	2415	4297	2426	3046
40	2169	4637	2827	3211
80	2102	5328	2669	3366
120	1877	5044	2325	3082
160	2297	4965	2648	3303
South Aspect Distance (m)	**96/97**	**97/98**	**98/99**	**Annual Av.**
5	3619	4793	2669	3694
10	2297	4573	2349	3073
20	2770	4714	2297	3260
40	2273	5437	2445	3385
80	2399	5334	2265	3333
120	2268	4843	2708	3273
160	2297	4965	2648	3303

2.5 Wind Run

Wind run measurements suggested that there was a relatively uniform wind speed in the three zones, with only minor differences across the profile (Table 6).

Table 6: Seasonal Wind Run between Poukawa shelterbelts

	Km wind run/day @ 0.5m height		
	South Aspect	**Mid-Zone**	**North Aspect**
Metres from Shelterbelt	**10**	**160**	**10**
Season			
Spring,1997	54	52	65
Summer,1997/98	39	52	36
Autumn, 1998	43	56	53
Winter, 1998	37	34	47
Spring, 1998	78	82	71
Summer, 1998/99	72	45	68

2.6 Soil Biology Survey

There were generally highest earthworm numbers in the early spring period on the southerly aspect, which relates to higher soil moisture levels. Numbers were higher there than in the open pasture site which had a lower soil moisture level. Earthworms were absent within the shelterbelts. Highest earthworm egg numbers were found in the open pasture. Tasmanian grass grubs were present on the northerly aspect and a low population of Porina caterpillar existed within the southern shelterbelt (Table 7).

Table 7: Soil Biota at Poukawa Shelterbelts

	Soil Biota / 100 cores				
	Total Earthworms	**Earthworm Eggs**	**Grass Grubs***	**Other#**	**% soil moisture by weight**
South Aspect					
0m	0	0	30	0	NR
7m	44	8	0	2	18
12m	583	20	0	0	24.3
Mid zone					
160m	228	67	0	13	21.9
North Aspect					
0m	0	0	0	3	NR
7m	92	30	10	13	14.3
12m	150	30	0	0	17.4

NR = not recorded
* = includes Tasmanian grass grubs
\# = includes wireworms, earwigs and porina

2.7. Needle litter

The overall trend was for needle deposition to extend further into the paddock on the northerly aspect (Table 8), than on the southerly aspect, indicating the presence of stronger southerly than northerly winds at times during the year. The total dry matter contribution from pine needles was low compared with pasture dry matter production, even in the dry years associated with this study.

Table 8: Pine needle litter (Kg Dm/ha) adjacent to shelterbelts at Poukawa

	1996/97 Total	1997/98 Total	1998/99 Total
North Aspect			
5m	265	142	224
10m	53	37	61
20m	20	34	142
40m	4	2	1
80m	0	0	0
South Aspect			
5m	81	62	181
10m	26	44	119
20m	2	0	38
40m	0	0	0
80m	0	0	0

3.0 DISCUSSION

The trend in pasture dry matter production on both aspects of the shelterbelts was similar, which was not surprising as the overall optical porosity for the two belts was almost identical at 23.35% and 23.65%. Neither shelterbelt regime significantly influenced the level of associated pasture growth, except at the 5m distance where it was lower. Results from other North Island studies support this finding (Hawke and Tombleson, 1993, Hawke *et al*, 1998). The distance between the shelterbelts of 320m may not have provided a completely unsheltered area in the mid-zone as the 160m distance only represented 8 tree heights. This was supported by the wind run data which showed that at 50cm height above the pasture, there was no increase in wind run at this distance.

The evidence from this study is that shelterbelts have not conserved soil moisture in the sheltered zone. In fact, in the zone close to the shelterbelt, competition effects from tree roots (Hawke *et al.* unpubl.) reduced soil moisture levels particularly during the drying out phases. In a drought situation, there was no beneficial effect of shelter as all sites suffered uniformly from moisture stress. The absence of shelter effects in dry conditions was similar to that reported by Radcliffe (1985) from Canterbury studies. Earlier studies in Central and Southern North Island in 1995 by the authors (Hawke *et al* 1999) found that the driest soil was close to the shelterbelt and was of increasing relative dryness as shelterbelt height increased.

In areas that receive regular and heavy rainfall, moisture levels throughout the sheltered zones would be expected to be similar, and shelter would not impose differential soil moisture stress conditions as was recorded here.

Soil nutrient accumulation, especially K, in a sheltered environment, has been shown to be an artifact of animal camping (Hawke and Gillingham 1996; Gillingham and Hawke1997). At this site, soil nutrient transfer occurred to a much greater degree on the northerly aspect, as evidenced by the relatively high soil P, K and S status in the 5m zone. Variations in soil P and S content in particular may also be associated with variations in routine fertiliser application and so are not useful in interpreting the effects of animal grazing and camping patterns unless these are marked. A consequence of the animal camping effects, and the amount of bare ground generated in the 5m zone at Poukawa, was the weed establishment and growth in the spring of 1997. Apart from this effect, nutrient accumulation close to the shelterbelt did not result in increased pasture production. The higher soil K levels at the 5m distance on the north aspect suggest that animals spent time sheltering from the southerly winds.

The direct effects of shelter on ryegrass yields suggested that there was a benefit close to the shelterbelt on the southern aspect, but not the northern aspect. This may be due to protection from the summer sun and less drying out of soil in the boxes. The ryegrass production beyond 10m was similar for both aspects and supports an earlier study in the Central North Island (Gillingham and Hawke, 1997).

The variation in earthworm numbers appears to be closely related to soil moisture status, although the zero populations within the shelterbelt may also be a consequence of the presence of pine trees (Yeates and Hawke, 1999). The presence of grass grub (*Costelytra zealandica)* on the southerly aspect of the north shelterbelt can be attributed to the shading and cooler environment and some ungrazed pasture within the fenced area. On the other hand, the Tasmanian grass grub (*Aphodius tasmaniae*) found on the opposite aspect of the south shelterbelt is attributed to the bare ground, higher dung presence and warmer environment at this site. This pest is known to establish on the drier and more 'open 'pastures at Poukawa (Slay, *pers comm*). The low population of Porina caterpillar (*Wiseana spp*) found within the southerly shelterbelt was significant, as Porina is not considered a pasture pest in these dry areas of Hawke's Bay, but under shady, moist conditions where there is ungrazed pasture, as existed here, there is an ideal environment to allow the caterpillar's survival.

Needle litter deposition was light relative to a study in the Central North Island (Hawke *et al,* 1999). Beyond 20m distance on both aspects, needle deposition was minimal which suggests that during the course of this study, high winds were not prevalent.

The shelterbelt timber yield and quality has been measured by ***Forest Research*** but is not reported on in this study.

4.0 ACKNOWLEDGEMENTS

The authors thank the owners of Poukawa Research Station for enabling this study to be conducted and Alister Holman for technical assistance. The Forest and Farm Plantation Management Cooperative provided the funding for this study.

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Fig 1:

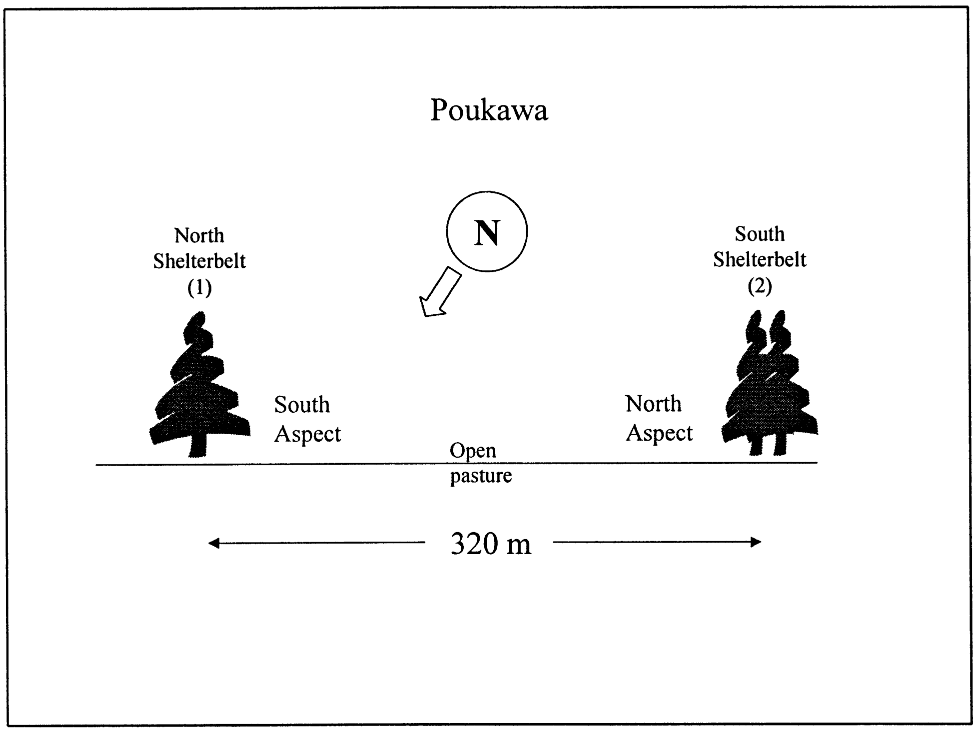

Figure 2:

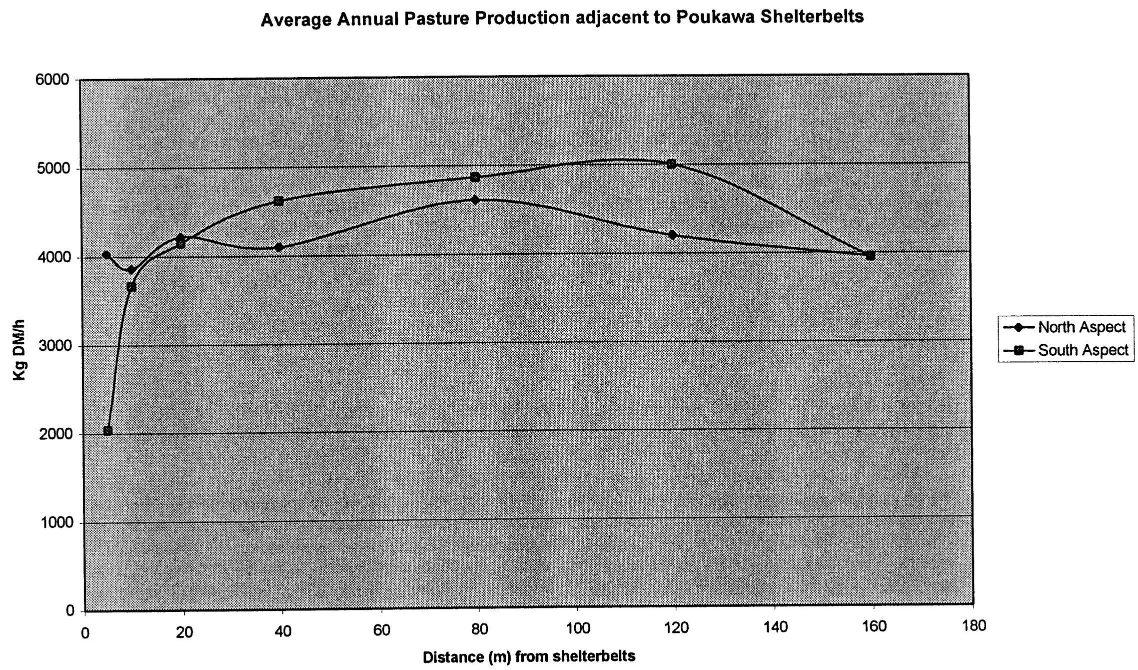

Figure 3: