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Flexibility and climate risk management in high stocking rate dryland sheep farming systems

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ABSTRACT

A trial unit of 87.8 ha with conventional grass-based pastures and one of 85.1 ha with high legume-content pastures were used to investigate the impact of climate-risk management strategies on production and profitability of dryland sheep farming systems. The target stocking rate of both units was 14 stock units (SU)/ha, which is markedly higher than the regional monitor farm at 8.8 SU/ha. Information on the feed supply and animal feed requirement of the two units for 2008/09 and 2009/10 are presented, along with differences in weather patterns, soils moisture, climate-risk responses used, and stock sales between the two years. Results from the grass-based unit indicated that the flexible livestock policies used and climate-risk management responses imposed were able to increase farm profitability and reduce its variability between years in comparison to the local Ministry of Agriculture and Forestry monitor farm model. However, the same was not true for the high legume-content unit, which encountered a number of problems with high lamb deaths and poor lamb finishing in 2008/09. Soil moisture level in the top 25 cm proved to be a simple, inexpensive and effective indicator for making appropriate farm management decisions in response to changes in the climate.

Keywords: dryland sheep systems; climate variability; flexibility; risk management.

INTRODUCTION

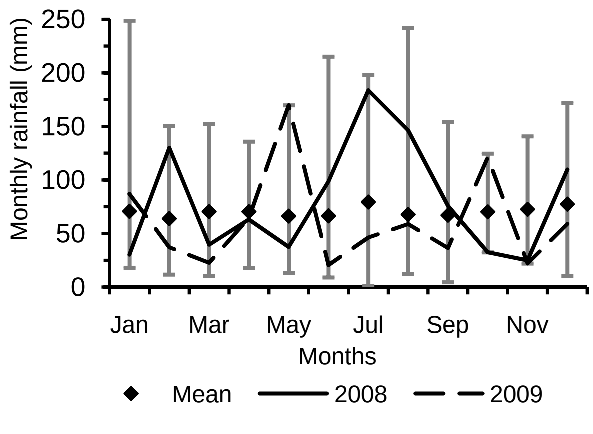
Dryland sheep farming systems are subject to significant annual and seasonal variability in pasture growth, driven primarily by variation in rainfall and temperature. Radcliffe and Baars (1987) suggested that spring and summer rainfall accounts for 60% of the variation in annual pasture production on dryland farms. We analysed 20 years of data from the National Institute of Water and Atmospheric Research (NIWA) virtual climate station network (Tait *et al*., 2006) for the trial site in mid Canterbury (Latitude: -43.56, Longitude: 171.85). This showed that although average monthly rainfall does not vary very much between 63.9 mm in February (summer) to 79.4 mm in July (winter), the variability across years is extremely large (Figure 1). In all months, the variability in rainfall is much greater than the mean. This variability between years has a marked effect on pasture production which is particularly important in late spring/early summer when farmers are trying to finish lambs. The possibility of rainfall decreasing at any time during this period to a point where grass growth stops represents a major source of risk in dryland farming (Avery *et al.*, 2008).

Important variables in managing this risk are lamb growth rate and the flexibility to change feed demand or supply rapidly if and when conditions dry out. Lamb growth rate is important because the risk of dry conditions and reduced feed supply increases as the season progresses (Avery *et al.*, 2008). Lambs which grow slowly obviously take longer to reach drafting weight than fast growing lambs and thus the chances that feed availability or quality will deteriorate before drafting, is higher. If this happens, growth rate may be depressed further, drafting date extended, and the possibility of lambs competing with ewes for high quality feed during flushing increases.

Pasture quality has been shown to be a key variable determining lamb growth rate (Waghorn & Clark, 2004). Previous trials on dryland farms have shown animal production advantages through the use of improved pasture species; however the advantage is not always sustained over time (Fraser *et al*., 1999). While feed quality may be enhanced by these species, plant persistence can be an issue.

Flexibility to change feed demand or supply rapidly is important in order to manage the risk of running out of feed if and when conditions dry out.

FIGURE 1: Twenty year mean and range in monthly rainfall at Silverwood Farm, Canterbury with monthly rainfall for 2008 and 2009 from National Institute of Water and Atmospheric Research (NIWA) virtual climate station network. Grey bar indicates range.



The aim is to reduce fluctuations in income associated with variations in either the proportion of lambs drafted to the works or in lambing percent resulting from inadequate feed supply or quality for ewes before and during mating (Avery *et al.*, 2008). It is also important to ensure that as policies designed to increase production and profitability are implemented, variability in these is not increased as well. There is a general tendency in farming that as returns increase, so does the variability of returns, or risk (Marshall *et al.*, 1997).

Following discussions with a local farmer group, who wanted to see research on a farm scale that "pushed the boundaries of dryland farming", a trial was established in March 2007 to investigate different management strategies that would increase production and profitability, and reduce the risks, of dryland sheep farming systems. Prerequisites of such systems identified by the group, included: an efficient ewe flock, with pregnancy scanning rates >175% and survival to sale >145%; high pasture quality and utilisation; and flexibility which would allow a rapid change in feed demand, such as through de-stocking, and/or supply as required.

The aims of the trial were to investigate and demonstrate management strategies that would maintain high pasture quality and utilisation, leading to high lamb growth rates and increased production and profitability, without increasing variability in the latter two. Two different approaches to maintain high pasture quality and utilisation were used: an intensively grazed conventional grass-based system, and a high legume-content system. The philosophy for both systems was to carry higher than average livestock numbers for the district to enable sufficient grazing pressure to maintain pastures in an active growth stage, and then to reduce this stocking rate to best economic advantage when soil conditions became dry. This required building flexibility into the livestock policies enabling on-farm animal numbers to be reduced quickly, and also required identifying appropriate "triggers" for initiating de-stocking responses. This paper describes the production and profitability of these systems in comparison with the Canterbury Marlborough breeding and finishing sheep and beef monitor farm (Ministry of Agriculture and Forestry, 2010). Pasture growth and quality, and lamb growth rates attained in the trial are described in Bywater *et al*. (2011).

MATERIALS AND METHODS

In 2007 two non-replicated farm-scale trial units were established at Hororata, mid-Canterbury: a conventional grass-based unit of 87.8 ha (G) and a high legume-content unit of 85.1 ha (L). Each unit had 16 paddocks, stocked at a target of 14 stock units per hectare (stock units (SU)/ha), which is 5 SU/ha higher than the regional monitor farm model (Ministry of Agriculture and Forestry, 2010). The first year of the trial in 2007/08 was used to bring data collection procedures and pasture and stock management into line with the trial protocol. Data collection was then carried out for two years over 2008/09 and 2009/10.

Pastures and forage crops planned on the grass unit were: 13 paddocks of predominantly grass-based pasture or approximately 81% of the unit; one paddock of lucerne (8% of the unit); and two paddocks in a pasture-renewal rotation (11% of the unit) including winter kale, followed by barley for silage and then a perennial grass mix in one paddock, and leaf turnips under-sown with a perennial grass mix in the other. Planned pastures and forage crops on the legume unit were: four paddocks of predominantly grass-based pasture (30% of the unit), five paddocks of "switch" pastures (30% of the unit) which are annual and perennial clovers over-sown with annual ryegrass each autumn (Nicol *et al*., 2010); five paddocks of lucerne (29% of the unit); and two paddocks in a similar pasture-renewal sequence to the grass unit (11% of the unit), except forage rape was used instead of leaf turnips.

Eight of the pastures on the grass unit were established ryegrass:clover pastures, two of which also contained cocksfoot and two tall fescue. Of the remaining grass paddocks, two older, brown top dominant pastures were renewed as described above in 2007/08 and two out of three Bareno brome pastures were renewed in 2008/09, all going into Alto ryegrass with white and red clover. On the legume unit, the grass pastures included two established ryegrass pastures and two of Bareno which were renewed in 2007/08 and 2008/09 respectively, also going into the Alto ryegrass:clover mix. All five switch pastures were established at the start of the trial in 2007. In 2009/10, pastures on this unit were changed to five paddocks of grass-based pasture and four paddocks of lucerne. Soil types on the trial units were Lismore and Ruapuna stony silt loams. Stock included sheep and trading cattle on the grass unit and sheep only on the legume unit. The main sheep breed used on the trial were Coopworths from the Ashley Dene farm, Lincoln University, breeding flock (Nsoso *et al*., 1999), mated to terminal sires.

Flexibility to destock quickly was built into the systems by: purchasing 23% of the grass unit's total SUs as 18 month-old trading cattle in May and selling these animals anytime after October according to feed conditions; lambing a portion of older ewes either three (G) or four (L) weeks before the main mob, allowing early weaning, selling of lambs and culling of ewes if required; changing the

FIGURE 2: Average daily pasture growth and feed requirements (kg DM/ha) on (a) the grass and (b) the legume experimental farmlets.

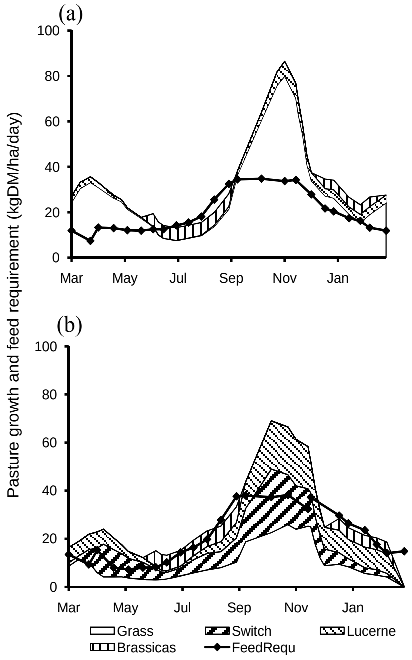


FIGURE 3: Pasture cover (kg DM/ha) for 2008/09 and 2009/10 on (a) the grass and (b) the legume experimental farmlets.

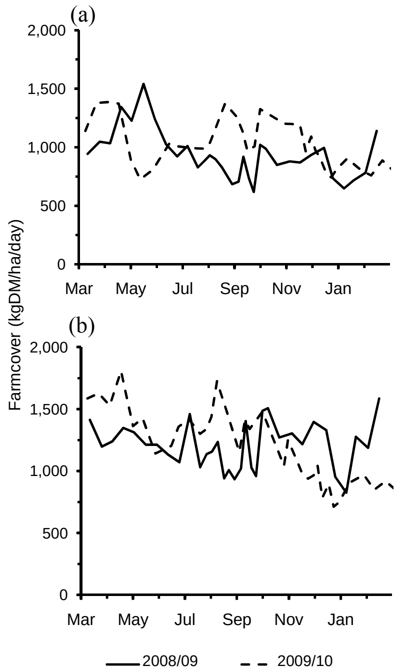
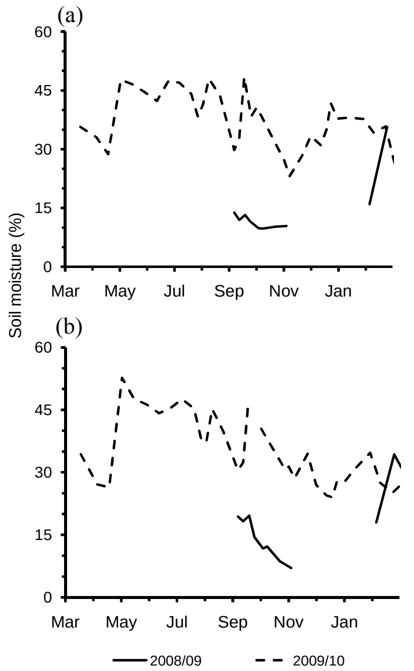


FIGURE 4: Soil moisture levels to 25 cm depth (%) for 2008/09 and 2009/10 on (a) the grass and (b) the legume experimental farmlets.



weaning date of the main mob lambs; and sale of store lambs at weaning based on projected feed availability. First cycle ewes comprised 7% and 20% of the SU on G and L respectively. The lucerne and leaf turnip paddocks on the grass unit and two lucerne paddocks on the legume unit were targeted for lamb finishing, but were also available for ewes if required. Home grown or purchased silage or balage was used as a last resort to fill feed supply deficits.

Permanent soil moisture probes were positioned at 25, 50, and 75 cm soil depth in three paddocks on each trial unit. Soil moisture readings were taken at weekly intervals from August to December and at fortnightly intervals for the rest of the year. Pasture cover was assessed on all paddocks on the same schedule, using a plate meter that was calibrated to the different pasture types every three months. Four grazing exclusion cages were placed in each of 12 paddocks, two each of the principal pasture types. Two cages in each of these paddocks were cut every two weeks to 2 cm to estimate pasture growth rates giving a 28 day cutting interval for each cage. Pasture samples were taken from the same paddocks at six weekly intervals, cut to 2 cm and sub-sampled for herbage quality analysis using near infrared spectroscopy and dissection into botanical species components. Five groups of either 30 or 40 ewes from the grass unit and three groups from the legume unit were weighed monthly from weaning through to one month before lambing and fortnightly with their lambs from six weeks after lambing to weaning. Ewes were laproscoped for ovulation rate five days before mating, and ultrasound scanned to determine pregnancy rank in June of each year. Lambing of first cycle ewes was planned to start on 13 August for the legume unit and 20 August for the grass unit, with the main mob of both units lambing on 6 September. Further details of stock and pasture measurements and management are provided in Bywater *et al.* (2010).

Variables initially investigated as indicators of the need to de-stock were soil moisture, pasture growth rate, and average farm cover. To be effective, de-stocking decisions need to be made and actioned within a short time frame. This needs to be three to four weeks, including any marketing delay which is usually seven to ten days, so as to pre-empt market responses to dry conditions, such as difficulty in obtaining space at the works and reduced price of store stock (Gicheha, 2011). Under the fortnightly pasture sampling regime used in this trial, we found that pasture growth rate information was not available soon enough to be useful. Also, pasture covers did not vary sufficiently to serve as a useful indicator, as shown below. On the other hand, soil moisture levels (SML) at 25 cm depth were read and available on a weekly basis and provided a clear indication of growing conditions. A value of 10% SML in the top 25 cm was used as the trigger to begin de-stocking as this approximates the point at which grass growth stops (N. Smith, Personal communication). A de-stocking priority list was defined for each unit, depending on sales to date and whether weaning had occurred. Trading cattle and cull ewes were generally sold first, followed by store lambs, prime lambs, and then capital stock.

RESULTS AND DISCUSSION

Pasture production and utilisation

Figure 2 shows pasture growth rates, calculated as a three period, rolling average over three years. Feed supply from brassicas over winter and late summer is the yield at the start of grazing divided by grazing days. The figure also shows the estimated feed requirements (Agricultural and Food Research Council, 1993) of the livestock calculated from the average number of stock and performance level recorded over the last two years of the trial. Overall, the feed supply and demand curves of the grass unit were reasonably well balanced, except for an excess feed supply during the peak spring and autumn growth periods (Figure 2a). For the legume unit (Figure 2b), there was a deficit in supply from mid December, managed through lamb sales, and in February/March. The latter was caused by the "switch pastures" not being available for grazing after over-sowing with annual ryegrass. The main pasture type available on the legume unit at this time of the year was lucerne. Despite farmer concerns over phyto-oestrogenic effects of lucerne, we have grazed lucerne in all three seasons prior to mating, although we moved the ewes onto grass just before putting the rams out, and have seen no clear evidence of any reduction in the scanning results, as detailed below.

TABLE 1: Average monthly temperature (°C) for the 2008/09 and 2009/10 growing seasons at Silverwood Farm in Canterbury.

Year	Month						
	Aug	Sept	Oct	Nov	Dec	Jan	Feb
2008-09	6.0	10.2	11.4	13.9	15.1	18.4	14.9
2009-10	9.0	9.4	9.0	12.7	14.6	15.7	17.2

TABLE 2: Lambing percentage at scanning and survival to sale for the two experimental farmlets.

Parameter	2008/09		2009/10	
	Grass unit	Legume unit	Grass unit	Legume unit
Scanning%				
1st cycle			176	171
Main mob			177	179
Overall	184	171	177	177
Survival to sale	127	106	139	136

Both trial units had low pasture covers throughout the year (Figure 3). This suggests there was high utilisation of the feed grown. The percentage utilisation calculated from the average pasture growth rates and the estimated average feed requirements (Agricultural and Food Research Council, 1993) shown in Figure 2 are 71.7% for the grass unit (10,414 kg dry matter (DM)/ha herbage production versus 7,472 kg DM/ha animal requirement) and 74.3% for the legume unit (10,336 kg DM/ha versus 7,682 kg DM/ha). These utilisation figures are slightly lower than we expected given the pasture cover profiles. Feed utilisation may be lower on the grass unit because average feed requirement was slightly lower than the legume unit since the cattle were not on the unit for the whole year. However, there is a closer fit between average feed demand and supply for the grass unit because of the late summer feed deficit around flushing and mating on the legume unit as discussed above.

The pasture-renewal programme on both units was an important means of ensuring adequate feed supply at critical times of the year; kale providing feed over winter on both units, leaf turnips for lamb finishing on the grass unit and forage rape for flushing ewes on the legume unit.

The feed quality of the pastures remained at or close to target levels of 11.5 MJ metabolisable energy/kg DM on both units in both years, as long as the pastures were growing. Details are provided in Bywater *et al*. (2011).

While this describes the average situation on both units, a key element of interest in the trial was the ability to manage climate variability. NIWA virtual climate station network data for mean monthly rainfall for 2008/09 and 2009/10 were included in Figure 1. Table 1 shows mean monthly temperatures from August to February for both years. These show that August 2008 was much cooler and wetter than in 2009 as well as being windier, whereas October and November were dryer and warmer in 2008.

This had a significant effect on the pattern of soil moisture levels between the two years. In 2008/09, SMLs reached 10% by volume by the first week in November, whereas in 2009/10 the SML remained above 20% by volume through to February (Figure 4). Soil moisture measurements began in July 2008, but there was a gap in data recording between late November 2008 and early February 2009 because of a malfunction in the meter reader. However the trigger point of 10% SML had already been reached by this time so that the malfunction had no effect on the management response.

TABLE 3: Stock sales and income for 2008/09 and 2009/10 for the two experimental farmlets.

Year and item	Grass unit					Legume unit				
	Number of head	Average live weight (kg)	Average value ($)	Total value ($)	Total weight[1] (kg)	Number of head	Average live weight (kg)	Average value ($)	Total value ($)	Total weight[1] (kg)
2008/09										
Works lambs	728	15.7[1]	75.76	55,156	11,409	299	16.3[1]	82.22	24,583	4,871
Store lambs	342	30.1	63.25	21,630	4,456	830	27.2	48.70	40,418	9,623
Cattle	54	519	1,016	54,880	14,772					
Less purchases	55	406	652	35,854	11,612					
Total				95,812	19,025				65,001	14,494
Per ha				1,091	217				764	170
2009/10										
Works lambs	864	17.0[1]	76.35	65,968	14,660	1,087	17.0[1]	75.07	81,602	18,472
Store lambs	273	30. 6	61.12	16,686	3,626	385	29.1	58.12	22,376	4,824
Cattle	49	525	821	40,233	13,383					
Less purchases	50	300	480	24,000	7,800					
Total				98,887	23,869				103,978	23,296
Per ha				1,126	272				1,222	274

[1]Carcass weight equivalent.

TABLE 4: Comparison of key indicators on the experimental farmlets with the Canterbury/Marlborough monitor farm (Ministry of Agriculture and Forestry (MAF), 2010).

Indicator	Grass unit			Legume unit			MAF monitor farm		
	2008/09	2009/10	Difference (%)	2008/09	2009/10	Difference (%)	2008/09	2009/10	Difference (%)
Effective area (ha)	87.8	87.8		85.1	85.1		469	469	
Number of breeding ewes	846	816	-3.5	1,066	1,082	1.5	2,250	2,250	0
Number of cattle	55	50	-9.1	-	-	-	150	130	-20
Total number stock units	1,231	1,172	-4.8	1,205	1,223	1.5	4,096	4,125	0.7
SU/ha	14.0	13.3	-4.8	13.7	13.9	1.5	8.7	8.8	0.7
Lambing % to sale	126.5	139.3	10.1	105.9	136.0	28.4	125.0	138.0	10.4
Net income/ha[1] ($)	1,211	1,170	-3.3	898	1,083	20.7	866	965	11.5
Direct costs/ha[2] ($)	351	357	1.6	492	481	-2.1	375	436	16.2
Gross margin/ha ($)	859	813	-5.4	406	602	48.2	491	530	7.9
Overheads/ha[3] ($)	72	61	-14.7	72	61	-14.7	80	72	-9.1
Surplus/ha[4] ($)	787	752	-4.5	334	541	61.7	411	457	11.2

[1]Includes sale of culls and wool and cost of replacements.
[2]Does not include labour.
[3]Farm overheads pro-rated/ha for grass and legume units; does not include interest costs.
[4]Does not include labour, wages of management or interest costs.

Ewe reproductive efficiency

Lambing percentages are shown in Table 2. While pregnancy scanning percentages were close to or in excess of the target of 175%, survival to sale did not attain the target of 145%. Ewe and lamb deaths were greater than expected on both units, with ewe deaths at 6.4% and 8.1% in 2008/09 and 7.3% and 6.5% in 2009/10 for the grass and legume units, respectively. Lamb wastage from scanning to sale was in excess of 40%. Adverse weather in August 2008 resulted in several ewe deaths particularly on the legume unit, and significant lamb deaths on both units. A confirmed outbreak of *Salmonella brandenburg* in 2009/10 would have contributed to, but may not be sufficient to explain all the deaths, particularly the lamb wastage. High stocking rates and particularly stock densities at lambing on the legume unit with over one third of the farm unavailable for grazing, combined with disturbance through tagging monitor ewes and their lambs soon after birth may also have contributed to the deaths. The high death rates on the legume unit were disappointing from the perspective of the overall trial objectives, and clearly affected the overall production and profitability of the unit in 2008/09.

Lamb growth rates from birth to sale, averaged over both years were 306.2 g/day ± 72.0 (standard error) and 297.4 g/day ± 77.1 for first cycle and main mob lambs on the grass unit and 266.2 g/day ± 100.6 and 295.8 g/day ± 76.6 on the legume unit. Target growth rate was 300 g/day. Further details are given in Bywater *et al*. (2011).

Climate-risk management

As noted above and in Figure 4, the SML dropped to 10% in the top 25 cm in the first week of November in 2008. This prompted the decision to begin de-stocking as rapidly as possible subject to availability of killing space. Weaning of both first cycle and main mob lambs was completed before the end of the month with drafts of lambs and first cycle cull ewes going to the works; all cattle were sold by 24 November; the remaining feed supply was assessed and light lambs which could not be finished were sold store in early December and any remaining cull ewes were sold over December and January as space became available.

In 2009/10, the SML did not reach the 10% trigger point and as a consequence, all weaning and sales were determined on weight alone. Two drafts of lambs were taken before weaning of the first cycle mob at the end of November; main mob lambs were weaned on 3 and 12 December on the grass and legume units respectively with cattle sold in January, cull ewes in February, and lambs sales through to mid-March.

Total stock sales and income are shown in Table 3. In 2008/09, only 26.5% and 68.0% of lambs from the legume and grass units, respectively, were sold to the works. A much higher proportion of lambs were sold early as stores on the legume compared to the grass unit because at weaning in 2008 there was little feed available on the former, primarily because of very poor performance of lucerne paddocks that were old stands. In contrast, 73.8% and 76.0% went to the works from the legume and grass units, respectively, in 2009/10. Thus, the high lamb wastage rate in 2008/09 was compounded by poor finishing on the legume unit.

The main objectives of risk management responses are to maximise performance in good years and to minimise losses in poor years, so as to reduce the variability in performance and profit between years. As a result of the rainfall patterns in 2008/09, pasture growth rates decreased early and a high proportion of lambs were sold early as stores. The dry conditions lasted until February (Figure 4) and had the potential to cause a significant feed deficit that would restrict ewe intake prior to mating potentially leading to a lower lambing percentage in the following season. The flexibility built into both trial units and the risk management responses worked well in this situation with essentially all stock sales completed within three-and-a-half weeks of reaching the trigger point of 10% SML, except for some cull ewes which took longer to move off farm. Both units came through the dry spell with no real difference in pasture covers between the two years, and pregnancy scanning percentages were similar in both years (Table 2). Covers between November and February on the legume unit were slightly higher in 2008/09 (Figure 3). Unfortunately because of the high lamb wastage rate and failure of the lucerne on the legume unit, this did not translate into high production and profitability for the season on that unit. In contrast, 2009/10 was a much more favourable season for lamb survival and finishing and all stock were held on the trial units for much longer, which is reflected in the overall financial results.

In Table 4 some key indicators of farm productivity and profitability for the two trial units are shown in comparison with results from the Canterbury/Marlborough breeding and finishing sheep and beef monitor farm model (Ministry of Agriculture and Forestry, 2010). Note that the farm size and stocking rates are markedly different for the two trial units compared to the monitor farm. Nevertheless, with the exception of the poor performance on the legume unit in 2008/09, the lambing percentage to sale is similar on the two units to that on the monitor farm.

Net income, gross margin and surplus after overheads on the grass unit were significantly higher but the differences between years were much lower than on the monitor farm. The surplus on the grass unit was 91.6% and 64.5% higher than the monitor farm in the two years. This suggests that it is not only possible to increase profitability but by building in the ability to identify and respond rapidly to changing growing conditions, to reduce year to year variability in profitability, that is to reduce risk.

The same cannot be said for the legume unit (Table 4) which, as discussed above, experienced difficulties in 2008/09. The main reasons for the difference between years on this unit were the high lamb wastage and failure of the lucerne in 2008/09, neither of which relate directly to the risk management responses used. Nevertheless it is clearly not possible to conclude that the risk management responses conveyed any advantage on this unit.

CONCLUSION

The management strategies used in the trial were successful in maintaining pasture quality and lamb growth rates at or close to target levels. However, the difficulties experienced on the legume unit demonstrate that rainfall variability in late spring is not the only source of risk in dryland farming. However, monitoring soil moisture provided a relatively simple and inexpensive way to identify a trigger for initiating tactical responses to this variability. On the grass unit, cattle provided a flexible stock class, increasing stocking rate to control pastures without increasing the number of ewes at flushing and lambing. Although the results for this unit suggest that building in flexibilities to deal with climate risk and responding to low SML can reduce variability in financial performance, this conclusion must be qualified by the fact that these were un-replicated trial units. It was not possible to consider different SML trigger levels or compare results over additional years with different weather patterns. An evaluation of different trigger levels with different management strategies and flexibility options, over 20 years of price and weather data is being undertaken using the Lincfarm simulation model, based on the trial results presented here (Gicheha, 2011).

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