Dryland Sheep Systems in Canterbury and Marlborough

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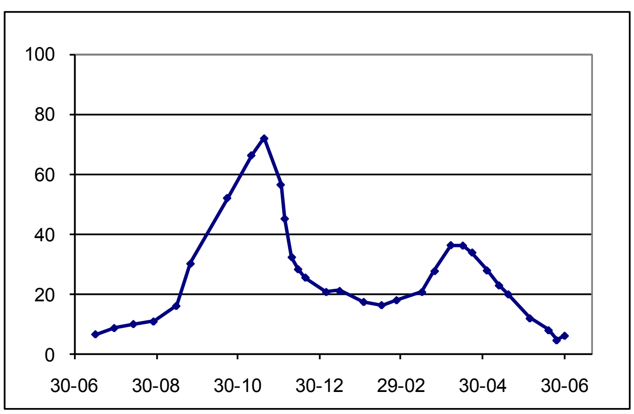
Introduction:

Livestock production in New Zealand is based primarily on pasture and forage for all classes of ruminants (Waghorn and Clark, 2004). Increasingly, sheep and beef cattle are being confined to dry hill country and some un-irrigated plains as the irrigated land is converted to dairy and cropping. Dryland farming on the east coast of both main islands is subject to significant climate variability. Rainfall is the main climatic factor constraining pasture growth, with spring and summer rainfall accounting for 60% of the variation in pasture production in New Zealand (Radcliffe and Baars, 1987). Baars and Waller (1979) identified both rainfall and temperature as influencing pasture production, with temperature playing an important role in pasture growth in winter and early spring.

On the Canterbury plains for example, winters are normally cool and wet and summers warm and dry - but not always so. Spring and autumn can either be wet or dry, warm or cool. A *typical* pattern of dryland pasture growth is shown in Figure 1. There is low growth during winter because soil temperatures are too low even though there may be sufficient moisture. Growth accelerates from mid August as soil temperatures start to increase, reaching a peak around October/November followed by an abrupt drop in growth as soils dry out because of lack of rainfall in summer (any time from October onwards). A resurgence of growth may occur with autumn rains in April/May followed by a return to low growth again as temperatures drop from June onwards.

Figure 1: Three year average growth rate (July-June) of Ryegrass:White clover swards (kg DM/ha/day) at Hororata in Mid-Canterbury.



(Bywater *et al.*, 2010)

However, spring growth may be delayed because of cooler or dryer conditions than are typical; spring/summer growth may cease early if there is little rainfall after September or it may continue throughout the season if there is a wet summer; there may or may not be autumn rain. Dryer, cooler conditions early in the season (September/October) *may* be followed by wetter, milder conditions later (November/December) so that growth patterns can be almost reversed. There have been some years when there was no rain for 18 months; the 1988-89 drought for example is estimated to have cost farmers on the east coast of the North Island $240 million in reduced income and the total region $1000 million (Nield, 1990). Dryland areas in Marlborough exhibit similar variability and growth patterns to Canterbury but being further north, generally experience a slightly earlier start in spring.

Although this is a typical pattern of growth, an analysis of 30 years of data from the NIWA virtual climate station network (Tait *et al.*, 2006) for Hororata in mid Canterbury (Latitude: -43.559962, Longitude: 171.84911) shows that in fact average monthly rainfall does not vary very much between months (Table 1). However, the variability across years is extremely large, with the highest standard deviation and range in August and the lowest in October and November. This variability in rainfall and thus pasture production between years, particularly in the critical period of late spring/early summer, represents the major source of risk for farmers trying to finish lambs before the dry period.

Climatic variation affects both feed availability and nutritional quality. Thus pastoral livestock production in dryland areas is constrained by this within- and between-season variability in feed supply which introduces uncertainty and risk and significantly complicates management.

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Table 1: Average Monthly Temperature and Rainfall for 30 years at Hororata, Mid-Canterbury

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Rainfall (mm per mo)												
30 yr Avg	50.0	58.0	58.7	62.0	61.2	58.2	63.7	75.5	57.0	63.9	56.7	61.7
SD	29.16	45.59	45.55	53.95	30.43	38.83	35.97	63.45	36.94	26.13	25.81	29.62
Min	11.4	10.2	5.6	5.6	15.1	9.7	1.3	8.3	2.3	23.8	6.7	9.8
Max	127.5	231.2	181.8	244.4	158.1	187.5	148.6	279.4	159.3	131.5	118.5	139.2
Temp (Daily average ^{O}C)												
30 yr Avg	16.5	16.1	14.1	11.6	8.3	5.9	5.7	7.0	9.2	11.2	13.0	14.9
SD	1.21	1.15	1.11	1.49	1.02	0.95	0.82	1.14	1.31	0.92	1.17	1.19
Min	14.0	13.2	11.6	9.4	5.8	4.2	4.0	5.0	6.4	9.2	10.5	12.9
Max	18.6	18.4	15.9	17.0	10.8	7.6	7.4	9.1	12.1	13.2	15.2	17.7

Traditional Dryland Systems:

From a livestock production perspective, the year can be divided into three or four distinct periods or phases. There is generally adequate high quality grass growth in most years to support production from mid-August (earlier in Marlborough) through to anytime after October when soils dry out and grass growth stops. This provides a 3 to 5 month 'window of opportunity' for production and most farmers aim to lamb in August/September (July/August in Marlborough) and have the majority of their lambs finished before Christmas.

As indicated above, the production window is highly variable in length so over the late spring and summer (typically November to February), farmers are in a high risk period when conditions can dry out quickly. The main source of uncertainty and risk is thus the timing of when conditions dry out and grass growth ceases. Most commentators note that farmers generally wait too long to respond to drying conditions in the hope that there will be some rain, grass growth will recover and they will be able to put more weight on their lambs before sale. In reality, there is the very strong possibility that lambs remaining on the farm during this period will not grow well because of inadequate feed quantity or quality or both. With typically falling prices from November onwards, it is often better to sell lambs as store stock early than keep them in the hope of finishing them for the works, only to be forced to sell them as stores later.

The second most difficult period is late summer/autumn in terms of providing adequate feed quantity and quality for flushing and mating ewes to ensure high lambing percentages in the following season. This can be exacerbated if lambs are retained on the farm, grow slowly over summer and are held too long. The longer lambs stay on the property, the more likely it is that they will start to compete with ewes for the best available feed as ewes are flushed in late summer prior to mating in March/April.

Once mating is over, typically large mobs of ewes are used to clean up remaining pastures in autumn prior to wintering either on brassica crops or on less favourable areas of the farm such as the hilly areas.

Avery *et al.* (2008) have characterised this annual pattern into the revenue phase (August to November), the risk phase (December to February) and the recovery phase (March to May), plus winter (June, July).

Traditionally, dryland farming along with most other forms of pastoral farming in New Zealand has been based on ryegrass:white clover pastures. Farmers on dry plains and rolling hills in Canterbury and Marlborough have generally taken a conservative approach by stocking at relatively low stocking rates (9-10 stock units (SU) ha^{-1} on the plains and 3-6 SU ha^{-1} on the hills), utilising cattle to provide some flexibility and in good years either buying in additional stock or conserving surplus growth as hay or silage. The problem of course is that if it's a good year, everyone wants to retain their stock as long as possible and buy in extra, so the store stock price goes up. In a poor year, everyone is trying to sell their stock early and no one wants to buy store stock; so the price drops. Export prices for finished stock on the other hand are influenced by international markets and generally have little to do with local climate. So there is a reasonable correlation between annual rainfall and store stock prices, but essentially no correlation between climate and export prices (Gicheha, 2011).

Ewes and lambs are normally set stocked from just before lambing to weaning. Another major problem with the traditional approach is that with a relatively low stocking rate, it is highly likely that during the

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period of peak pasture growth (usually October/November), farmers will find it extremely difficult to keep pasture mass under control with the consequence that pasture quality deteriorates even when there is sufficient moisture to maintain growth. High pasture mass of low quality material will not support high lamb growth rates of 300-400 g/day which is quite possible on high quality pastures and legumes and is what is required if a high proportion of lambs are to be finished before the risk of drying out starts to increase. Typical pre-weaning growth rates in these circumstances are 250g/hd/day or less leading to retention of lambs for longer and competition with ewes for feed as noted above.

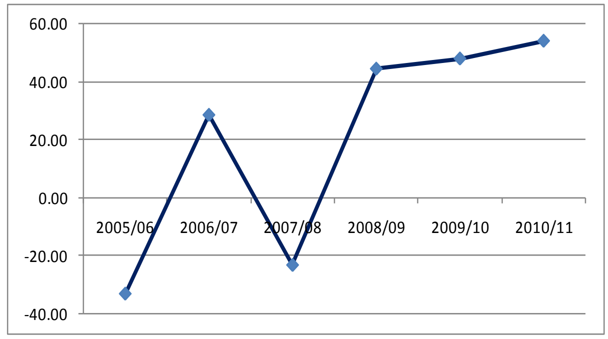
The importance of feed quality in all forms of livestock production has been increasingly recognised by farmers over the last two decades. Dairy farmers were probably the first to focus on feed quality since the consequences are immediately obvious in the vat. But dry stock farmers are also becoming much more aware of the influence of feed quality on growth rate, the time and total amount of feed required to finish lambs, and the impacts these have on the rest of the system (Brown, 1990).

In addition, if the summer dry period is long enough or severe enough, traditional pasture species may not recover easily or quickly when it rains again. As soon as pastures start to green up, farmers with few alternatives are forced to put stock back onto them too soon, damaging the pastures further, compromising current and future production, and increasing the number of paddocks that have to be replaced with the associated costs of doing so. Moreover, pastures grazed bare of vegetation are much more vulnerable to water and wind erosion, leading to loss of top soil and environmental problems elsewhere in catchments. A prolonged sequence of drier than average years has led to major concerns over environmental impacts of over-grazing in some areas (eg. Avery *et al.*, 2008). Even without severe summer dry periods, the persistence of some pasture species in dryland conditions is an issue, meaning that pasture renewal is likely to be required more frequently (Fraser *et al.*, 1999).

Given these problems, dryland farmers have struggled over recent years to make a decent return. Data from MAF (2010) on farm surpluses available for re-investment (cash surplus from farming operations minus living costs) on the Canterbury/Marlborough Sheep and Beef Monitor Farm are shown in Figure 2.

Two out of the last six years have resulted in a loss once family drawings are accounted for. Even where a profit has been made, the returns are well short of the returns possible through dairy and cropping activities which is why drystock farming is being

Figure 2: Surplus available for re-investment ($/ha) on the Canterbury/Marlborough Sheep and Beef Monitor Farm (MAF, 2010)[1]



[1] 2010/11 is a budget estimate.

pushed back onto the hills and less favourable (un-irrigated) flats as the better land is converted to these other uses.

Alternative Approaches:

The issue then in dryland livestock production comes down to how best to utilise the 3-5 month window of opportunity for production, the revenue phase as described by Avery *et al.* (2008). In most years, it is possible to grow high quality grass or forage during this period to support lamb production. The challenge is to optimise productivity and profitability in this period and do so consistently from one year to the next, despite the highly variable rainfall patterns.

The key variable in this context is lamb growth rate. To put it simply and taking an extreme example, lambs growing at 100 g/day will take 300 days to gain 30 kg from birth weight to drafting weight whereas lambs growing at 300 g/day will take 100 days. Lambs born weighing 4 kg in mid-August will reach an acceptable drafting weight of 34 kg by the last week in November growing at 300 g/day; it would take to the middle of June the following year if they only grow at 100 g/day.

While this is obviously an overly simplistic comparison, the reality is that a few weeks difference in the time taken to reach drafting weight can make a huge difference to productivity and profitability in dryland environments. The longer it takes, the greater the risk of conditions drying out, the higher the probability that growth rates will decline with deteriorating feed quantity or quality, pushing drafting further and further out and increasing the possibility of compromising ewe condition prior to mating and thus next years lambing percentage. In addition, more feed will be required to finish the lambs and there is a greater chance that pastures will be over-grazed, compromising their future productivity and risking environmental degradation.

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The emphasis recently has therefore been on two main areas; improving feed quality in order to ensure high lamb growth rates; and finding ways of either building flexibility into dryland systems to more easily and rapidly respond to changing conditions, and/or of reducing the risk by using pasture species more tolerant of dry conditions.

Key factors in keeping grass based pasture quality high are a high proportion of green leaf with little reproductive development and low dead matter accumulation (Litherland & Lambert, 2007) and high legume content (Hyslop *et al.*, 2000). Pasture quality can be improved either through growing different species or by keeping the more traditional species – ryegrass:white clover – in a uniform and actively growing state by maintaining pasture mass within a fairly narrow band through increased grazing pressure. Increasing the grazing pressure generally means increasing stocking rate which therefore increases the risks and consequences of running out of feed when conditions dry out, making it more important to build in flexibility to retreat from a high stocking rate when required.

The difficulties with using higher quality forage species is that these species generally have low cool season growth rates and often require different grazing management to the more traditional species. Deep rooted species like lucerne and chicory are more tolerant of dry conditions but become dormant or semi-dormant over winter and cannot be set stocked, requiring grazing intervals of 4-6 weeks. Thus they need to be combined with other feed sources to cover winter/early spring and require rotational grazing rather than set stocking which has been the traditional management from lambing to weaning. They therefore require a fairly fundamental shift in thinking and a greater emphasis on managing pastures to accommodate the growth requirements of the plant than ryegrass:white clover swards which are more tolerant of poor grazing management. On the other hand, many legumes and herbs will retain their quality for much longer than ryegrass if left un-grazed and once they dry out.

The Winchmore Trials:

Fraser *et al*. (1999) compared conventional ryegrass:white clover pastures with a mix of improved pastures in farmlet trial at Winchmore in mid-Canterbury. The trials were conducted on a Lismore stony silt loam soil without irrigation. Each farmlet was 4.4 ha with 12 paddocks. On the improved farmlets, 5 paddocks were planted in a mix of hybrid ryegrass, chicory and white clover, 4 were chicory and red clover and 3 were tall fescue and white clover. On the control farmlets, all 12 paddocks were in ryegrass and white clover. Stocking rate was 12 ewes ha^{-1} over winter with ewes re-randomised to farmlets prior to mating each autumn. Grazing management was the same on both farmlets with ewes and lambs rotationally grazed on 3-10 day shifts from lambing to weaning on the 11 November.

Except for a higher growth rate of chicory pastures over summer, all pastures on both sets of farmlets grew at similar rates during the year, with a pattern similar to that shown in Figure 1. Farm cover was higher on the conventional farmlets over most of the year but pasture quality, as measured by green grass leaf plus clover or chicory leaf vs dead material, was higher on the improved farmlets. For the two years reported, pre-weaning lamb growth rates were slightly but significantly higher on the improved pastures (300 vs 284 and 312 vs 289 g/day in year 1 and 2) and post weaning growth rates were much higher (292 vs 150 and 298 vs 133 g/day). The higher growth rates led to a large difference in the proportion of lambs drafted by the first week in January, when all remaining lambs were sold as store. On the improved farmlets an average of 92% and 97% of lambs were drafted to the works in years 1 and 2 with only 53% and 58% drafted on the conventional system. Ewe liveweight in late summer was 6 and 4 kg heavier on the improved farmlets. No differences in lambing percent are reported since ewes were reallocated to farmlets prior to mating.

These trials confirm the advantage of high feed quality on lamb growth rate and income ha^{-1}. Income on the improved farmlets was \$104 ha^{-1} and \$94 ha^{-1} higher than on the conventional farmlets. However, the trials also illustrate some of the difficulties of using different species to achieve high feed quality. Considerably less pasture was conserved on the improved farmlets than on the conventional farmlets in both years while more was fed on the improved farmlets, especially in the second year of the trials. Overall, there was a surplus on the conventional farmlets in year 1 and deficits on the improved farmlets in both years and on the conventional farmlet in year 2. This suggests a higher bought-in feed cost (not reported) for the improved farmlet. In addition, the trial protocol included a higher rate of pasture renewal for the improved than for the conventional farmlets, also indicating higher costs. A companion trial with the same species compared under irrigation (Moss *et al.*, 2000) showed that the advantage to the improved pastures disappeared by the third year due to a reduction in clover percentage and an increase in weed invasion. Total costs and returns are not reported for the trials, so it is not possible to say whether there was an overall dollar advantage to the improved system over the conventional system or how large any difference might have been. Never the less, they clearly

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illustrate the effect of pasture quality on lamb growth rate and ewe liveweight prior to mating.

Bonavaree:

A more radical approach to improving feed quality, productivity and profitability is illustrated by the changes which have been implemented on the Avery farm in north eastern Marlborough over the last decade or so which have been reported in the popular press (Moot *et al.*, 2008) and academic literature (Avery *et al.*, 2008). Bonavaree is an 1100 ha dryland property on rolling hill country with 400 ha of cultivatable land in valley bottoms and lower slopes and 600 ha of grazeable hill slopes, of which 75% are north facing (sunny faces) and 25% south facing (shady faces). The farm runs 2450 breeding ewes and 650 hoggets with 150 breeding cows and 60 young stock. 100 Friesian bull calves are bought in spring and sold the following spring. In the past, pastures were mainly ryegrass:white clover with approximately 50 ha of lucerne grown for hay and seed production and some brassicas used to finish lambs in late summer and grow replacement hoggets.

Six consecutive years of below average rainfall starting in the late 1990's had seriously affected the financial viability of the property. The failure of ryegrass and white clover to survive prolonged dry periods and provide a reliable feed supply had led to overgrazing of the rolling hill country and serious degradation of the soil resource. The need to renew pastures when the cost could be ill-afforded, and affects on ewe reproduction of competition for feed in late summer and autumn indicated the need to change to a system which could generate a higher and more reliable income from a low and variable supply of moisture. In 1998 following attendance at a field day on lucerne, the decision was made to completely change the farming system to one based on lucerne, rotationally grazed directly by stock whenever possible.

On Bonavaree, lucerne is renewed by overdrilling annual grass into older stands which will be used as the "transition" feed the following spring (from around the third week in August) before ewes and lambs are turned out onto the younger lucerne paddocks. The transition and run-out grass paddocks are sprayed out in mid-October and left fallow to conserve moisture until planting with Omaka forage barley in mid-February. When there are autumn rains, the barley may be used for flushing or grazed before being shut up on the 10 July; otherwise it is held over for lambing which starts on the 23rd July. Following two years of barley, paddocks are sprayed out in mid-September and direct drilled with lucerne again in mid-October.

By 2007-08, 300 ha of the farm was in lucerne, 50 ha was in Omaka barley and 20 ha in annual ryegrass, accounting for most of the cultivatable land. The results of this paradigm shift in the farming system have been quite spectacular. After a few years of teething problems and learning how to manage both the lucerne crop and the health of the animals grazing it, economic farm surplus (EFS) has increased from around \$20 ha^{-1} in 2004-05 to around \$140 ha^{-1} in 2007-08 (Avery *et al.*, 2008) at a time when the national average EFS on sheep and beef farms dropped from around \$160 ha^{-1} to \$30 ha^{-1} (MAF, 2007).

The system on Bonavaree is geared to maximising the growth rate of sale stock during the "revenue phase" between August and November with a target of having all sale lambs off the property by the end of November. With ewes and lambs grazing lucerne on 7-10 day shifts, followed by bulls or steers to clean up the less palatable stems, pre-weaning lamb growth rates are between 350 - 400 g/day and 80% of the lambs are sold by the end of December.

By mid October, decisions have been made on contingency plans for all stock classes when conditions dry out. This includes sale of remaining lambs on the store market, sale of bulls, and if necessary sale of cows with calves at foot. If these decisions have been made and implemented appropriately, problems can be avoided during the "risk phase" from December through February so that there is no need to be finishing stock in dry conditions, there is no need to put weight on ewes over this period, and moisture is conserved in the fallowed paddocks by spraying out any weeds again if necessary. Once conditions dry out, ewes and cows are moved onto the shady faces of the rolling hills avoiding damage to the more vulnerable sunny faces.

During the "recovery phase" between March and May, the emphasis changes to ensuring the sustained productivity of the lucerne stands by allowing them to achieve 100% flowering and replenish root reserves. They are then hard grazed in autumn with the order of the clean-up grazing determining the order in which the paddocks are grazed by ewes and lambs the following spring. Ewes are flushed and mated on lucerne or if necessary may remain on the shady hill faces, supplemented with balage and peas to assist with flushing.

A few days after hard grazing, the lucerne paddocks are sprayed for weeds and then spelled until they are brought back into the rotation in spring. Ewes are returned to the hill country with the cows until just before lambing on the Omaka barley.

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By ensuring high lamb growth rates and by including flexibilities in the system with various classes of cattle and the option to sell store lambs or purchase trading stock, the returns on the Avery property have not only increased markedly but the variability in income has been significantly reduced. While the climate remains variable, operation of the system and its outcomes is much more predictable. A similar philosophy and approach was built into a recent trial at Hororata in mid-Canterbury but based on a more conventional ryegrass:white clover feed base.

The Silverwood Trials:

The Silverwood high performance sheep systems trials at Hororata (Bywater *et al.*, 2010) set out to investigate and demonstrate key aspects of productivity and profitability in dryland environments, including high pasture quality and utilisation and flexible management strategies to allow rapid destocking as soon as conditions dry out. Two large scale research and demonstration units (87.8 and 85.1 ha), each with 16 paddocks, were stocked at 14 stock units (SU) ha^{-1} rather than the district average of around 9-10 SU ha^{-1}. One unit was a conventional grass based unit with a predominance of perennial ryegrass and clover swards plus some paddocks with a mix of cocksfoot or tall fescue with ryegrass and clover. Clovers included subterranean, which is endemic in the district, and white and red clover sown in the pastures mixes. One paddock was in lucerne and two paddocks were renewed each year through kale planted in October/November for winter feed followed by a) barley for silage planted in October and then perennial pasture planted in March, and b) leaf turnip planted in October and under sown with a perennial pasture mix. In some instances, paddocks scheduled for renewal the following spring were over drilled with annual ryegrass in autumn to provide an early source of good quality feed for a 1st cycle ewe mob.

The other unit was a high legume unit with 5 paddocks in perennial grass mixtures, 4 in lucerne and 5 in “switch” pastures which are a mix of annual and perennial clovers oversown with annual ryegrass in February/March each year, plus 2 paddocks going through a similar renewal programme but with rape substituted for leaf turnip to provide high quality feed for flushing.

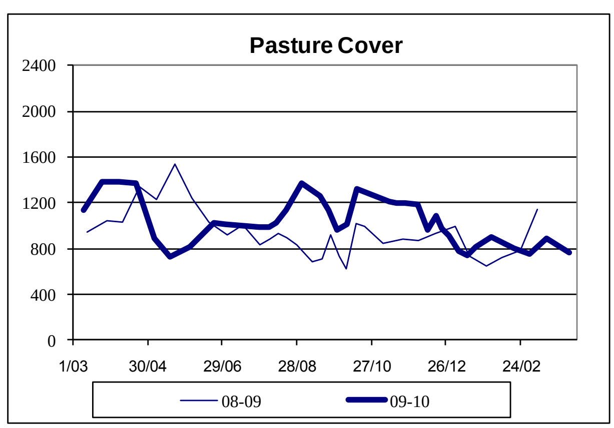
The emphasis here will be on the conventional grass based unit. Flexibilities built into the system included approximately 23% of stock units as 18 month old cattle, bought in May and sold any time after October when conditions dry; approximately 7% of older ewes (1st cycle mob), mated and lambed three weeks earlier than the main mob (20th August vs 6th September) which could be weaned early if required and ewes sold as culls; a flexible weaning date for both mobs with a target weaning weight of 24 kg but earlier weaning if required to reduce feed demand; and a policy of retaining only those lambs which could be finished on feed available when conditions dried out with the bottom end sold as stores as early as possible. The lucerne and the leaf turnip also provided some flexibility, providing high quality feed for finishing lambs if there was sufficient other feed to carry the ewes through, or saved for ewes if there was not sufficient feed.

Ewes were set stocked in individual paddocks from one week prior to lambing and then mobbed up after weaning to clean out the grass paddocks over summer. Ewes were flushed and mated on the best available paddocks and rotated round the pastures before wintering on kale with a daily supplement of barley silage. Cattle were also wintered on kale and silage and moved out into the sheep paddocks when required to maintain pasture mass below 1500 kg DM ha^{-1}. This ensured that pasture quality was kept at a high level throughout the season for as long as there was sufficient moisture to keep pastures growing.

The trigger to begin destocking (sale of cattle, weaning and sale of 1st cycle ewes, earlier weaning of main mob, and sale of store lambs) was the soil moisture level in the top 25 cm of soil (SML_{25}). This was measured weekly with relatively inexpensive moisture probes with the trigger value set at 10%.

One of the main objectives of the trial was to demonstrate that close control of pasture mass would result in high quality pastures which would lead to high lamb growth rates. Cover on the farm (Figure 3) did not vary very much throughout the season despite very large changes in both pasture growth rates (as shown in Figure 1 earlier) and feed demand. For 2009-10, pasture mass averaged 1135 ± 210 kg DM ha^{-1}. Average pasture utilisation over

Figure 3. Pasture Cover on the Grass Unit at Silverwood



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the two years of the trial, calculated from growth rates estimated from exclusion cages and animal requirements estimated according to AFRC (1993) was 72%.

Pasture quality, measured every six weeks in seven monitor paddocks, varied between 10.82 and 12.45 MJ ME kg^{-1} from April to early November when conditions dried out in 2008-09, and from 10.97 to 12.5 MJ ME kg^{-1} from April through to mid January in 2009-10. The second year of the trial was much wetter and SML_{25} remained above 20% throughout the season. Most paddocks were close to or above the target value of 11.5 MJ ME kg^{-1} for most readings (Bywater *et al.*, 2010).

Average lamb growth rates for 1st cycle and main mob lambs are shown in table 2 for the two years of the trial. While these are slightly lower than the growth rates achieved at Bonavaree on lucerne, they nevertheless demonstrate that high growth rates are achievable with conventional pastures even with low pasture mass if they are maintained in an actively growing state and their quality is high.

Table 2: Average pre-weaning growth rates of single and twin lambs at Silverwood

		2008-09	2009-10
1st Cycle	Singles	353.8	354.4
	Twins	301.6	294.9
Main Mob	Singles	359.8	365.4
	Twins	302.1	314.3

Bywater *et al.*, (2010)

The main objectives of using a high stocking rate with flexibilities built into the system to allow a rapid reduction in stock numbers when conditions dry out are to maximise performance in good years and minimise losses in poor years, in other words to reduce risk, the variability in performance and profit between years (Bywater *et al.*, 2011). As noted above, conditions dried out (SML_{25} reached 10%) around the first week of November in 2008-09. This prompted the decision to begin destocking as rapidly as possible subject to availability of killing space. First cycle ewes were weaned on 12th November with 28.5% of lambs going to the works at weaning; dry and 1st cycle cull ewes were sold on 19th November; 19 cattle had already been drafted and the remaining 35 were sold on 24th November; main mob ewes were weaned on 30th November with 22.5% of lambs going to the works; feed was assessed and light lambs which could not be finished were sold store in early December; remaining cull ewes were sold over December and January as space became available. Because of the season, only 68% of lambs were finished, with the remainder sold as stores but early in the season before the price really dropped.

In 2009-10, SML_{25} did not reach the 10% trigger level at any time during the season and as a consequence, all weaning and sales were determined on weight alone. First drafts of lambs were taken on 16th November with a second cut on 29th. 1st cycle ewes were weaned on 29th November, main mob ewes were weaned on 3rd December with cattle sold in January, cull ewes in February, and lambs sales through to mid-March. 76% of lambs went to the works with only 24% sold as stores.

The dry conditions lasted until February in 2008-09 with the potential of a significant feed deficit and poor feeding of ewes prior to mating leading to lower lambing the following season. The flexibilities and 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 (except for cull ewes which took longer to move off farm) so that the unit came through the dry spell in good condition. This is evidenced by the fact that there is no real difference in farm cover between November and February in the two years (Figure 3) and scanning percentages were only slightly reduced in the second year (177.2% in year 2 vs 184% in year 1).

Some key indicators of performance and profitability are shown Table 3 compared with results from the MAF Canterbury/Marlborough sheep and beef finishing monitor farm model (MAF, 2010) for the two years of the trial. Note that the stocking rates are significantly different between the trial unit (close to 14 SU ha^{-1}) and the monitor farm (9 SU ha^{-1}) but lambing percentages to sale are similar on both. While there are small differences in stock numbers between years, the differences between years in net income, gross margin and surplus per SU on the trial unit are much smaller than the difference between years on the monitor farm indicating that the ability to identify and respond rapidly to changing growing conditions can reduce year to year variability in financial results (ie. reduce risk). Results per ha are confounded slightly by small changes in stocking rate but the same pattern is evident. It is our view that the use of soil moisture probes to track growing conditions provides an opportunity to react perhaps no more than two weeks sooner than might otherwise be the case, but even this short time frame can make all the difference to stock sales (availability of killing space), income and returns.

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Table 3: Comparison of Key Indicators with the Canterbury/Marlborough Monitor Farm[1]

	Trial Unit			MAF Monitor Farm		
Effective area (ha)	87.8			469		
	2008-09	2009-10	Diff %	2008-09	2009-10	Diff %
Breeding Ewes	846	816	-3.5	2250	2250	0
Cattle	55	50	-9.1	150	130	-20
Total Stock units	1231	1172	-4.8	4096	4125	0.7
SU / ha	14.0	13.3	-4.8	8.7	8.8	0.7
Lambing % to sale	126.5	139.3	10.1	125.0	138.0	10.4
	$	$		$	$	
Avg Works Lamb Price	75.76	76.35	0.8	84.09	80.00	-4.9
Avg Store Lamb Price	63.25	61.12	-3.4	66.31	76.00	14.6
Avg Cattle Price[2]	273.56	273.12	-0.2	980.00	840.00	-14.3
Net Income/ha[3]	1,210.57	1,170.11	-3.3	865.74	965.46	11.5
/SU	86.34	87.65	1.5	99.13	109.77	10.7
Direct Costs/ha[4]	351.49	357.01	1.6	375.07	435.94	16.2
/SU	25.07	26.74	6.7	46.80	49.56	5.9
Gross Margin/ha	859.08	813.11	-5.4	490.67	529.52	7.9
/SU	61.27	60.91	-0.6	52.32	60.20	15.1
Overheads / ha[5]	71.62	61.11	-14.7	79.71	72.44	-9.1
Surplus/ha[6]	787.46	751.99	-4.5	410.96	457.08	11.2
/SU	55.51	56.33	1.5	42.38	51.97	22.6

[1] The Canterbury/Marlborough Breeding and Finishing Sheep and Beef Farm model comprises farms in coastal areas, located on the dry downs and plains, in irrigated areas, and in the higher rainfall upper plains. There is a wide range of farm size, stocking rate, stock class and performance. MAF (2010). [2] Cattle price for the trial unit is on Carcass weight and for the Monitor Farm on Liveweight. [3] Includes sale of culls and wool and cost of replacements. [4] Does not include labour [5] Farm overheads pro-rated ha^{-1} for trial unit; does not include interest costs. [6] Does not include labour, wages of management or interest charges.

A more comprehensive analysis of management flexibilities and risk responses in this situation has recently been completed by Gicheha (2011) using the simulation model LincFarm. The analysis considered 7 different combinations of pasture types and stock classes, each run at 4 different stocking rates with 3 different trigger values for SML_{25}. The analysis identified a range of risk efficient combinations of management flexibilities and risk response triggers from low risk, low return options (low stocking rate and high SML_{25} trigger value) to high risk, high return options (high stocking rate and low SML_{25} trigger value) with some intermediate strategies. This provides farmers with a choice of risk:return profiles and production systems to suit their attitudes to risk and to different combinations of pastures, stock and stocking rate. Interestingly, all risk efficient combinations which included the ability to respond dynamically to climate risk include cattle, whereas none of the risk efficient combinations which do not include the possibility of reacting to climate conditions include them. If cattle are included in sheep farming systems as a separate fixed production policy, they are a liability exacerbating feed shortages in dry periods. If they are included as a flexible stock class which may be sold at short notice when conditions dry out, they are an asset.

Discussion:

With an increase in cropping and dairy farming on the best land, sheep and beef producers are being pushed onto the hills and poorer, un-irrigated flat land. Traditional dryland farming systems based on ryegrass and white clover with low stocking rates to reduce the risks and consequences of feed shortages caused by a highly variable climate are

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unlikely to generate acceptable levels or stability of income. Moreover, the potential for soil degradation in such systems is quite high threatening their sustainability in the long run.

The challenge is to maximise revenue generation during the period of relatively reliable pasture growth starting in mid-August and finishing whenever conditions dry out in summer and build sufficient flexibility into the production system to be able to react quickly to drying conditions so that the operation and outcome of the system is relatively predictable even when the weather pattern is not.

The key to achieving high lamb growth rates, allowing animals to be finished and sold off the farm in a short time frame, is feed quality and there are a number of alternative ways to develop feed supply systems which are adapted to the growing conditions and reliably provide quality feed when required. Strict control of traditional pasture species is one option, combined with other feed sources to allow capital stock to be maintained during and immediately after dry periods so as to protect pastures from damage with the associated chance of environmental degradation. High quality, warm season plants such as lucerne and chicory can be combined with cool season plants such as annual ryegrass or forage cereals as another option to generate predictable, high performance systems.

Analysis indicates that there is a range of different combinations of pasture types, stock classes and stocking rates which are risk efficient from a risk: return perspective but the key factors involved are ensuring high quality feed to allow rapid growth and sale of lambs and flexibility to react to the situation when conditions dry out so that the operation and profitability of the farm remains predictable even when the climate is not.

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