Adapting farm systems to a drier future

D. AVERY[1], F. AVERY[1], G.I. OGLE[2], B.J. WILLS[3] and D.J MOOT[4]
[1]*Bonavaree Farm Co Ltd, RD, Seddon*
[2] *Ogle Consulting, RD1, Cambridge*
[3]*Central Environmental Services, Alexandra*
[4]*Agriculture and Life Sciences Division, PO Box 84, Lincoln University, Canterbury*
graeme.ogle@rezare.co.nz

Abstract
In the Starborough-Flaxbourne area the local farming community, alarmed at the increasing hill slope erosion, set up a soil conservation group. Accelerated erosion was a symptom of the past 12 years of below average rainfall. Removal of vegetative cover by livestock had enabled wind to erode areas of the thin topsoil exposing vulnerable sodic subsoil to rill and tunnel erosion. This highlighted the need for farms to adapt their livestock systems to a drier environment if they were to survive. An adaptation process had been undertaken on Bonavaree by the land owners, the Avery family. In redesigning their farm system they moved away from ryegrass pastures and brassica crops to a lucerne grazing system. This system prioritised the performance of multiple bearing ewes, high pre-weaning lamb liveweight gains (390 g/day) and a rigorous decision making process that avoided relying on the most risky periods of forage growth. The result has been 5 years of an improving economic farm surplus, lower grazing pressure on hill slopes and improving vegetative cover.
Keywords: adaptation, conservation, decision making, drought, erosion, lucerne, *Medicago sativa*

Introduction
In 2004, a meeting of farmers from the northern-eastern South Island, concerned at the increasing erosion of hill slopes, set up the Starborough Flaxbourne Soil Conservation Group (SFSCG). Hill slope soils in this region are naturally erosion-prone due to their sodic nature. The impact farming has had on enhancing this erosion was described by farmers at a SFSCG workshop in November 2006. Prolonged drought had caused hill slopes to be grazed bare by stock that had no alternative feed. Wind had eroded the thin topsoil on areas of hill slope to leave a fragile subsoil which, when saturated, inherently lost strength and suffered from rill and tunnel erosion.

Lack of rainfall has dominated the climate since the autumn of 1996 when the Marlborough region entered a drought that was to continue through the next summer and following winter. That period of below average rainfall (480 mm) has continued unabated with the current decade (2001 to 2007) likely to be lower than all other decadal rainfall averages (580 mm) since 1890 when records began (Porteous 2008).

An increasingly drier environment coupled with a down turn in sheep and beef commodity prices was not conducive to the private land owner's ability to improve the condition of hill slopes in this region. This paper describes a farm within this region; Bonavaree owned and operated by the Avery family. It has made considerable progress in adapting to these drier conditions, improving profitability and making substantial progress in re-vegetating hill slope erosion. To assist in describing this performance the property was modelled and its performance monitored using the computer model Farmax Pro, a recent development of the programme Stockpol (McCall *et al.* 1991).

Farm Description
Contour, soils and vegetation
Bonavaree is a 1100 ha sheep and beef property situated near Lake Grassmere in north-eastern Marlborough. It is comprised of 400 ha of flat to rolling cultivatable land and 700 ha of hill slopes of which 75% are northerly facing and 25% southerly facing. The hill soils are Flaxbourne Hill soils consisting of a clay-loam base covered with a thin layer of windblown loess deposited by the prevailing north westerly winds (Blakemore 1968). When saturated the sodium-clay aggregates lose strength and become highly erodible. Where the subsoil is exposed to water running downhill it is susceptible to rill and tunnel erosion. The priority on these soils is to maintain vegetative cover as this reduces wind erosion of the thin loess layer and reduces runoff. Hills are predominantly low quality annual grasses and danthonia (*Notodanthonia racemosa*).

The flat and rolling country is comprised of fertile Dashwood and Hurunui soils (Blakemore 1968). They are free draining and have a naturally high pH that increases with depth (5.8 to 7.3) making them ideal for growing lucerne (*Medicago sativa*). In the current season (2007/2008), 300 ha has been planted in lucerne, 50 ha of 'Omaka' barley and 20 ha of annual ryegrass.

Stock
The farm runs 2450 breeding ewes and 650 hoggets.

Older ewes are from a Corriedale and Corriedale-Poll Dorset base. The breeding programme has shifted to a composite sheep type with four-tooth and two-tooth ewes bred from a Romney Finn Texel ram. Cattle include 150 Angus Hereford breeding cows, 30 heifers and 30 steers.

Friesian bull calves (100) have previously been purchased in spring and sold the following spring. This year these were replaced by steers from the breeding herd. After summers with above average rainfall, dairy cow grazers are also brought on to over-winter.

The need for change

Prior to 1996 the farm system had evolved from more benevolent rainfall patterns. For example, from 1975 there were 8 consecutive years of rainfall well above average (Porteus 2008). Forage supply was based on growing ryegrass and clover pasture with 50 ha of lucerne grown for hay and seed production. Grasses provided early and late pasture growth while lucerne provided reliability by conserving winter feed.

With winter-active ryegrass pastures, lambing could occur early with a proportion of these sold before Christmas. After this, lamb growth decreased as pastures lost palatability with increasing temperature and dryness. Brassicas such as rape and turnips were grown to fill this feed gap and finish the remaining lambs in late summer and autumn and raise replacement hoggets.

As the climate became drier this system proved unsuccessful. Grass based pastures were slow to regenerate after drought or simply did not survive. Management was faced with the repetitive renewal of pasture at times when it was least affordable. Pastures that were not renewed became invaded by poorer species from surrounding hills resulting in a uniform lack of quality that spread stock pressure across flats and hills alike. Brassica crops failed in dry years while in wetter years they became an enticement to take lambs through to summer when the meat schedule had fallen and their value had diminished. Within this system, the carry-over effects of drought on pastures and sheep fecundity would flow through to spring and affect stock performance and revenue generation when forage again became plentiful.

To adapt to a drier environment the farm system needed to generate more revenue from less rainfall. Strategically, the first step was seen to utilise water where it fell with plants that could survive drought and flourish when rain occurred. Tactically more structured decision making was required to preserve the capacity to generate revenue for periods when pasture growth was relatively reliable.

Strategic redesign of the farm system

Lucerne proved it would survive drought and emerge after rain to provide large quantities of high quality forage when it was needed. The value of this forage was most effectively captured by grazing it with a stock class that had a high potential to generate revenue; scanned multiple ewes. With high quality forage, lamb losses could be decreased, their liveweight gain maximised and drafting dates brought forward into a period of higher meat schedule prices.

Grazing ewes on lucerne in spring had potential animal health problems such as red gut, bloat and lowered performance as their rumen adapted to a different feed. Evolving a grazing system to cope with these included:

- Starting ewes on older weedy lucerne stands that had a mix of other species that assisted with the transition between feed types.
- Not fencing off hill slopes so that ewes could balance their diet with lower quality forage.
- Ensuring that ewes were not hungry when shifted onto lucerne to avoid gorging and potential bloat problems.
- Accepting that some losses would occur as natural genetic selection removed bloat prone individuals.
- Ensuring salt blocks were always available.

Once the overhead cost of transitioning ewes to lucerne was complete the greatest return is made if they stay on lucerne for 6 to 8 weeks until weaning.

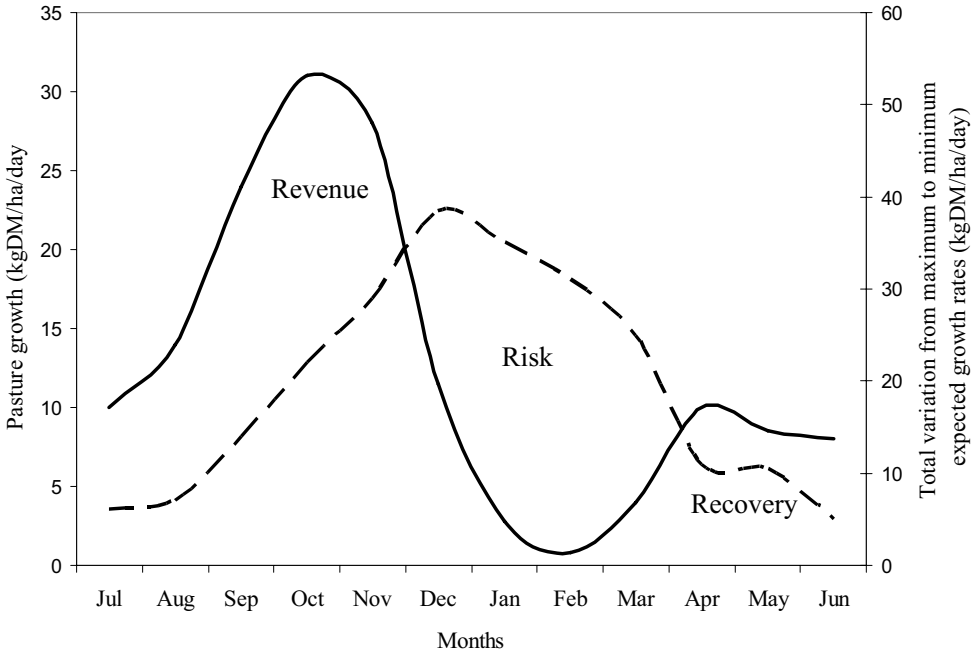
As the lucerne area increased and higher stock performance targets were set, a forage gap was identified in the winter and early spring. This was filled by 'Omaka' barley planted in mid February. Barley, with its large seed could be drilled deep into summer fallowed land and once germinated could sit until autumn rains.

Structured Tactical Decision Making

The pasture growth calculated on Bonavaree demonstrated the need for timely decision making. In Figure 1, pasture growth was calculated through the use of the Farmax programme. These were derived from pasture covers measured monthly and stock intake derived through measured animal performance. Pasture growth has been calculated as that which is required to equate the change in pasture cover from one month to another whilst meeting the intake demand of livestock. Livestock demand is calculated by intake equations from stock performance such as numbers, liveweight and gain, and pregnancy percentage. Adjustments are made by the programme for supplements conserved, calculated pasture decay and supplements fed. Based on 2 years data and management experience, an estimation in the variation of pasture growth (highest minus lowest) has also be added.

From August to November, the majority of reliable pasture growth occurs. By December the variation is higher than the average growth rate and this signals an important transition. A phase of relative reliability, which in Figure 1 is termed the Revenue Phase, finishes as a phase dominated by variability begins (termed the Risk

Figure 1 Phases of decision making based on pasture growth and variability. The average pasture growth for the 2006 and 2007 years as calculated by Farmax (solid line), and the expected variation based on the 2 year variation and farmer expectation.



Phase). Reliability in growth improves with the autumn rain from March onward, a phase termed Recovery.

The revenue phase

When the rate of pasture growth is relatively high and reliable the farm must generate a substantial proportion of its livestock revenue. Bonavaree generates 60% of its livestock revenue at this time. To achieve this there are four objectives:

- High liveweight gain. Approximately 60% of all ewes will have multiple lambs and these will have made the feeding transition from 'Omaka' barley to lucerne with their lambs growing close to 400 g/day. This cannot be achieved if stock or pastures are suffering from previous drought events.
- Market planning. Management will have decided on 'fall-back' plans for all stock classes by mid October that can be initiated if the season dries out early. These include target dates for selling Friesian bulls and any remaining lambs on the store market and, if conditions worsen, a proportion of cows with calves at foot.
- Conservation only occurs from a true surplus. Forage will not be made if it risks reducing livestock performance any time during the year. Supplements will be purchased if they are needed or if supplements are seen as a bargain they are purchased and stored.
- Borrowing moisture. Areas to be planted in winter crops will be sprayed off in mid October. This will limit evapo-transpiration leaving soil moisture to carry over for 'Omaka' barley that will be drilled in mid February.

Sheep are fully fed during this time and as a result are unlikely to spend prolonged periods grazing hill slopes.

The risk phase

The high variability in pasture growth rate during this phase (Fig. 1) requires tactics of 'avoidance'. A system that must generate more than 20% of its livestock revenue in this period will on average fail. Such a situation should not occur if decisions were well implemented during the previous revenue phase. Avoidance tactics include:

- Avoiding the need to finish stock if conditions are dry.
- Avoiding the need to put weight on ewes. If they grew well in the revenue period they can remain on a maintenance diet or below.
- Avoid transpiration losses in summer fallow paddocks by spraying again if weeds are present.

If the right decisions have been made entering this phase then the ratio of livestock demand to farm cover will not necessitate having sheep graze vulnerable sunny aspect hill slopes and they can be confined to the shady aspect hills.

The recovery phase

The objective during this phase is to recover from the summer dry and set up revenue opportunities for the

spring. These include:

- Replenish lucerne root reserves. These are replenished by allowing stands to achieve 100% flowering (Moot *et al*. 2003). The timing depends on the season but can commence any time after the longest day. Weeds are sprayed after hard grazing. This conserves moisture for spring growth and also sets up the grazing rotation so that not all paddocks become available at the same time. The first paddock hard-grazed in autumn will be the first grazed in spring.
- Stock condition. As ewes are grazing the hills at this time, feed quality is often substandard and baleage and peas are used to assist with flushing.
- Winter crop establishment. 'Omaka' barley is drilled into summer fallowed, weed-free paddocks in mid February.
- Trading opportunities. Depending on the previous summer, trading cattle or dairy grazers can be brought on to be run during a period of relatively reliable pasture growth and maximise revenue during the revenue phase.

Results and Discussion

Financial

Over the past 5 years the lucerne area has been increased from 120 ha to 250 ha. This has been associated with an improvement in economic farm surplus that contrasts with a general decline in the average New Zealand sheep and beef farm performance.

An increasing economic surplus has been achieved from the high productivity of the ewe breeding flock (Table 1). This is demonstrated by the high ewe breeding efficiency (BE) measure. BE is calculated from the weight of lamb weaned at 90 days as a percentage of ewe tupping weight. It is therefore a measure of the efficiency with which a ewe produces lamb weight from tupping to weaning. To achieve a superior result, some or all of the factors of scanning index (a measure of fecundity derived

Figure 2 Five-year trend in Economic Farm Surplus for Bonavaree against the New Zealand average sheep and beef farm. Data source: Ministry of Agriculture and Fisheries Farm Monitoring Report 2007.

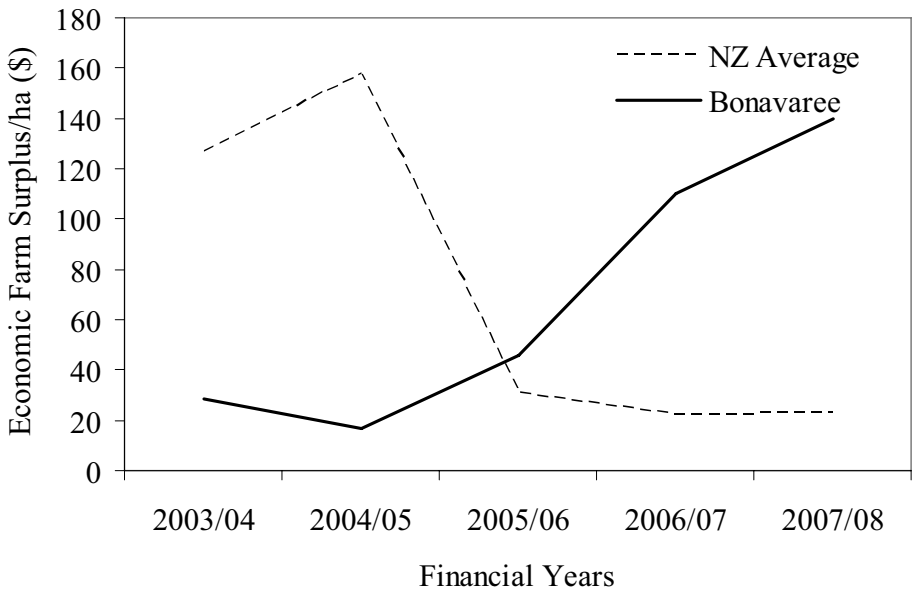
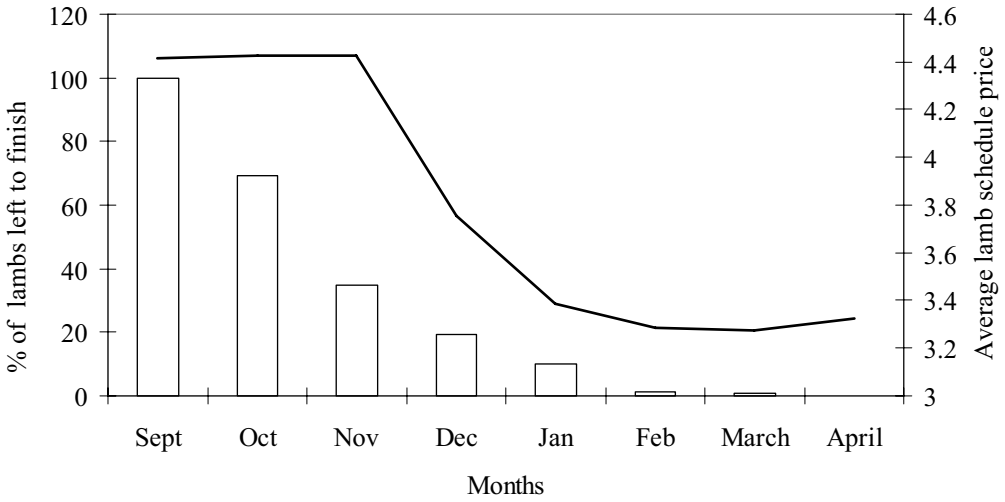


Table 1 Sheep breeding performance compared with the average and top 20% of the Farmax National Database.

	Bonavaree 05/06	Bonavaree 06/07	Farmax Group Average 06/07	Farmax Top 20% 06/07
Tupping body weight (kg)	67.1	61.5	61.1	61.5
Scanning index	2.4	2.5	2.7	2.7
Survival – scanning to weaning (%)	85	88	78	72
90 Day weaning weight	39.3	40.3	29.7	39.2
Average growth rate to weaning (g/d)	379	396	276	382
Ewe efficiency	80	88	61	72
Cents gross margin/kg DM eaten by sheep	13.3	11.2	6.0	9.9

Figure 3 The percentage of lambs left to finishing at the end of each month (bars), and the average South Island meat schedule payment for 15 kg PM lambs. Data source: *Agrifax.*



from the scanning percentage divided by ewe liveweight), lamb survival and lamb growth rate to weaning must be superior. Bonavaree ewes are not superior in their fecundity but the high lamb survival and growth rates pre-weaning result in a breeding efficiency of 88%, well ahead of the top 20% in the Farmax base.

The high growth rates enable an early finishing with 80% of all lambs off the farm by the end of December. Lambs finished in November have an advantage of 67 cents/kg of carcass premium on those finished in December and a $1.04 on those finished in January. For Bonavaree lambs, which average a 17.1 kg carcass weight at sale, this equates to premiums of $11.52 and $17.86 per head respectively.

Hill slope erosion

The redesigned farm system has had positive effects on hill slopes. The practice of not fencing off lucerne means sheep grazing pressure is drawn off hill slopes onto areas of higher quality forage. When sheep do start to graze hill slopes it is a sign to management that they have run out of quality feed and must be shifted. As a result the overall utilisation of hill slopes has been calculated by Farmax at approximately 46%. This enables hill slope vegatation to set seed during summer and, combined with the practice of not grazing with sheep during this time, has allowed vegetative cover to improve year on year.

Badly eroded, steeper hill slopes with sodic soils are progressively being fenced off and planted with forage shrubs like saltbush (*Atriplex halimus*) and tagasaste (*Chamaecytisus palmensis*). Fodder from these is grazed during pinch periods in winter and early spring – it is estimated that a saltbush block of 4 ha can now support up to 1000 sheep for 5-6 days. Where necessary this is followed by cattle grazing to clean up the bushes and inter-shrub pasture.

Conclusions

Adapting to a drier environment meant the Bonavaree farm system must generate 'more from less'. This was considered unachievable from the ryegrass, clover and brassica based system. The constant need to re-establish pasture after drought was a failure that occurred when it was least affordable. Acknowledging the need for change was an important starting point in the adaptation process. Redesigning the Bonavaree system had to be based on a plant that survived in the environment. Lucerne provided this prerequisite and could produce large qualities of high quality feed when it was most needed at the end of a drought. Utilising this plant required evolving a livestock feeding system with a stock class that was highly efficient and achieved a market premium for early production.

Dry environments are risky because unreliable pasture growth creates an unreliable cashflow. To minimise this, Bonavaree follows rigorous decision making principles. These have been built on the relative reliability of pasture growth between seasons to avoid dependence on generating revenue when the likelihood of failure is high.

The principles of this adaptation process can be applied to other environments where businesses must change if they are to survive. In this example the adaptation of Bonavaree has seen the convergence of the private landowner's goal to have a more resilient and successful business, the adaptation to a drier environment and the environmental stewardship needed to rejuvenate eroded hill slopes.

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REFERENCES

Blakemore, L.C. 1968. General Survey of the Soils of the South Island, New Zealand. Soil Bureau Bulletin 27. Department of Scientific and Industrial Research. 404 pp.

Marshall P.R., McCall, D.G.; Johns, K.L. 1991. Stockpol: A decision support model for livestock farms. *Proceedings of the New Zealand Grassland Association 53*: 137-140.

Moot, D.J.; Brown, H.E.; Teixiera, E.I.; Pollock, K. 2003. Crop growth and development affect seasonal priorities for lucerne management. *Legumes for Dryland Pastures. Grassland Research and Series Practice Series 11*: 201-208.

Porteous, A. 2008. Beyond reasonable drought. http://www.niwa.co.nz/ncc/cu/ma/2008-05/article.