2014 Graham Centre Sheep Forum
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Graham Centre Sheep Forum  
4 July 2014 - CSU Convention Centre, Wagga Wagga

8.30-8.55am  
Registration and coffee

8.55-9.00am  
Welcome and outline of the day  
**Ms Toni Nugent** (Industry Partnerships and Communications Manager, Graham Centre)

9.00-9.30am  
A well-developed, $4m, medium-sized, high-equity sheep farm business wanting to build wealth: Where to from here?  
**Professor Bill Malcolm** (The University of Melbourne)

9.30-9.50am  
Nutritional management to reduce embryo mortality in ewes  
**Dr Susan Robertson** (CSU)

9.50-10.10am  
Drought lots success during dry times  
**Ms Janelle Jenkins** (LLS)

10.10-10.30am  
Drought lot experience since 2008 – a successful strategy for us  
**Mr Owen Blake** (Producer)

10.30-11.00am  
Panel session (all session speakers)

11.00-11.30am  
MORNING TEA

11.30-11.50am  
The quest for acid-tolerant lucerne  
**Mr Richard Hayes** (NSW DPI)

11.50-12.10pm  
Determining the optimum grazing system  
**Dr Warwick Badgery** (NSW DPI)

12.10-12.30pm  
Lifting limits imposed by worms on sheep meat production  
**Dr Bruce Allworth** (CSU)

12.30-1.00pm  
Panel session (all session speakers)

1.00-1.15pm  
Forum summary, wrap up and evaluation  
**Ms Toni Nugent** (Industry Partnerships and Communications Manager, Graham Centre) and **Associate Professor Michael Friend** (CSU)

1.15pm  
LUNCH (sponsored by Knights)
Silver sponsor

NOVARTIS
ANIMAL HEALTH

Bronze sponsors

nab agribusiness

Local Land Services Riverina

Co-op

Animal Health Australia

Regional Development Australia

Knights

Making More From Sheep

Ancare
Welcome to our 2014 Sheep Forum

This year our Sheep Forum addresses the nutritional management of ewes to reduce embryo mortality, drought lots and their success during dry times, worm control in prime lamb flocks, structuring flexible management to maintain profitable and sustainable lamb production systems and the quest for acid-tolerant lucerne.

Increasing costs are putting considerable pressure on growers to manage complex mixed farming systems, to ensure profitability, viability and sustainability into the future. Our research focuses on improving profitability for the livestock industries through the development of efficient feedbase options, including pastures, crops and annual legumes and fodder conservation. Reducing the impacts of diseases, parasites and other factors impacting on animal productivity by improving feedbase management, on-farm bio-security and animal welfare practices are also key research areas to ensure increased productivity and profitability of the livestock industries.

The latest research from the Graham Centre and our partners is showcased at our forum today, to assist producers to develop and maintain robust and profitable sheep production systems. This also provides an opportunity for you to meet and network with industry experts.

We look forward to some robust discussion about the drivers, opportunities, challenges and research needs facing our livestock production systems.

Regards,

Professor Deirdre Lemerle,
Director, Graham Centre for Agricultural Innovation
Speaker biographies

**Associate Professor Bill Malcolm**
Associate Professor Bill Malcolm works in the Faculty of Veterinary and Agriculture Sciences, University of Melbourne and is a Principal Scientist, Farm Economics with the Victorian Department of Environment and Primary Industries. Bill has worked in farm economics with farmers, agriculturalists and agricultural scientists since 1977.

**Dr Susan Robertson**
Dr Susan Robertson is a research fellow with Charles Sturt University (CSU). In her PhD, she evaluated nutritional management of ewes to improve staple strength of wool, before becoming a livestock officer in the Victorian Mallee, and joining CSU in 2006. Susan's area of interest is sheep production. She has been involved in projects investigating methods of increasing ovulation rate and lamb survival, and has most recently been using simulation models to compare sheep production systems.

**Ms Janelle Jenkins**
Ms Janelle Jenkins works as a Senior Land Services Officer, Mixed Farming Systems, for the Riverina Local Land Services (Riverina LLS) based in Tumut. Her work involves providing advice to landholders on crop, pasture and livestock systems in the higher rainfall areas of the Murrumbidgee catchment. Janelle worked with the Murrumbidgee Catchment Management Authority (CMA) for eight years prior to the formation of the Riverina LLS. Janelle worked on numerous environmental projects and Native Vegetation legislation. Many of these projects had a conservation farming focus, including the early development and implementation of the drought lot feeding facility and grazing management incentive projects.

Prior to working with the Murrumbidgee CMA, Janelle worked extensively in production agriculture and environmental positions within the Department of Primary Industries and other organisations.

**Mr Owen Blake**
Mr Owen Blake has been actively involved in the “Tarandi” farm activities since he could walk. Owen graduated with a Bachelor of Applied Science (Agriculture) from Charles Sturt University in 2001 and took over the management of “Tarandi” in 2009.

**Mr Richard Hayes**
Mr Richard Hayes is a research scientist with the pastures branch of the NSW Department of Primary Industries based at Wagga Wagga. He has 15 years’ experience in pasture related and farming systems research. Richard has worked on a large number of industry-relevant projects, including improving cropping systems on highly sodic soils, developing lucerne for acid soil environments, assessing the role of composted dairy waste as an alternative fertiliser and the development of perennial wheat.

**Dr Warwick Badgery**
Dr Warwick Badgery has spent 14 years researching native pastures, farming systems and soil carbon in the Central West of New South Wales. He graduated with Honours from a Bachelor of Wool and Pastoral Science, NSW University in 1998 and completed a PhD through Sydney University at the Orange Campus (now CSU's Orange Campus) in 2004. Warwick took up a position with NSW Department of Primary Industries as a research agronomist in 2005.

Warwick’s research has focused on competition between native pasture and serrated tussock, pasture cropping, grazing management and the influence of land management on soil carbon. He is currently the site leader for the Orange EverGraze Proof site, which is examining the profitability and sustainability of grazing systems in native pastures. He has also coordinated soil carbon research in Central NSW for the National Soil Carbon Research Program (SCaRP), and has contributed to developing a soil carbon pilot in the Lachlan Catchment (CAMBI), examining different contract options to price soil carbon, which was the first of its type in Australia. Warwick was the executive officer for the organising committee of the 22nd International Grasslands held in Sydney last year. He is also working on an ACIAR project examining the sustainable development of grazing systems in Western China.

**Associate Professor Bruce Allworth**
Associate Professor Bruce Allworth, has a Bachelor of Veterinary Science, Masters of Veterinary Science and a PhD. He is a Registered Sheep Specialist and a Diplomat for the European College of Small Ruminant Health and Management. Bruce is an Associate Professor in Livestock Systems, and is currently the Director (part-time) of the Fred Morley Centre, School of Animal and Veterinary Sciences, Charles Sturt University. He also runs a sheep and beef cattle property in Holbrook and has previously operated a sheep and cattle consulting service for more than 20 years.
Using capital to counter the threat of low and volatile farm income

Mr J Tocker  
Agriculture Research Division, Department of Environment and Primary Industries, Hamilton, Victoria

Dr Alex Sinnett and Associate Professor B Malcolm  
Agriculture Research Division, Department of Environment and Primary Industries, Parkville, Victoria  
T: 0428 499 266 Email: b.malcolm@depi.vic.gov.au

Around 25,000 farms in Australia sell more than 200 slaughter lambs per year. Of these farms 1,400, or 6%, sell more than 2,000 slaughter lambs per year, and account for around 30% of total annual lamb production (ABARES, 2012). A question of interest, and one facing all lamb producers, is ‘for the next five to eight years, for a set of goals that include maintaining or increasing profit and building wealth, what changes will be best for the business and the farm family?’ This question was investigated for a case study lamb producing business in Western Victoria that is medium-sized, has high equity, and is performing at a high standard, being among the best 20% of lamb producing businesses in most years.

Rising costs

The farm sectors of wealthy and growing economies shrink steadily as a portion of the total economy, and farm costs continually rise in real terms. Agriculture’s share of national income in growing economies declines because economic growth in the economy brings greater growth in the non-agricultural sectors of the economy than in the agriculture sector. This is partly a consequence of the phenomena that as people get wealthier with rising incomes, they do not spend much of their extra income on agricultural products. The more rapidly growing sectors of the economy compete with agriculture for resources; land, labour and capital, and the costs of these resources rise. Consequently, farmers’ costs rise in real terms, paying more for labour, and other inputs such as fuel and power, equipment, fertilisers and chemicals.

The story of agriculture in Australia is encapsulated in Figures 1, 2 and 3. Costs have risen more rapidly than prices over most of the past half century, (i.e. farmers’ ‘terms of trade’ have generally deteriorated) (Figures 1 and 2). On the positive side, productivity has generally increased at more than 1% per annum (Figure 3) to offset the deterioration in terms of trade and enable the best farm businesses to grow and maintain profit and earn returns to capital. Productivity gain means producing more output with the same input, or increasing output more than increasing inputs. A major source of increases in farm productivity has been the take-over of farm businesses that are unable to earn sufficient profit or competitive returns to capital by farm businesses that are better able to do these things. A major way farm businesses maintain or increase profit is by increasing the output and gross income from the fixed and variable costs employed. This has the effect of spreading the total fixed costs of a business over greater output and income, a phenomenon called economies of size.

Take home messages:

- over a long time the prices broadacre farmers pay for their inputs have generally risen more rapidly than the prices they have received for the products they sell. The best performing farm businesses have increased productivity to counter the downward pressures on profit.
- looking at change on-farm requires whole farm analysis that includes the human, biophysical, economic and financial and risk dimensions. The aims of the change and the attitude to more risk are key to decisions about change.
- the capacity of a farm business to borrow and preparedness of the owners to take on extra risk will ultimately determine the size of the farm business.

The imperatives for change

Farmer goals

All farm businesses face imperatives for change. A major motivation for changing how a farm business operates is that the current set-up is not meeting the needs and aspirations of the farm family, or will not meet them in the near to medium-term future. For example, goals to build sufficient wealth to have a comfortable retirement and to also meet family succession and estate goals, or goals to get more out of the resources the family controls, to farm better and bigger because doing so not only represents a surmountable challenge, it also helps meet numerous other hopes and aims of the family.

Source: ABARES (2012)
Figure 2. Farmers terms of trade

![Graph showing farmers terms of trade over time.](source: ABARES (2012))

Figure 3. Broadacre total factor productivity in Australia.

![Graph showing productivity growth.](source: ABARES (2012))

Farm management economic theory

Costs and size of business

Economic theory has a lot to say about the costs incurred by farms. The costs of running a business can be separated into two categories; fixed and variable, over a specified production period, such as a year (note: accounting tends not to use this breakdown). Another way to describe these costs for a short-term period are as costs that are unavoidable (fixed) and costs over which farmers have control (variable). In a production year it is the variable costs that make the output that generates the income, which is hoped to cover both types of costs, and leave a surplus (profit). Whether costs are fixed or not depends on the time involved: over a medium-term period or longer, all costs are considered to be changeable. When a reasonable time is involved, businesses can change the amount of capital invested in their business, which has the effect of introducing new technology and changing the size of the business, measured as size of gross income from production.

The phenomenon that in a short planning period some costs are fixed leads to the notions of average cost of production and economies of size. Economies of size refers to how the size of average cost of production changes as output increases and dilutes the fixed cost component of each unit of output.

An example is the fixed costs of owning machinery; annual depreciation, opportunity interest cost, registration, insurance and shedding costs, which are constant in a year regardless of how much output is produced in that year. If the output is small, the average fixed cost per unit of output is large. If the output produced is large, the average fixed cost per unit of output is small. The other major fixed costs include wages for permanent labour, owner-operator allowance for labour and management, and the opportunity interest cost of the capital invested in the land and livestock. Variable costs such as fuel, energy, water, power, fertiliser and chemicals are added to these fixed resources to produce output. Output is likely to rise in quite direct proportion to these variable costs, rainfall permitting, and subject to the law of diminishing marginal returns (also known as the law of variable proportions). This law reflects the phenomenon that as more of an input is added to a production process, with other inputs held in their initial proportions, the extra output and extra income that result from the extra input eventually declines. This causes the average variable costs per unit of output to rise.

Figure 4 shows the total, fixed and variable costs, while Figure 5 shows fixed cost, average variable cost and average total cost changes with changes in output.

The theoretical shape of the curve labelled ‘average total cost’ (Figure 5) tells a lot about why farms in Australia have steadily increased in size over decades. It also tells a lot about why there are fewer farmers farming as each decade passes.

There are two cost imperatives for farmers to change their business:

- the imperative from real costs rising
- the imperative of reducing the average total cost of doing business by increasing output.

A further imperative comes from the prices farmers receive for their production. Historically, farm product prices have declined in real terms since the Industrial Revolution, as a consequence of the supply of farm production growing at a faster rate than the demand for farm product.

Figure 6 shows the process of changing business size to reduce average fixed cost per unit of output, while still remaining profitable. Over time, operators of farm businesses with small output and gross income find that rising costs and declining real prices, allied with insufficient increase in productivity, combine, bringing an end to aspirations to remain in farming and, at the same time, create opportunities for farm businesses that have increased and made a better show of productivity and are striving to further do so.
Economic thinking and analysis is about costs, income, productivity and profits. This is different to finance thinking and analysis, which is about the flows of cash into and out of a business, in particular, the capital introduced into a business and meeting the requirements to service that capital with regular interest payments and often, regular repayments of principal. The relationship between own-capital (equity) and borrowed capital in a business is the key in determining the rate of growth of own-capital. Using other peoples’ capital well enables own-capital to build-up. Using borrowed capital poorly erodes own-capital. The key principle of financial management is called the principle of increasing financial risk. The operation of this principle determines how rapidly an owner of farm capital builds wealth, or the rate at which own-capital is destroyed. The proportion of debt to equity in a business is called gearing or leverage.

When a business earns a return on total capital that is greater than the rate of interest on the debt, a highly geared business (high ratio of debt to equity, low equity percentage of total assets) will grow wealth faster than a lower geared business. The converse is also true; when returns to total capital are less than the rate of interest on debt, lower geared businesses grow wealth more rapidly than do businesses with more debt and lower equity percentage. More significantly, whilst a business that is geared highly will grow wealth more rapidly than a business with a lesser proportion of debt, the opposite is true when things break badly for the business. In the example in Table 1, the higher geared business grew at 12% when it earned 10% return on capital, but eroded equity at 28% when an operating loss of minus 10% on capital was made. This is called the principle of increasing risk. Higher gearing means faster growth in wealth when return on capital is more than the cost of debt, but, with higher gearing, equity grows slower or reduces at an even faster rate when the rate of return is less than the interest rate.

<table>
<thead>
<tr>
<th>Proportion of debt in total capital</th>
<th>0%</th>
<th>50%</th>
<th>0%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate of return on total capital</td>
<td>10%</td>
<td>10%</td>
<td>-10%</td>
<td>-10%</td>
</tr>
<tr>
<td>Interest rate on debt</td>
<td>8%</td>
<td>8%</td>
<td>8%</td>
<td>8%</td>
</tr>
<tr>
<td>Tax</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Consumption</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Total capital</td>
<td>$10 m</td>
<td>$10 m</td>
<td>$10 m</td>
<td>$10 m</td>
</tr>
<tr>
<td>Debt</td>
<td>$0</td>
<td>$5 m</td>
<td>$0</td>
<td>$5 m</td>
</tr>
<tr>
<td>Equity</td>
<td>$10 m</td>
<td>$5 m</td>
<td>$10 m</td>
<td>$5 m</td>
</tr>
<tr>
<td>Operating profit</td>
<td>$1 m</td>
<td>$1 m</td>
<td>-$1 m</td>
<td>-$1 m</td>
</tr>
<tr>
<td>Cost of interest on debt</td>
<td>$0</td>
<td>$0.4 m</td>
<td>$0</td>
<td>$0.4 m</td>
</tr>
<tr>
<td>Net profit (operating profit minus interest)</td>
<td>$1 m</td>
<td>$0.6 m</td>
<td>-$1 m</td>
<td>-$1.4 m</td>
</tr>
<tr>
<td>Minus tax</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Minus consumption</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Equals growth in equity (net worth, wealth)</td>
<td>$1 m</td>
<td>$0.6 m</td>
<td>-$1 m</td>
<td>-$1.4 m</td>
</tr>
<tr>
<td>Growth rate (% change in equity; growth/starting equity)</td>
<td>10%</td>
<td>12%</td>
<td>-10%</td>
<td>-28%</td>
</tr>
</tbody>
</table>
The limits to how much a business can change in size

Returns to total capital from farming activities are volatile by any standard of comparison because of yield and price fluctuations from year to year (business risk). The principle of increasing financial risk and gearing (financial risk) makes life, and profit, even more volatile for farmers. Considering the possibilities of reducing average total cost of production by increasing output from the set of fixed costs (fixed resources) that farmers have to work with, the question arises; why not just keep growing the size of the business, getting bigger and bigger?

There are important factors at work that limit the size to which a business can feasibly expand. These factors cause costs to rise as output increases, reducing the extent of economies of size and creating what is called ‘diseconomies’ of size. In farming the causes of rising costs as size and output increase include:

- diminishing marginal returns as variable inputs increase
- increasing maintenance costs as fixed resources are worked to their limits
- the management challenges of running larger, more complex farm systems - problems such as loss of timeliness, quality of operations and managing extra labour. Only the best mentally-equipped farmers are able to manage large operations successfully.

In cropping the scope for exploiting economies of size is much greater than with livestock activities, as the significant capital investment in machinery can be spread over more output, and capital in the form of larger machines can be substituted for labour. In livestock, reducing average total costs of production by running more livestock is trickier, as the main costs of livestock activities; feed and labour costs, tend to increase directly with increases in the number of animals carried. Feed costs increase in direct proportion to output; more animals, more output, more feed. Labour requirements act similarly. There are limited opportunities to substitute capital for labour in livestock production, which means as livestock numbers increase, labour costs increase in fairly similar proportion, for the majority of types of animal production systems at least.

Though it is common to focus on the technical possibilities and limits to achieving the benefits of economies of size by making more profit from the same or less resources, the most important factor limiting the size to which a business can aspire to expand is finance. In most situations the principle of increasing financial risk does more to limit farm size than technical and management considerations about the system.

An example: investing extra capital and changing a business

The following analysis is based on a prime lamb case study farm located in south-west Victoria. This example expands on previous analysis of this farming business by Tocker et al. (2013).

The case study farm

The prime lamb case study farm comprises 560ha and receives an average rainfall of 730mm. The farmer is a second generation owner/operator, operating the farm using family labour plus some casual labour. Total farm capital is $3.7 million, with 98% equity.

There are three classes of land, with corresponding pasture types and carrying capacities:

- 312ha of rocky barrier country, growing wallaby grass and subterranean clover, with an annual average carrying capacity of approximately 14.5DSE/ha
- 168ha of black flats growing phalaris and strawberry clover, carrying 15DSE/ha
- 80ha of open country growing perennial ryegrass and subterranean clover, carrying 21.5DSE/ha. Across the whole farm the average annual carrying capacity is estimated to be 16DSE/ha. This carrying capacity involves feeding approximately 40t of supplementary feed each year.

The sheep activity comprises 3,000 Coopworth Composite ewes, with 1,000 ewes joined to a maternal sire and the remainder joined to a terminal sire. The feed requirements of this type of ewe producing lambs, most of which are sold within the year, is rated at 2.4DSE/ewe/year, stocked at 6.6 ewes/ha. The ewes produce around 3.3kg of clean wool each year, with an average fibre diameter of 32 micron. Ewe flock numbers are maintained by retaining around 700 replacement Coopworth Composite ewe lambs each year.

Lambs are born in mid-July and weaned in early December. Typically, around 3,900 lambs are marked each year, which is 129% of the number of ewes joined. Allowing for the retention of replacement ewe lambs, around 3,000 lambs are usually sold each year. Total carcass weight of lamb sold is about 62,000kg. The usual 25% light lambs are sold as stores in early December at approximately 34kg liveweight and the remaining 75% heavier lambs are sold at approximately 44kg liveweight to a supermarket chain throughout December.

Under current conditions and in a reasonable year, annual gross income for the base farm is expected to be around $410,000. This comes from $50,000 in wool sales and a $360,000 livestock trading profit. Total annual variable costs are $160,000, giving a $250,000 total gross margin (GM). Gross margin per DSE is $250,000/8750 DSE = $29. The GM per hectare is $440. Annual average overhead costs are $100,000, which includes a $60,000 owner / operator allowance for labour and management. The balance is for depreciation and other fixed costs. Expected average annual operating profit is $150,000, with a standard deviation of $75,000. Net profit after interest costs and tax is $110,000. Return on capital from a ‘typical’ year of the farming operation is 4% per annum.

Change options

Four opportunities for changes that were technically feasible were defined. These changes are shown in Figure 7. Further details for each change are shown in Appendix 1.
Figure 7. Changes investigated for case study farm

The four changes each involved different amounts of capital to be invested, and thus different borrowing and annual debt servicing obligations, and different implications for the balance sheet and growth of equity. The expected performance of the four changes was assessed in terms of how well each change contributed to meeting the goals of making the change. If the goals are to make better use of own-capital in order to build wealth, the changes were evaluated in light of criteria such as:

- what are the implications for average total cost per unit of output?
- is it a good use of the resources involved? This is measured by the extra profit produced over the life of the investment from the extra capital invested, called return on marginal capital (or marginal internal rate of return)
- is the return on the capital involved attractive considering the risk and when compared to alternative ways the capital could be used?
- is it financially feasible if all extra capital is financed, indicated by expected ability of the farm business to service the extra debt involved, once the riskiness of annual net cash flows are considered?
- how much is each change likely to contribute to wealth by the end of the defined planning period, in light of the risks involved and considering what the situation will be if the change is not made?

The likely performance of these changes to the farm business were analysed over a planning period of seven years, using distributions of possible yields, prices and costs to represent the risk that could happen. As well, a cost-price squeeze was included, with real costs rising 1% per year over the planning period.

Results

Implications for average total cost per unit of output from the alternative changes

In a farming business, output varies each year because of variability in seasonal conditions and production ability. So too does the average cost of production. Each of the changes had the effect of increasing output of lamb and wool, and reducing average total cost of production below that of the status quo. If prices per unit of output were to remain around the same level as present prices, the reduction in average cost of production would mean profit would increase above that of the status quo. If prices of output fell to the same extent as average costs reduced, the current profit of the business would be maintained by the change.

For this case study farm 1,000 scenarios with different output yields and input prices were run over seven years of farming to form distributions of average total cost of production for the status quo and each change. Note, the average total cost does not include opportunity cost of capital invested in land, plant and livestock. This is what the return to total capital aims to cover. In years of low output (e.g. low rainfall), average total cost was higher, and in years with good seasons and high output, average total cost was lower. To derive average cost per unit of output, total output was measured as total kilograms of lamb and wool produced over each ‘run’ of the seven-year analysis period along with the associated total fixed and variable costs – all in real terms (1,000 ‘runs’ of seven-year planning periods were simulated). The average cost of producing wool and lamb for each run of seven-years was estimated, and the median of the numerous seven year average total cost of production estimates was identified (Figure 8).

The breakdown of average variable cost, average fixed cost and average total cost, compared with average output, is shown in Figure 8 for the base farm and each change. Each change had the effect of reducing the average total cost of producing lamb and wool below the average total cost of the base farm system. The variability of average total cost of production for each option is shown in Figure 9. Overall, the variability in annual average total cost of production was similar between the status quo and each change. Increasing lambing percentage had the least variability, while increasing stocking rate had some potentially high variability.
Figure 8. Average variable cost, average fixed cost and average total cost versus average output for the base farm (SQ) and each change: increase lambing percentage (C1), increase stocking rate (C2), increase land area (C3) and increase land area and stocking rate (C4)

Figure 9. Variability in average total cost versus average output for the base farm (SQ) and each change: increase lambing percentage (C1), increase stocking rate (C2), increase land area (C3) and increase land area and stocking rate (C4)

One way to show that average costs are falling and economies of size are occurring as output increases is to calculate what it costs to produce a dollar of income (Figure 10). For each future change and associated level of output, the cost to produce a dollar of income, in current dollar terms, fell as output increased. The smallest output and income was the status quo, with increasing lambing percentage, increased stocking rate, increased land, and increased land and stocking rate progressively increasing income and reducing cost per dollar of income. This occurs because fixed costs are spread over more output with each of the changes in question.

Figure 10. Average variable cost, average fixed cost and average total cost per $ of income versus total income for the base farm (SQ) and each change: increase lambing percentage (C1), increase stocking rate (C2), increase land area (C3) and increase land area and stocking rate (C4)

Profit, finance, growth and risk

The next criterion concerns the magnitude of the gains: to what extent will the changes provide additional profit, net cash flow and greater wealth? Which change best meets the farm family goal of building wealth, taking account of the risks involved? How does the variability of outcomes, measured as variation around the average (Coefficient of variation - CV) differ between the options?

The two changes that did not involve a lot of additional capital to be invested (C1) lifting the lambing percentage from 129% per annum to 145% pa, and (C2) lifting the stocking rate on the base farm from an average of 16DSE/ha across the whole farm to 20DSE/ha, performed as follows (mean results):

(C1) Increasing lambing percentage:
- Return on marginal capital (over seven years) - 11.4% (CV 491%)
- Return on total capital (over seven years) - 5.1% (CV 34%)
- Probability of servicing debt (in steady state year) - 98%
- Addition to wealth (at the end of year seven) - $1,826,000 +/- $522,000

(C2) Increasing stocking rate:
- Return on marginal capital (over seven years) - 17.0% (CV 491%)
- Return on total capital (over seven years) - 5.1% (CV 34%)
- Probability of servicing debt (in steady state year) - 90%
- Addition to wealth (at the end of year seven) - $1,821,000 +/- $590,000

The two changes that involved larger amounts of capital investment (C3) expanding by increasing land area of the base farm from 560 to 800ha and running 16DSE/ha; and (C4) intensifying and expanding by increasing stocking rate from 16 to 20DSE/ha across an enlarged farm area of 800ha, performed as follows (mean results):

(C3) Increasing land area:
- Return on marginal capital (over seven years) - 7.2% (CV 91%)
- Return on total capital (over seven years) - 5.0% (CV 33%)
- Probability of servicing debt (in steady state year) - 79%
- Addition to wealth (at the end of year seven) - $1,689,000 +/- $657,000
(C4) Increasing land area and stocking rate:
Return on marginal capital (over seven years) - 8.7% (CV 66%)
Return on total capital (over seven years) - 5.7% (CV 32%)
Probability of servicing debt (in steady state year) - 78%
Addition to wealth (at the end of year seven) - $1,974,000 +/- $833,000

All four changes generated a higher return on total capital (internal rate of return) and addition to end wealth than the status quo with $1,522,000 addition to wealth and 4% return to total capital (CV 40%). The change expected to add the most to wealth after seven years was (C4) - buying extra land and lifting stocking rate across the increased farm area. From the angles of building wealth and servicing debt, the low capital options of increasing lambing percentage or stocking rate compared favourably with the option where extra land is purchased (with no real capital gain) but the stocking rate not increased. In terms of building wealth, buying more land and developing it ranked highest, albeit also with the most extra risk.

The total risk is the volatility of annual profit and cash around the average, and is made up of the business risk and financial risk (Figure 11). Business risk and financial risk combined as total risk is shown in Figure 12. Total risk is the greatest for the high capital changes (Figure 12), because of the additional financial risk involved with the land purchasing options.

**Table 2. DuPont measures for the base farm and each change (in a steady state year).**

<table>
<thead>
<tr>
<th></th>
<th>Base farm (status quo)</th>
<th>Increase lambing percentage</th>
<th>Increase stocking rate</th>
<th>Increase land area</th>
<th>Increase land area and stocking rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating profit margin ratio</td>
<td>36%</td>
<td>41%</td>
<td>40%</td>
<td>39%</td>
<td>41%</td>
</tr>
<tr>
<td>Asset turnover ratio</td>
<td>11.0%</td>
<td>12.3%</td>
<td>13.2%</td>
<td>11.5%</td>
<td>13.7%</td>
</tr>
<tr>
<td>Equity multiplier (assets to equity)</td>
<td>1.02</td>
<td>1.04</td>
<td>1.12</td>
<td>1.39</td>
<td>1.53</td>
</tr>
<tr>
<td>Return on assets</td>
<td>4.0%</td>
<td>5.1%</td>
<td>5.4%</td>
<td>4.6%</td>
<td>5.6%</td>
</tr>
<tr>
<td>Return on equity</td>
<td>4.0%</td>
<td>5.1%</td>
<td>5.5%</td>
<td>4.0%</td>
<td>5.4%</td>
</tr>
</tbody>
</table>
The asset turnover ratio (ATO), calculated by gross income divided by total assets, indicates how well the business is generating product, and sale of product, from assets. All options had a higher ATO than the status quo. A high ATO indicates how good the business is at using capital assets to generate gross income. Increasing land area and stocking rate generated the highest ATO of all the changes. As expected, increasing land area had a lower ATO, because assets were not being fully utilised (lower stocking rate) to generate product to sell.

Relative to the status quo where there was little debt in the system, all changes were expected to have a higher assets to equity ratio (equity multiplier, also expressed as the ratio of debt to assets – gearing ratio) whereby there was a higher proportion of debt in the system. However, for the two high capital development changes, in a steady state year, with the 7% cost of interest greater than the percentage return on assets, the return on equity was less than the return on assets.

Implications of financial risk of the alternative changes
Average total cost, return on the new capital invested and the DuPont measures all show how each change compared to the status quo, with consideration of business and financial risk. However, financial risk can have significant implications for alternative changes in growth of equity. The two choices that did not involve much extra capital investment did not have big implications for the balance sheet, nor gearing ratio or financial risk. The options involving buying extra land had major implications for the gearing ratio and balance sheet, and financial risk. The added business risk for each change was quite similar in that they reflected the same yield and price conditions that could occur, therefore, the added financial risk became the critical consideration.

The effect of adding financial risk to business risk for each change is shown in Table 3. The principle of increasing financial risk is demonstrated whereby the business with each change performs well in one year and earns a good positive return on assets, and then the less attractive but plausible scenario whereby the business with each change performs poorly in one year and makes a negative return on assets. The large capital investments involving buying more land all with borrowed funds carries with it the promise of the highest growth but also the potential for rapid decline of equity (i.e. the greatest financial risk).

<table>
<thead>
<tr>
<th>Base farm</th>
<th>Increase lambing percentage</th>
<th>Increase stocking rate</th>
<th>Increase land area</th>
<th>Increase land area and stocking rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profit made</td>
<td>Loss made</td>
<td>Profit made</td>
<td>Loss made</td>
<td>Profit made</td>
</tr>
<tr>
<td><strong>Business structure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total assets managed</td>
<td>$3.713 m</td>
<td>$3.713 m</td>
<td>$3.785 m</td>
<td>$3.785 m</td>
</tr>
<tr>
<td>Debt</td>
<td>$80,000</td>
<td>$80,000</td>
<td>$152,000</td>
<td>$152,000</td>
</tr>
<tr>
<td>Equity</td>
<td>$3.633 m</td>
<td>$3.633 m</td>
<td>$3.633 m</td>
<td>$3.633 m</td>
</tr>
<tr>
<td>Proportion of equity in total assets</td>
<td>98%</td>
<td>98%</td>
<td>96%</td>
<td>96%</td>
</tr>
<tr>
<td><strong>Business returns</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operating profit</td>
<td>$371,000</td>
<td>-$371,000</td>
<td>$379,000</td>
<td>-$379,000</td>
</tr>
<tr>
<td>Return on assets</td>
<td>10%</td>
<td>-10%</td>
<td>10%</td>
<td>-10%</td>
</tr>
<tr>
<td>Interest rate on debt asset</td>
<td>7%</td>
<td>7%</td>
<td>7%</td>
<td>7%</td>
</tr>
<tr>
<td>Interest costs</td>
<td>$5,600</td>
<td>$5,600</td>
<td>$10,600</td>
<td>$10,600</td>
</tr>
<tr>
<td>Net farm income</td>
<td>$365,000</td>
<td>-$377,000</td>
<td>$368,000</td>
<td>-$390,000</td>
</tr>
<tr>
<td>Growth / decline in equity</td>
<td>$365,000</td>
<td>-$377,000</td>
<td>$368,000</td>
<td>-$390,000</td>
</tr>
<tr>
<td>Return on equity</td>
<td>10%</td>
<td>-10.4%</td>
<td>10.1%</td>
<td>-10.7%</td>
</tr>
</tbody>
</table>
Conclusion

In essence, the prices broadacre farmers have paid for their inputs have generally risen slightly more rapidly than the prices they have received for the products they sell. The downward pressure this phenomenon places on profit can be offset by increasing output without increasing inputs to the same extent. That is, increasing productivity to counter the downward pressure on profit and thereby maintaining competitive returns to capital.

Each of the four changes investigated for this medium-sized lamb producing business represented ways of increasing productivity and maintaining or increasing profit above that of the current farm system. The downward effect of rising costs was countered by each of the changes that were investigated. Two of the changes, buying more land (C3) and buying more land and intensifying it (C4) and the base farm, involved significant extra capital investment. This had the dual effect of increasing gearing and financial risk, and at the same time increasing growth in wealth and annual net cash flows and profits. Buying land and increasing the stocking rate on the base farm and the new land generated the highest potential increase in wealth. Buying land without any capital gain gave the lowest increase in potential wealth of all four changes, because of the substantial burden of financing the additional land (financial risk). This means that if land is purchased, intensification is also required to cover some of the financial risk.

The changes that involved intensifying the current farm by lifting stocking rate or lifting lambing percentage involved less new capital investment than the land purchase options, thus had less serious effects on gearing and the balance sheet, and on exposure to additional financial risk. These intensification changes generated less wealth than buying land and developing it.

Regarding the exposure to business risk (risk from yield and price volatility), each option had similar implications, because the business remained exposed to lamb and wool prices and seasonal pasture production. As the size of the business grew with these potential changes, annual cash flows and profit also grew along with the extent of the upside and downside in volatility. However, volatility grew in proportion to the increase in annual flows of cash and profit, meaning business risk did not change much. Total risk changed because of the increase in financial risk. Importantly, without change, the current business can expect to experience steadily declining profit as a result of costs increasing at 1% per year and no increases in productivity.

References


6. Appendix 1 – details of each change

Change 1: Increasing lambing percentage

Increasing lambing percentage involved growing more pasture and subdividing paddocks for improved ewe nutrition and stock control to increase the number of lambs marked from ewes mated from 129% to 145%. Biophysical modelling suggested that such an increase was achievable from additional pasture production, without substantially lifting supplementary feed levels, by lifting soil fertility on the black flats and open country land classes, from applying a capital application of 56t of superphosphate fertiliser. Extra fencing and expansion of the water supply was required, and in total an extra $72,000 in capital was invested. Some additional fuel and vehicle costs and labour for the busy times were also required.

Change 2: Increasing stocking rate

Increasing whole farm stocking rate from 16 to 20DSE/ha involved lifting soil fertility on the black flats and open country, with more tightly managed grazing, to increase pasture production and consumption, while still maintaining adequate pasture cover levels and respectable levels of supplementary feeding. This involved applying 169t of superphosphate fertiliser in year one. Soil fertility and stocking rate were progressively increased from 6.6 to 7.5 ewes/ha in year one, up to 8.5 ewes/ha in year two and thereafter. An annual stocking rate of 24DSE/ha, on average, was carried on the black flats and open country. The total cost for fertiliser, additional livestock (1,065 head) and subdivision of paddocks (fencing and water system) was $344,000. Variable costs (animal health, shearing, freight, selling costs, supplementary feed and maintenance fertiliser application) increased directly with stocking rate. Fuel and vehicle running costs and general repairs and maintenance increase slightly too, but not in direct proportion to stocking rate, and labour for the busy times was also required.
Change 3: Increasing land area
Increasing land area involved buying 240ha of the same type of land within a 20km radius of the home block, with similar carrying capacity to the existing farm, and with similar proportions of soil types, pastures and fertility. This land was purchased for $4,660/ha and carried 16DSE/ha, the same as the base farm. An extra 1,580 sheep were purchased costing $145/head and $230,000 in total. No extra plant was purchased. Variable costs increased in proportion to the number of DSEs. Fixed costs increased slightly, including labour.

Change 4: Increasing stocking rate and increasing land area
This change involved increasing stocking rate from 16 to 20DSE/ha on the base farm and purchasing 240ha of additional land similar to the existing farm and increasing its stocking rate from 16 to 20DSE/ha, all up farming 800ha at a stocking rate of 20DSE/ha. As per change two, stocking rate was increased by lifting soil fertility levels on the black flats and open country land areas, which involved applying 241t of superphosphate fertiliser in year one. Additional infrastructure required included extra fencing and expansion of the water system. The total cost of extra investment in land, capital fertiliser, livestock (3,104 head) and improvements was $1.8 million. Variable costs increased in proportion to DSEs and fixed costs increased too. An additional labour unit was employed and the owner/operator allowance was also increased to reflect the increase in management demands arising from the increase in size, complexity and risks of the expanded farm business.

For each change, all capital development was funded using borrowed funds. An amortised seven year loan at 7% interest (nominal) was assumed for the base farm and the low capital development changes (one and two). A 15 year amortised loan at 7% interest (nominal) was assumed for the high capital development changes (three and four).

6. Appendix 2 – results of each change
Production and profitability information for the base farm and each change.

<table>
<thead>
<tr>
<th>Status quo</th>
<th>Change 1</th>
<th>Change 2</th>
<th>Change 3</th>
<th>Change 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base farm</td>
<td>Increase lambing %</td>
<td>Increase stocking rate</td>
<td>Increase land area</td>
<td>Increase stocking rate and land area</td>
</tr>
<tr>
<td>Mean</td>
<td>Standard deviation</td>
<td>Mean</td>
<td>Standard deviation</td>
<td>Mean</td>
</tr>
</tbody>
</table>

Physical details

Average SR (DSE/ha) | 15.7 | 0.7 | 16.5 | 0.6 | 20.2 | 0.9 | 15.7 | 0.7 | 20.2 | 0.9 |
Average No. adults over the year (mature and 1-2 y.o.) | 3,190 | 17 | 3,193 | 19 | 4,114 | 20 | 4,559 | 24 | 5,875 | 26 |
Supplementary feed (t) | 41 | 77 | 33 | 67 | 52 | 96 | 60 | 111 | 74 | 138 |
Lamb production kg (cwt/ha) | 111 | 13 | 132 | 12 | 146 | 18 | 111 | 13 | 146 | 18 |
No. kg of wool produced/ha | 22.2 | 0.9 | 22.6 | 0.9 | 29.3 | 1.2 | 22.3 | 0.8 | 29.2 | 1.2 |

Profit and loss

Gross income | $407,307 | $68,411 | $465,354 | $73,195 | $536,343 | $90,060 | $583,026 | $97,182 | $762,954 | $129,483 |
Variable costs | $162,161 | $19,584 | $169,552 | $17,476 | $204,106 | $24,018 | $209,399 | $28,495 | $290,309 | $34,176 |
Total gross margin | $245,145 | $48,827 | $295,802 | $55,719 | $332,237 | $65,942 | $353,627 | $68,687 | $472,645 | $95,307 |
- per DSE | $28 | $14.6 | $32 | $21 | $32 | $16 | $28 | $16 | $32 | $16 |
- per Ha | $438 | $74.6 | $528 | $58.6 | $593 | $59.3 | $442 | $56.5 | $591 | $61.2 |
Overhead costs | $35,751 | - | $40,903 | - | $53,267 | - | $59,964 | - | $87,782 | - |
Owner / operator Allowance | $61,818 | - | $61,818 | - | $61,818 | - | $61,818 | - | $72,121 | - |
Operating profit (EBIT) | $147,576 | $74,891 | $193,081 | $78,016 | $217,152 | $98,101 | $231,845 | $106,908 | $472,645 | $141,695 |
Interest and lease costs | $3,520 | $190 | $6,705 | $370 | $18,672 | $1,737 | $87,148 | $5,532 | $117,227 | $8,538 |
Net farm income | $144,056 | $74,891 | $186,376 | $78,016 | $198,480 | $96,371 | $144,697 | $105,372 | $195,515 | $138,610 |
Tax payable | $31,047 | $190 | $6,705 | $370 | $18,672 | $1,737 | $87,148 | $5,532 | $117,227 | $8,538 |
Net profit / change in equity | $113,009 | $66,623 | $149,037 | $68,487 | $159,650 | $86,587 | $113,970 | $98,048 | $155,793 | $123,931 |

Balance Sheet

Assets | $3,713,000 | $3,785,000 | $4,057,000 | $5,061,000 | $5,553,000 |
Debt | $80,000 | $152,000 | $424,000 | $1,428,000 | $1,920,000 |
Equity | $3,633,000 | $3,633,000 | $15,553,000 | $3,633,000 | $3,633,000 |
Nutritional management to reduce embryo mortality in ewes

Dr Susan Robertson\textsuperscript{1,2}, Dr Ed Clayton\textsuperscript{1,3}, Dr Stephanie Knott\textsuperscript{1,2}, Dr Bindi King\textsuperscript{2}, Ms Bess Morgan\textsuperscript{2} and Associate Professor Michael Friend\textsuperscript{1,2}
\textsuperscript{1}Graham Centre for Agricultural Innovation
\textsuperscript{2}Charles Sturt University
\textsuperscript{3}NSW Department of Primary Industries
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Increasing the number of lambs born is one means of increasing the profitability of sheep production. Increasing nutrition in the period around mating (i.e. flushing), can increase the number born, although attention to survival of twins is required to obtain the most benefit.

Grazing naturally cycling ewes on adequate amounts of live pasture, such as lucerne, for seven days before joining, and for the first seven days of joining, can increase the number of foetuses by 21 lambs per 100 ewes joined (Robertson et al. 2013) compared with grazing dead pastures. However, it is not known whether more lambs will be produced if ewes graze live pasture for longer into joining, and whether the quantity of pasture may affect the response.

While feeding ewes at only half their maintenance requirement is likely to increase embryo mortality (Abecia et al. 2006), feeding levels at twice the maintenance energy requirement is also known to increase embryo mortality, with higher losses likely if these levels are fed on days 11 and 12 of pregnancy (Parr, 1992). Feeding high levels of protein is also known to increase embryo mortality in some circumstances (Velazquez, 2011), and concerns have been raised that the high protein content of lucerne may increase mortality.

The aim of this experiment was to compare the effect of feeding lucerne pasture at different quantities and times around the mating period, to allow recommendations to be made for nutrition around joining.

Methodology
A pen study was conducted in 2013 and 2014. Where day 0 = day of artificial insemination, the treatments comprised:

1. Control - commercial maintenance pellet (low grain / protein) at maintenance energy
2. Day 0 to 17 fresh lucerne pasture \textit{ad libitum}
3. Day 0 to 17 fresh lucerne pasture \textit{at maintenance energy}
4. Day 0 to 7 fresh lucerne pasture \textit{ad libitum}
5. Day -7 to 17 fresh lucerne pasture \textit{ad libitum}

In each year, Merino ewes were allocated to 10 pens (two of each treatment) of approximately 20 ewes, and remained in the pens from two weeks before the start of feeding to 18 days after insemination in each year. Oestrous cycles were synchronised and the ewes artificially inseminated. Ovulation rate was estimated and blood samples were collected on days five, 12 and 17 after insemination. The ewes were pregnancy scanned at around day 60 after insemination.

Results and discussion
The proportion of ewes having more than one ovulation tended to increase if ewes were fed lucerne for seven days before insemination, as expected. Pregnancy rates were not reduced if ewes were fed either maintenance or \textit{ad libitum} levels of lucerne, compared with maintenance pellets, before or from the day of insemination (Table 1). However, the proportion of pregnant ewes with twin foetuses was almost halved if ewes were fed \textit{ad libitum} lucerne from insemination for 17 days, compared with those fed maintenance levels of either pellets or lucerne. The difference is assumed to be due to embryo mortality. The proportion of ewes with twin foetuses was not statistically reduced in the other \textit{ad libitum} lucerne treatments, but was 10% lower than ewes fed maintenance pellets. The number of foetuses per ewe scanned was not statistically reduced by feeding lucerne, but was 10-20% lower for groups fed \textit{ad libitum} levels of lucerne.

Take home messages:
- both under and over-feeding can increase embryo mortality
- flushing using grain or live pasture can increase the number of lambs born
- to avoid any risk of increased embryo mortality, avoid feeding ewes at high energy levels to day 17 of pregnancy.

Nutritional management to reduce embryo mortality in ewes
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• flushing using grain or live pasture can increase the number of lambs born
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5. Day -7 to 17 fresh lucerne pasture \textit{ad libitum}

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The differences in fetal numbers were not related to urea concentrations in the blood of ewes, indicating that excess protein was not the cause. Progesterone increased more slowly between days five and 12 for ewes that were fed ad libitum levels of lucerne to day 17, compared with those in the control group, and a smaller increase was associated with less ewes being pregnant. This indicates the effect of feeding high rates of lucerne on embryo mortality and fetal number is likely because high levels of lucerne reduce progesterone levels.

The results suggest that feeding maintenance levels of lucerne does not reduce fetal numbers compared with feeding a pellet. Feeding ad libitum lucerne to day 17 of pregnancy had an adverse effect. While feeding ad libitum levels only to day seven of pregnancy did not statistically reduce fetal numbers, the trend suggests there may be an effect. This contrasts with studies that show naturally-joined ewes flushed and grazing ad libitum levels of lucerne during the first seven days of joining produce more lambs than those grazing dead pasture and maintaining weight.

It is possible that pen feeding, rather than grazing, and synchronisation and artificial insemination, rather than a natural joining, may both influence whether high levels of lucerne cause embryo mortality. A grazing trial is currently underway to determine whether grazing lucerne only to day seven, or throughout joining, will result in more lambs than grazing on dead pasture.

**Conclusions**

Producers should avoid grazing or feeding artificially inseminated ewes at high levels (1.5–2 times maintenance energy requirement) from insemination to Day 17 of pregnancy to avoid any risk of increased embryo mortality.

Studies continue to determine whether grazing naturally joined ewes on lucerne past day seven of joining will increase or reduce fetal numbers.

### Table 1

Mean reproductive performance of ewes fed maintenance levels of pellets (control) or maintenance or ad libitum levels of fresh lucerne between days -7 and 17 relative to artificial insemination (2013 and 2014)

<table>
<thead>
<tr>
<th></th>
<th>Proportion of ewes with multiple ovulations</th>
<th>Proportion of ewes pregnant</th>
<th>Proportion of pregnant ewes with multiple foetuses</th>
<th>No. foetus / ewe scanned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (pellet)</td>
<td>0.64</td>
<td>0.67</td>
<td>0.34&lt;sup&gt;a&lt;/sup&gt;</td>
<td>0.90</td>
</tr>
<tr>
<td>0-17 Maintenance</td>
<td>0.67</td>
<td>0.63</td>
<td>0.32&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.83</td>
</tr>
<tr>
<td>0-17 ad libitum</td>
<td>0.77</td>
<td>0.69</td>
<td>0.18&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.81</td>
</tr>
<tr>
<td>Minus 7-17 ad libitum</td>
<td>0.83</td>
<td>0.59</td>
<td>0.23&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.73</td>
</tr>
<tr>
<td>0-7 ad libitum</td>
<td>0.67</td>
<td>0.57</td>
<td>0.22&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>0.71</td>
</tr>
</tbody>
</table>

<sup>a,b</sup> Different letters within columns indicate means differ at P<0.05.

### Acknowledgements

This work is funded by Meat and Livestock Australia.

### References


Evaluation of the effectiveness of Stockplan® training and the use of publicly funded drought lots in the management of groundcover issues in the Murrumbidgee catchment area

Ms Janelle Jenkins
Riverina Local Land Services
T: 02 6941 2253, E: Janelle.jenkins@lls.nsw.gov.au

Take home messages:
- drought lot feeding facilities have proven to be a valuable asset to help with livestock management during dry conditions
- protection of pastures and maintenance of groundcover is one of the main motivations for landholders to construct drought lot feeding facilities
- landholders found the Stockplan® course a useful tool when helping to design and implement a drought lot feeding facilities.

The impact of periodic dry conditions and drought have the potential to significantly affect the long-term stability and sustainability of grazing systems in the moderate to high rainfall zones of the Murrumbidgee Catchment area. Drought lots have proven to be a useful tool to assist landholders to manage livestock and groundcover on farm during dry conditions.

Over the past six years the Murrumbidgee Catchment Management Authority (CMA) has accessed public funding to assist landholders in the catchment to participate in Stockplan® training and then, if interested, undertake the development and building of drought lot feeding facilities on their individual properties.

The Murrumbidgee CMA chose to invest public funds in both training and on-ground incentives to aid in the construction of drought lots due to the substantial potential flow on effects when landholders are able to better manage groundcover on-farm. It has been recognised that the on-farm maintenance of groundcover has significant benefits, both on and off site. On-farm benefits include overall biodiversity maintenance and protection, better plant production post drought (resulting in significantly reduced costs of re-establishing pastures (AWI, Undated), protection of the soil resource and protection of on-farm water resources from siltation (on-farm dams and local creeks).

Off-farm benefits from improved on-farm groundcover include reduced erosion, waterway sedimentation and siltation (resulting in an overall improved downstream water quality), control / remediation of dryland salinity impacts, protection of native pastures and an overall increase in a catchment’s biodiversity and connectivity.

Stockplan® is a computer software package that contains decision support tools to assist livestock producers to formulate management decisions before and during seasonal dry periods or in the early stage of drought. The program and the accompanying training workshop encourage a proactive approach to drought, resulting in reducing environmental and financial impacts.

Landholders generally found benefit from attending Stockplan® training to help design drought lots and plan for future dry conditions. However few used the software packages post-training. Landholder considerations on the construction of drought lots centred on the on-farm production, groundcover and livestock protection factors. Very few considered off-farm natural resource benefits as important in the decision making process. The evaluation aimed to determine the effectiveness of Stockplan® training and the subsequent development of on-farm drought lot feeding facilities to assist landholders to better manage groundcover during climatic conditions ranging from season dry periods to full drought declaration in the moderate to high rainfall mixed farming and grazing zones of the Murrumbidgee catchment.

Methodology

The questionnaire / interview was undertaken on-farm with each of the landholders by Mixed Farming Officer Janelle Jenkins. The process involved a formal questionnaire followed by an inspection of the drought lot. The questionnaire was divided into five sections:
- general information - regarding the participants, type of agricultural enterprises they were engaged in, and future plans for the farm business
- Stockplan® training – usefulness of participation in the training
- drought lot feeding facility – type, design process and subsequent usefulness of the drought lot
- stocking rate and groundcover management - interactions between the use of the drought lot, groundcover management and other natural resource issues on the farm
- further training and information – how landholders prefer to receive information.

The inspection of the drought lot was an informal process which allowed the landholder to further expand on issues discussed as part of the questionnaire or that were outside the scope of the questionnaire.

A total of 22 landholders participated in the questionnaire. This is a relatively small sample size and as so did not allow extensive statistical analysis (NSW DPI Biometrician per comms). Simple analysis was undertaken to investigate the quantitative data, including averages and means. The qualitative sections of the questionnaire were analysed by theme analysis, where the frequency of common themes mentioned were noted and grouped into like themes.
Results

Participant information

All 22 landholders interviewed were classified as owner-managers. The main age brackets were 36-50 years (8) and 51-60 years (8). The average time they had owned and managed the farm was 20.6 years, and the average farm size was 1,143.5 hectares. All 22 landholders derived their primary source of income from the farm business.

The majority of the landholders were expanding or planning to expand their business as funds became available (Figure 1). About half the landholders were livestock dominated enterprises, while half had a significant cropping component (Table 1 and Figure 2).

Figure 1. Future plans for farm businesses

Table 1. Enterprise mix

<table>
<thead>
<tr>
<th>Enterprise mix</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mixed farming</td>
<td>8</td>
</tr>
<tr>
<td>Crop dominate mixed farming</td>
<td>3</td>
</tr>
<tr>
<td>Livestock dominate mixed farming</td>
<td>5</td>
</tr>
<tr>
<td>Livestock production with minor cropping</td>
<td>2</td>
</tr>
<tr>
<td>Livestock only</td>
<td>4</td>
</tr>
</tbody>
</table>

The majority of the landholders (15 of 22) estimated the dry sheep equivalent (DSE) stocking rate of their farm in normal years to be between 7.5 and 15 DSE. Most of the landholders were planning to keep their stocking rates the same, while four were planning to increase stocking rates.

There was a large variation in the composition of the pasture types on the 22 properties sampled (Table 2).

Table 2. Pasture composition on sampled properties

<table>
<thead>
<tr>
<th>Pasture</th>
<th>Av. percentage (%) of total pasture area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native pasture</td>
<td>21</td>
</tr>
<tr>
<td>Fertilised native (includes naturalised and / or introduced species)</td>
<td>28</td>
</tr>
<tr>
<td>Naturalised annual pasture (not sown and no perennial species, with or without legumes)</td>
<td>17</td>
</tr>
<tr>
<td>Sown annual pasture species (no perennial species, with or without legumes)</td>
<td>19</td>
</tr>
<tr>
<td>Sown short-term perennial-based pasture species (&lt;3-5 year pasture phase; may also include annual species)</td>
<td>67</td>
</tr>
<tr>
<td>Sown long-term perennial-based pasture species (&gt;5 year pasture phase, may also include annual species)</td>
<td>45</td>
</tr>
<tr>
<td>Timbered grazing area</td>
<td>18</td>
</tr>
<tr>
<td>Forage crops</td>
<td>29</td>
</tr>
<tr>
<td>Other</td>
<td>50</td>
</tr>
</tbody>
</table>

Assessment of Stockplan® training

All landholders participated in the Stockplan® training course from 2006–2008. They were some of the earliest participants to undertake the training in the district.

Table 3 shows that some of the software was not relevant. Some of the early Stockplan® training did not have all the packages included. Table 4 also shows post-training general usage of the software.

Table 3. Use of Stockplan® material

<table>
<thead>
<tr>
<th>Packages/Information</th>
<th>Never</th>
<th>Sometimes</th>
<th>Most of the time</th>
<th>Always</th>
<th>Not Relevant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drought Pac software</td>
<td>9</td>
<td>8</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>FSA software</td>
<td>8</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Impact software</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Stockplan® resource material</td>
<td>3</td>
<td>15</td>
<td>1</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Drought lot information booklet</td>
<td>3</td>
<td>14</td>
<td>2</td>
<td>3</td>
<td>0</td>
</tr>
</tbody>
</table>
After attending Stockplan® training, 19 of the 22 landholders installed a drought lot for the first time, 21 developed a drought plan, 19 considered animal welfare issues as part of drought lot development, 16 sought further information regarding drought and 22 considered groundcover management impacts on pastures.

When asked to comment generally on the Stockplan® training the responses received were classified into different themes; positive (18 comments), neutral (11 comments) and negative (three comments). The positive themes included reinforcement of prior knowledge, general enjoyment of the training, abilities of the presenters, practicality of the information presented, enjoyment of visiting other farmers and talking to other landholders, design ideas and usefulness of animal health issues. The neutral comments included the decline to make comment and the similarity to existing landholder knowledge. The negative comments included compulsory aspect (to receive incentive funding), use of computer programs and time constraints to undertaking the training.

**Assessment of drought lot feeding facilities**

All 22 landholders had accessed incentive funding to assist with the construction of drought lots. The main type of drought lot constructed was the small paddock type with trail feeding (12), followed by multiple yards with trough one side (six) and multiple yards with a common trough area (four).

As shown in Table 4, incentive funding was an important factor in the decision to construct a drought lot. Few landholders used private consultants in the design phase with most preferring the training and government extension officer. Suitability of location and sourcing feed and water were all important design considerations.

<table>
<thead>
<tr>
<th>Information source</th>
<th>Not important at all</th>
<th>Not important</th>
<th>Not sure</th>
<th>Important</th>
<th>Very important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incentive funding provided</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>7</td>
<td>13</td>
</tr>
<tr>
<td>Stockplan® training provided</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td>Advice from my private consultant</td>
<td>18</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Advice from another farmer</td>
<td>8</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td>2</td>
</tr>
<tr>
<td>Advice from a government extension officer</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Finding a suitable location for the drought lot</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>The ability to store sufficient on-farm feed</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>The ability to source sufficient feed during drought</td>
<td>0</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>12</td>
</tr>
<tr>
<td>Sufficient water availability on farm during drought</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>17</td>
</tr>
<tr>
<td>Reduced stocking rates</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delayed reintroducing stock to paddocks if impending rain was likely to cause runoff</td>
<td>1</td>
<td>2</td>
<td>7</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Delayed reintroducing stock to paddocks if water logging was likely to be an issue</td>
<td>1</td>
<td>1</td>
<td>6</td>
<td>5</td>
<td>9</td>
</tr>
</tbody>
</table>

When asked to comment generally on groundcover management on their farms, the comments could be subdivided into 5 themes: pasture issues (18), stocking rate issues (5), rotational grazing (3), climate (2) and cropping country options (3).

**Analysis of landholder training and information sources**

Landholders were asked to indicate how they prefer to receive information on groundcover and drought management strategies (Table 8). They were able to give multiple responses depending on individual preferences.
Table 8. Preferred information sources

<table>
<thead>
<tr>
<th>Information source</th>
<th>Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use adviser to keep up-to-date with information</td>
<td>12</td>
</tr>
<tr>
<td>Fact sheets – hard copies</td>
<td>15</td>
</tr>
<tr>
<td>Fact sheets – electronic copies</td>
<td>18</td>
</tr>
<tr>
<td>Half-day workshops</td>
<td>19</td>
</tr>
<tr>
<td>Comprehensive workshop spread over a number of days</td>
<td>17</td>
</tr>
<tr>
<td>Field days</td>
<td>20</td>
</tr>
<tr>
<td>Online training programs that you can work through at your own speed</td>
<td>3</td>
</tr>
<tr>
<td>Computer-based decision support systems, such as Stockplan®</td>
<td>9</td>
</tr>
<tr>
<td>Other</td>
<td>18</td>
</tr>
</tbody>
</table>

Other preferred sources of information included agronomist and private advisers, rural magazines and newspapers, experience and other farmers.

Discussion

Landholders indicated they had learnt some valuable lessons about managing land within its capacity from the long-term dry period that was experienced during the ‘Millennium’ drought. This was strongly reflected in the desire not to greatly expand current stocking rates.

Although a relatively small sample, the landholders interviewed were united in their praise of the usefulness of the drought lot to their enterprise. Many commented on the increased flexibility drought lots have allowed when making stock trading decisions. Other comments included the reduction of pressure on pastures and how integral the use of the drought lot had become to their enterprise. These findings are reflected in other case studies where drought lots have been implemented (AWI, Undated; Hunt et al, 2011).

The general consensus from the landholders sampled was that Stockplan® training was useful for drought lot design and drought planning practicalities, but few used the software packages post-training. This may be a reflection of the age of the landholders interviewed.

The decision to construct a drought lot appears to have been driven mainly by the need to maintain core livestock and protect pastures. On-farm and off-farm natural resource protection issues (outside of on-farm pastures and soils) did not rate highly in the landholder’s decision-making process on construction. This is despite the abundant information available to landholders on the negative impacts of poor groundcover on natural resources.

This evaluation indicates that landholders largely prefer to undertake groundcover monitoring using an informal visual basis compared to more formal evaluation methods.

Conclusion

The evaluation project investigated a small sample of early adopters of drought lots in the moderate to high rainfall mixed farming and grazing zones of the Murrumbidgee catchment. The overall consensus of the evaluation indicates that landholders saw the value of drought lots as a multi-faceted asset to their enterprise. The link between the retention of groundcover and the use of a drought lot was recognised as a major benefit to the property. Off-farm benefits were not rated as highly as motivation for the implementation of drought lot. The value of the Stockplan® training and on ground incentive funding provided was also recognised as being highly valued.

References

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“Tarandi” is a mixed farming enterprise of 1,488ha, 37km north-east of Wagga Wagga. On average, we crop 600ha of grazing wheat, canola, narrow leaf lupins and new pasture with or without a cover crop each year. Pastures sown include two types of phalaris, lucerne, chicory, arrowleaf and a sub clover.

“Tarandi’s” main enterprise is breeding prime lambs out of crossbred ewes. Currently we run more than 3,700 ewes all joined to a Dorset ram for six weeks, to start lambing the last week in July.

In November 2013, we weaned 4,550 lambs. Weaning decisions are made according to seasonal conditions (e.g. what proportion of lambs are to be sold to a fattener straight off the ewes and the number to be kept and sold as trade or export).

The grazing wheat crops allow for backgrounding more than 500 steers or heifers from the mid-June to mid-November, again influenced by seasonal conditions. Grazing wheat crops are de-stocked of cattle around 15 August or growth stage 30 (i.e the start of stem elongation).

In early August a monitor weigh is done, allowing investigation of marketing options, with some cattle usually sold at this time.

Over the last couple of years we have sown wheat into degraded pasture paddocks, with the plan not to harvest but to graze longer and then fallow out in September. The following year the paddock is brought into a crop rotation starting with canola.

Livestock are an important part of “Tarandi’s” makeup, but more important are the pastures themselves. Pastures are costly to establish so it’s important to look after them, particularly during drought or when critical groundcover limits are reached so they are not degraded.

Drought lots help main pastures

Our aim is to maximise saleable kilograms per hectare of various commodities (e.g. lamb, wool, beef or crops), hence drought lots have been built so we can maintain our pastures in the best possible condition.

There are various terms used to describe the practice, including containment areas, sacrifice areas or drought lots. Drought lots refer to the maintenance feeding of sheep at high stocking rates in confined areas, where all feed and water is supplied, primarily in order to minimise pasture and soil degradation.

When establishing a drought lot area, the following key points should be considered, but the main one is to keep it simple. Key considerations include location, fence type, costs, space requirements, mob sizes, troughs and water. There are a number of publications available listing recommendations, but at the end of the day you have to be practical and realistic, and your decision-making should be based on what you have available. “Tarandi” drought lots are simple, costs have been kept to a minimum, but most importantly they work.

Advantages and disadvantages

Advantages of drought lots include:

• pasture density and composition is preserved with rapid regrowth while destocked post-drought
• soil and nutrient loss from paddocks is minimised
• sheep are prevented from chasing green pick and expending energy after a rain event
• full ration feeding costs little more compared to paddock feeding but paddocks have adequate groundcover, ready to respond to the break

Disadvantages of drought lots include:

• cost of full ration feeding (little more than when paddock feed is nearly exhausted)
• sheep need to be removed from the pens if there is heavy rain and mud
• potential animal health issues including salmonella, pulpy kidney, grain poisoning and worms. We have experienced no issues other than grain poisoning when ewes are removed from drought lots after rain and then returned to the drought lots. Ewes are vaccinated pre-lambing with five in one and worm tests are done
• need clean water in each pen (at least seven litres of water per sheep each day in summer).

When selecting the site for our drought lots, we considered the following.

• drainage – need to have a well drained site
• shade from trees allows normal sheep shade-seeking behaviour; it looks and feels more natural
• some protection from prevailing winds
• convenient to sheep yards
• the site should be located close enough to home to minimise travel, but far enough away to avoid the potential effects of dust. The dust is very fine and infiltrates everything close by, as we discovered with our first lots which were too close to the shearsers’ huts and shearing shed, so we relocated the lots.

Drought lot experience since 2008 – a successful strategy for us

Take home messages:

• drought lots are cost effective but keep it simple
• feed on the ground
• destocked paddocks have much less erosion than stocked paddocks
• paddocks respond more quickly post-drought when sheep are absent and some groundcover is preserved.

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Sheep behaviour

Sheep seem to adapt to life in a drought a lot better than imagined. Initially it was a mental battle penning up the sheep in these confined areas. However, when it was windy the ewes would sit bum into wind, eyes closed, and chew their cud. They did not walk around, they stayed still. It seemed to be a behavioural adaption on windy days.

Fencing and pen design

Hinge joint is commonly used for fencing, but the extra expense and time to construct a hinge joint fence is not necessary. The “Tarandi” drought lot fences are six plain wires spaced about 150mm apart. We electrified wire three or four with a gap of 180mm to encourage the ewes to challenge the fence between the bigger gap resulting in them being hit by the electric fence, and we have not had a ewe boxed yet. Again some drought lots are just too complicated!

We do not have gates between the pens or sheep will get boxed when you are feeding. Our gates open into a paddock and our experience is the gate can stay open while the pen is fed. Any sheep that leave the pen quickly re-enter to get to the feed, so the gate is shut as we leave the pen.

According to an article I read, adult dry ewes have a minimum space requirement of 2.5m$^2$. “Tarandi” pen sizes are 100m x 20m which is close to 2.9m$^2$, with about 700 ewes to a pen. For ease of turning the ute and feed trailer around, 22m wide pens would have been better.

We have also found the density of 2.9m$^2$ was useful as the urine helped settle the dust. In our original pens we had a lower density and did not get this benefit from the urine.

According to some publications, feed troughs are necessary to prevent feed wastage, and animal health problems and 15-20cm feed space / sheep is recommended. So for 700 sheep per pen, we would need a 140m long trough per pen - impractical. Keep it simple.

“Tarandi” drought lots are fed on the ground in a neat trail, as the sheep have all day to pick at the feed. It is important to get the trail length right so each sheep gets a go at the trail. As an example, our grain feeding runs 7.5kg/sec to get 700g/head (i.e. 1500/1800 rpm 1st gear (Nissan)). If you go slower sheep get under the feed trailer and get run over. We have put deflector wings on the trailer to prevent this.

Feed rations

We use our local district veterinarian or sheep and wool officer to check / calculate our final feeding rates, after first having the wheat and roughage feed tested and deciding what sheep weight / condition we want. Lupins, which are the safest to feed due to their low starch content, are used to educate sheep to come to a feed trail. Feed by feed the wheat component is increased. Hay or straw is also fed on alternate days to the grain. We also put a loose mix of two parts sodium bicarbonate, one part lime, and one part salt in troughs as these additives supply the necessary buffer, calcium and sodium for grain feeding. Mixing with the grain can interfere with the free flow of the grain from the trailer. (Note: no fancy mixes, no vitamin supplements). Eskalin has also been used to safe guard against grain poisoning.

Our feed requirements are calculated based on the Metabolisable Energy (ME) figures for the tested feed we have on hand. The last time we fed in drought lots our hay was 9.1ME and wheat 12.6ME.

We do not concern ourselves with protein as it only has to be 6% crude protein for dry sheep or sheep in the first four months of pregnancy, and invariably our feed will exceed this figure. While energy from cereal grain is usually cheaper than energy from hay, we do use some hay or straw to reduce the risk of grain poisoning, and also reduce the risk of soil impaction in the gut. We are sometimes prepared to allow some weight loss, say from fat score four to fat score three, which reduces feeding costs. At joining we try and maintain weight. Feeding to gain weight for higher conception rates is not done as it is rarely profitable.

We keep it simple. Using round bales, it is not possible to provide part bales, so the starting point we work from forour feeding is a 330kg bale/pen three times a week.
Once we decide how much energy is being provided (e.g. from a drought manual or computer program like GrazFeed), we then calculate how much wheat we need for maintenance or slow weight loss. Pens can vary in sheep numbers so the requirements are calculated for each individual pen. About 1kg roughage per week is generally recommended as the minimum to maintain good health in drought lots.

The last time we used our drought lots our hay analysed at 9.1ME. So, if we feed a 330kg bale / feed three days a week to 700 ewes, that is 990kg / 700 head = 1.4kg / head / week which is adequate roughage. With a 9.1ME for hay, it would have provided about 21% of 55kg ewes feed requirements. Usually we would prefer to keep the crossbred ewes heavier than that for joining, say 65kg and fat score three. After the hay contribution is calculated, the wheat required can be determined.

The proportion of grain and hay or straw used will also vary depending on the relative costs of the energy and the risk of grain poisoning from different grains. While containing less energy straw is better than hay at preventing grain poisoning as it is less digestible and the sheep spend more time chewing their cud (saliva contains bicarbonate which is a good buffer).

**Water troughs**

Various water troughs can be used. We find a plastic 200L drum cut lengthwise gives adequate water supply in our shaded pens as not all 700 sheep want to drink at the same time. We clean the troughs once a week. Big troughs waste considerably more water when they are cleaned out.

We are aware of the problems some have experienced with weaners in unshaded pens where they camp around troughs and the weaker weaners cannot get to the water.

Our routine is designed for our welfare and that of the sheep:

Monday, Wednesday, Friday - feed hay / straw
Tuesday, Thursday, Saturday - feed grain
Sunday - clean water troughs. Sheep also have the opportunity to clean the pen up, and little wastage was observed.

It is important to be set up so that feeding of both hay and grain is done quickly and efficiently. We allow two hours per day for hay feeding and about 1.5hrs per day for grain feeding and topping up loose licks for 2,800-3,000 sheep in four pens. This provides us time for other work and to not get bogged down and depressed by feeding.

Hopefully, with no feeding Sunday, it is mostly free for some rest and recreation, important especially in a drought.

**Conclusion**

The drought lots are a permanent fixture used sporadically as required, and are an excellent investment. The big message is keep it simple. The ability to keep groundcover on paddocks in a drought or tough autumn, and not flogging out paddocks and hence struggling once it does rain, has a big advantage. There is very little difference in the expense of full ration feeding compared to paddock feeding, but there is a big difference between pasture production after the rain if paddocks have been de-stocked or not.
The quest for acid-tolerant lucerne: an overview

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Lucerne is one of the most important fodder plants to agriculture in Australia and internationally. Although it is the most broadly adapted perennial legume species across the Australian agricultural landscape, it remains highly sensitive to soil acidity.

Soil acidity is arguably the most common soil constraint across southern and central NSW, with over three quarters of soils in a survey of 4,700 observed to have a pH_{s, 0} ≤ 5.0 (Scott et al. 2007). Given that NSW comprises more than 50% of the Australian domestic lucerne seed market (Slinger et al. 2010), the case for improving the acid soil tolerance of lucerne appears obvious. However, Australia is not the first country where attempts have been made to develop lucerne germplasm for acid soil environments. Hayes et al. (2012) identified 13 published scientific articles between 1958-2002, mostly from North America, which report on various aspects of developing lucerne for acid soil environments. A more recent initiative has been undertaken in Australia to develop lucerne for acid soil environments. Despite this collective effort spanning over 50 years, still no lucerne cultivar exists with enhanced tolerance to acid soil environments.

This paper summarises key results from this recent research and describes the challenges that lay ahead.

**Acid soil environments**

Acid soil environments are inherently complex and variable. Soil can vary by up to 1.5 pH units within one square metre of soil, with variability also occurring with time and depth (Conyers and Davey, 1990). Soil is a dynamic environment, constantly changing in response to temperature and moisture conditions, and the presence of plants and other organisms growing within it.

By strict definition, an acid soil is a soil with a pH <7. However, commonly associated with low pH are nutrient imbalances, such as deficiencies of available phosphorus (P), nitrogen (N) or trace elements, or toxicities of aluminium (Al) or manganese (Mn) in the soil solution. All these factors can independently inhibit plant growth, and different plant species have different tolerances to the acid soil-related stresses. The key point is that plants are not usually selected for tolerance to acid soil environments; instead, they are selected for tolerance to particular stresses commonly associated with soil acidity.

**Legumes and acid soils**

The task of developing legumes for acid soils is more complex than for non-legumes. For legumes to function effectively, the plant needs to coexist with complementary root nodule bacteria living in the soil, which themselves can be sensitive to factors associated with acid soils. So in developing a legume such as lucerne for acid soils, three things are required:

- a lucerne genotype tolerant of the acid soil environment
- root nodule bacteria tolerant of the acid soil environment
- complementarity between the legume host and root nodule bacteria, such that the legume roots can be nodulated and symbiotic nitrogen fixation occurs.

**Selecting lucerne for acid soils**

To date most research has focussed on developing lucerne genotypes that are tolerant of aluminium toxicity, with few studies focussing on other acid soil related factors such as Mn toxicity or root nodule bacteria compatibility with lucerne.

Aluminium toxicity inhibits root growth, reducing the plants ability to explore the soil for water and nutrients. Previous attempts in North America to select lucerne for acid soils relied on field-based selection; that is, sowing lucerne at an acidic field site and selecting more promising individuals to develop an ‘acid-tolerant’ population. While this approach developed populations exhibiting improved adaptation to acid soil environments such as the Georgia Acid Tolerant population, the level of genetic improvement was deemed insufficient to be economically useful in acid soil environments (Bouton, 1996). The lack of success here is likely to be attributable to a number of factors including:

- variable soil environments led to the selection of ‘escapes’; that is, individual plants that were selected may have been growing in more favourable/less acidic micro-environments and were therefore not more tolerant genotypes
- Al tolerance occurs infrequently in lucerne populations, and is perhaps present in only 2% of the population. Lucerne is largely an obligate out-crossing population, so to develop a viable population a large number of Al-tolerant individuals are required. This is difficult when Al-tolerance occurs so rarely among the population
- the root nodule bacteria were not considered, so even if tolerant genotypes were found, they would probably not persist because they were unable to fix atmospheric nitrogen.

Take home messages:

- the world’s first genuinely aluminium tolerant lucerne cultivar is expected to be released in Australia within the next three years
- a new strain of lucerne rhizobia will also be released commercially within the next few years
- manganese toxicity may limit the effectiveness of these new technologies in southern NSW and Victoria.
Results

Aluminium tolerant genotypes

The more recent Australian approach sought to improve on previous attempts by selecting lucerne genotypes in high Al solution culture (Scott et al. 2008). This overcame some of the problems associated with in-field selection, with the solution culture providing uniform exposure to the stress being imposed, in this case, a toxic concentration of Al. It also ensured large numbers of tolerant genotypes could be identified and selected to form the basis of a viable out-crossing population.

But notable limitations of the solution screening procedure were:

• lucerne is ultimately grown in a soil environment which differs markedly from a solution environment. So efforts were required to ensure plants selected in a hydroponic environment remained relevant and robust in soil
• the selection was based on seedling growth, and it was therefore possible to mistake enhanced Al-tolerance with enhanced seedling vigour
• the process still did not account for the root nodule bacteria.

Nevertheless, recurrent selection in solution culture resulted in the development of elite lucerne populations. A subsequent evaluation in soil showed the best of these populations exhibited up to 40% greater seedling root growth compared to a related unselected population (Figure 1), despite not all populations selected in the solution culture exhibiting enhanced Al tolerance (Hayes et al. 2011).

Figure 1. The distribution of length of seedling tap roots of three lucerne populations selected in high-Al solution culture exhibiting evidence of enhanced Al-tolerance (●), three selected populations exhibiting evidence of increased seedling vigour (●) compared with individuals from six control populations (▲). Error bars indicate where differences are significant at $P=0.05$.

The GAAT population was included in this study and was shown to have inferior root growth compared to some of the elite populations selected in solution culture, adding confidence that the more recent methodologies were an improvement over the field selections that had previously occurred. Breeding and selection of lucerne genotypes has continued in order to maximise the seedling root growth under high Al conditions and to select populations with enhanced capacity to nodulate with elite rhizobia under acid soil conditions (Charman et al. 2008). The world’s first genuinely Al-tolerant lucerne cultivar is expected to be released in Australia within the next three years.

Root nodule bacteria

The effective nodulation of lucerne on acidic soils was a high priority for the Australian initiative (Charman et al. 2008). In 2007, a collection of naturalised soil rhizobia was undertaken across southwest NSW, targeting paddocks that had mature (> 5 years old) lucerne stands on acidic soils. The collection followed the Hume Highway, from Holbrook / Wagga Wagga in the south to Goulburn / Crookwell in the north. A total of 227 strains of lucerne rhizobia were isolated, assigned a unique code and used as the basis of subsequent rhizobia evaluation experiments. Strains were tested initially in a hydroponic screen at pH 4.8 and compared to the current commercial strain for lucerne, RRI128. A shortlist of better performing strains were then evaluated in the field to test their impact on lucerne performance under acidic soil conditions.

On the basis of those evaluations, it is recommended a strain collected from Book Book, SRD1736, replace the current strain, RRI128 (Figure 2).

It is likely this new strain of lucerne rhizobia will be released commercially within the next few years, along with the first Al tolerant line from the Heritage Seeds / South Australian Research and Development Institute lucerne breeding program.

Manganese toxicity

Many acid soils across southern NSW contain levels of Mn that can be toxic to plants. The extent of Mn toxicity across the region is difficult to ascertain as Mn is not quantified in standard soil tests, and the impact of Mn toxicity on plants is similarly unknown as its effects in the field are difficult to isolate from other acid soil related factors.

But Mn toxicity is well known to impact lucerne performance in southern NSW environments (e.g. Flemons and Siman, 1970; Figure 3). Manganese toxicity can be transient as its expression in the field is related to soil and seasonal conditions. Lucerne is known to be highly sensitive to Mn toxicity in contrast to subterranean clover which is remarkably tolerant (Hayes et al. 2012).

Early evidence suggests that lucerne cultivars that were selected for enhanced tolerance to Al toxicity will offer little advantage in soil environments where Mn toxicity limits production. Ultimately, lucerne populations which are tolerant both to Mn and Al toxicity should be the aim of breeding programs chasing acid-tolerant lucerne. However, no population of lucerne with enhanced Mn tolerance currently exists.
Conclusion

The release of the world’s first Al tolerant lucerne cultivar appears imminent. This cultivar has been derived from several cycles of selection for enhanced seedling root growth in high Al solution culture. Cultivars released from the South Australian breeding program have also undergone selection for their ability to nodulate with the new strain of lucerne rhizobia, expected to also reach the market concurrently with the first Al tolerant genotype. This will be an exciting development for Australia and the world as acid soil tolerance has long been considered the Holy Grail in lucerne development.

However, the prevalence of Mn toxicity across much of southern NSW provides some caution ahead of the anticipated commercial release as there is little reason to think that cultivars selected for enhanced Al toxicity will offer any advantage where Mn toxicity limits production. Further research investigating this is underway.

The application and incorporation of lime prior to the establishment of Al tolerant lucerne cultivars will go some way to limiting the effects of Mn toxicity in newly established Al tolerant lucerne stands. Ultimately, lucerne cultivars with tolerance to both Al and Mn toxicities should be sought for genuinely acid tolerant lucerne for southern NSW.

References


Structuring flexible management to maintain profitable and sustainable lamb production systems

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Take home messages:
• modelling shows that flexible management options are better based on altering the sale time of lambs rather than altering ewe numbers
• moderate stocking rates (four ewes/ha) with animal demands weighted towards spring and options to decrease stocking rate through late spring and summer if rainfall is inadequate are best
• autumn groundcover can be improved by lowering ewe numbers rather than selling lambs earlier.

Lamb production systems are replacing fine wool on native pasture in the High Rainfall Zone (HRZ) of south eastern Australia due to increases in lamb prices (Bell et al. 2013). There are considerable challenges in running lamb production systems in this environment due to low winter production and variation between years in forage supply from pastures. Understanding variation in pasture production and how management decisions can be varied in response to seasonal conditions has received little objective assessment. Furthermore, field experiments designed to examine grazing systems often cannot adequately address variability in forage supply because they rarely run for long enough to experience a full range of climatic extremes.

The post-experimental modelling phase of the research at the Orange EverGraze Proof Site was used to evaluate the flexible management used in the experiment over a 30 year period, and to assess stocking rate and flexible management options not used. Two questions were addressed:

• are flexible stocking rate systems more profitable than rigid systems?
• what are the best cues to make decisions about flexible management and at what stage of the production cycle / season should these decisions be made?

Methodology
The AusFarm® model was used due to its suitability when examining complex management scenarios, such as varying ewe numbers between years based on seasonal conditions. The model used the GRAZPLAN pasture, livestock and soil nutrient and water modules. It was calibrated to represent the pasture growth of the Microlaena pasture and ewe weights and lamb growth rates for the one paddock (1P) and 20 paddock (20P) grazing systems from the Orange EverGraze Proof Site from 2008 to 2012 (see Badgery 2013 for results).

There were two parts to the study. The first examined differences in ewe numbers, lamb sale age, including flexible sale criteria, for a spring lambing merino ewe joined to terminal sires (lambing 1 September). The second investigated options for varying ewe numbers prior to joining or at scanning in response to seasonal conditions.

The analysis was performed using 30 years of historic climate data (datadrill) from 1982 to 2011 with a 12-year run-in period. Four stocking rates, 3, 4, 5.3 and 7 ewes/ha, and six lamb sale times, lambs sold at 81 (21 November), 92 (2 December), 112 (22 December), 153 (2 February) and 170 (18 February) days old plus a flexible sale time, were used as factors. The flexible sale time was determined when lambs reached a target weight of 40kg per head, their growth rate was <100g per head per day or the final date of 22 February was reached.

Ewe numbers were adjusted based on green herbage mass, rolling average rainfall over the previous three, six and 12 month period, and average monthly maximum temperatures for November, December, January and February prior to joining (pre-joining only). Three stocking rates were chosen: 4, 5.3 and 7 ewes/ha. A threshold range was then determined based on the top, middle and bottom third of years for each measurement. For example, the lowest third of years was allocated a stocking rate of four ewes/ha, the middle third allocated a stocking rate of 5.3 ewes/ha and the top third allocated a stocking rate of seven ewes/ha. They were compared with the four ewes/ha, flexible lamb sale treatment.

The information was used to develop gross margins for each treatment and year based on average prices from 2008 to 2012, including seasonal discounts for early lamb sales. Autumn groundcover was used to assess the sustainability of management practices.

Results and discussion
The gross margins were highest at four ewes/ha, similar at three and 5.3 ewes/ha and lowest at seven ewes/ha (Figure 1A). Generally, the variability in profitability increased with ewe numbers represented by a standard deviation (SD) of $54.3 per ha for three DSE per ha and $89.4 per ha for seven DSE per ha.

For lamb sale age, gross margins increased with increasing sale age up to 153 days (Figure 1B). There was some increase in the variability of profitability between sale dates, increasing from a SD of $60.8 per ha for sales at 81 days to $77.1 per ha for sales at 170 days, but this was not as great as with ewe numbers.
Figure 1. The box plots present the gross margins (GM) for factorial combinations of ewe stocking rate (A) and lamb sale age (B).

Of interest, was the observation that the most profitable systems varied between years for the different ewe stocking rates (i.e. high numbers did better in good years and worse in poor years), while for the lamb sale age, the difference between sale times was consistent between years (i.e. the later sale time always performed better than the earlier sale time).

The flexible lamb sale time was found to be as good as 153 day sales, though lambs were sold earlier in poor seasons. In the flexible lamb sale treatment, lambs were sold on average at 121, 133, 134 and 135 days (1, 13, 14, January) for the 3, 4, 5.3 and 7 ewes/ha treatments respectively, and were on average 38.1, 37.3, 35.4 and 29.5kg at sale for these treatments. While the earlier sale time at seven ewes/ha clearly reduced the sale weight, the average lamb growth rate declined with increasing ewe number, and was 249, 238, 224 and 200g per head per day for the 3, 4, 5.3 and 7 ewes/ha treatments respectively.

There was no significant difference in the gross margin for ewe sale policies and the four ewes/ha flexible lamb sale treatment, which was considered best practice (average $150 per ha). This was due to the extremely high variability in gross margin between years. For the flexible ewe policies, the average SD was $247 per ha (ranging from $179-$310 per ha) compared to $59 per ha for the four ewes/ha. While on average the gross margins for these policies were marginally less than the optimal treatment, the considerably higher variability makes these policies much more risky.

Stocking rate was increased more by increasing ewe numbers (range of average 5.2-10.3 DSE/ha) than by keeping lambs for longer (range of average 7.2-8.2 DSE/ha). As a result, there were larger reductions in autumn groundcover with higher ewe numbers than with later sale time of lambs (Figure 2), although both showed significant differences. The flexible ewe policies (average 0.66) nearly all had significantly lower groundcover than the four DSE per ha with flexible lamb sale (0.75).

Figure 2. The box plots present the proportion of groundcover (0-1) in autumn for factorial combinations of ewe stocking rate (A) and lamb sale age (B).
Conclusion

The modelling demonstrated that flexible management options are better based on altering the sale time of lambs rather than changing ewe numbers. When ewe numbers were varied this dramatically increased the variability in gross margin without increasing the profitability or improving groundcover. The reason altering ewe number resulted in such variable outcomes was that it occurred six to 12 months in advance of when the progeny from those ewes were sold, and so the seasonal conditions prior to the decision often did not relate to the seasonal conditions immediately prior to the sale of the lamb.

The underlying flexible management principle developed from this modelling is to have moderate stocking rates with animal demands weighted towards spring (e.g. spring lambing), with options to decrease stocking rate through late spring and summer if rainfall is inadequate as occurred with the flexible lamb sale treatment. This principle may be extended to other areas in the HRZ of south-eastern Australia. Further options need to be examined to adjust grazing pressure in different pasture types, livestock enterprises (particularly trading enterprises) and environments.

References


Effective worm control in prime lamb flocks is an important part of flock management. Worms are estimated to cost sheep producers over $360 million annually, and losses in prime lamb flocks can be in excess of $10 per head (Sackett and Holmes, 2006). The majority of Australian research on worms in sheep flocks has been done in self-replacing Merino flocks. In Merino flocks the focus is on minimising worms in weaner sheep between three to 12 months of age. The widespread adoption in southern Australia of double summer drenching was aimed specifically at reducing the autumn/winter worm challenge to these young sheep (Andersen, 1972 and 1973).

However, in prime lamb flocks, the majority of lambs are sold by six months of age. For most prime lamb producers, minimising the worm challenge is therefore aimed at lambs between six weeks and five months of age. So contamination of lambing paddocks is potentially a much greater problem in prime lamb flocks.

Meat and Livestock Australia (MLA) has funded a three year on-farm national project to assess the benefits of ‘best practice’ worm control in prime lamb flocks. The project ‘Lifting the Limits’ (LTL) is coordinated by the University of New England and has sites in the New England district, Central Tablelands and south-western NSW and Victoria. The Fred Morley Centre is coordinating the four sites in south-western NSW.

Methodology

The project aims to compare ‘best practice’ worm control with ‘typical’ worm control for each region. Results from all properties will be used to better define ‘best practice’ worm control for a region. The project started in April 2012 and concludes in June 2015.

To achieve this, four properties have been selected, with two properties implementing ‘best practice’ (LTL farms), and two properties having their existing worm control programs monitored (TYP farms). On each farm, two mobs of ewes (and their lambs) are being monitored (i.e. eight mobs in total). Within each mob, a group of 60 ewes have a suppressive worm control treatment (SUP) to indicate the level of production in the absence of worms. A second group of 60 ewes receive either ‘best practice’ treatments or ‘typical’ treatments. The ewes and their lambs are monitored every two to three months, with worm faecal egg counts (WECs), bodyweight, condition score and reproductive performance recorded.

In addition to monitoring the ewes, lambs born from these ewes are identified at lamb marking (via udder painting) and also become part of the trial. Lambs also receive SUP treatments, ‘best practice’ treatments or ‘typical’ treatments. Lamb bodyweights are recorded at marking and prior to sale, as well as the collection of WECs.

Each LTL farm is ‘matched’ with a TYP farm and comparisons are made between the two worm control programs. While it is difficult to gain credible scientific data when comparing treatments done on different farms (due to the potential large number of uncontrolled variables), the common use of a worm suppressed group provides a means to compare treatments. So to compare the difference between the LTL and TYP farms, the production data is first compared within the farm between the LTL or TYP treatment and the SUP group. This difference is then compared between the two farms. For example, if on Farm 1, the bodyweight of the ewes in the SUP group was 65kg and in the LTL group 62kg (a 3kg difference), and on Farm 2, the bodyweight of the ewes was 70kg and TYP treatment 63kg (a 7kg difference), you would surmise that the LTL group had a 4kg advantage over the TYP group.

Best practice management

One of the aims of the LTL project is to establish the best way of controlling worms in prime lamb flocks for each region. This means achieving adequate worm control for minimal cost (i.e. maximising returns). Monitoring WECs is a key factor in achieving effective worm control. Regular WECs allow producers to assess the need for drenching, indicate the contamination level of worm eggs going out onto pasture, and give producers a good feel for how effective their worm control is. Drenching based on regular WECs is an important strategy used on LTL farms to determine drench frequency.

It should be noted that WECs do not always accurately indicate the worm burdens in flocks, particularly in adult sheep. Increasing sample size helps reduce inaccuracies, and WECs are a useful guide.

Knowing the drench resistance status of the worms in the flock is also essential for effective worm control. Surveys have shown widespread resistance to all the major older drench groups. The only way of determining which drenches are effective is to test for drench resistance. This is most effectively done using a Faecal Egg Count Reduction Test. The very minimum required is regular testing using WECs seven to 14 days after drenching.

For prime lamb flocks, minimising the periparturient rise (i.e. the increase in worm egg output from ewes over lambing), theoretically should be an important part of worm control.
control. This is because this is likely to be a major source of contamination, especially as there are small numbers of carryover weaner sheep to add to the contamination. Lambs tend to be kept on their mothers for longer, meaning that contamination of lambing paddocks may challenge lambs as they approach sale age.

This aspect is being examined as part of the LTL project by CSU. If preventing contamination during and immediately after lambing is important, the use of longer acting drench products may be justified. However, results to date indicate any differences are lower than expected.

**Results**

Year 2 (May 2013 - June 2014) is the first full year of comparisons between LTL and TYP farms, and the available data is presented in this paper, although it is important to note it is only preliminary. We are expecting to present the full set of results at the 2015 Graham Centre Sheep Forum.

Looking across all the sites in all regions, reasonably consistent findings include:

- worms are causing a small but detectable loss in ewe bodyweight (1.8kg). This is having a small impact on lamb marking weights
- suppressive worm treatments to lambs do not generally result in weight advantages at sale
- monitoring ewe worm egg counts enables better targeting of drenches
- knowing the drench resistance status of flocks is important.

**Discussion**

The Lifting the Limits project provides a unique opportunity to more closely examine worm control in prime lamb flocks. It is expected that when the 2014-2015 results are finalised, ‘best practice’ worm control for prime lamb flocks in this region will be better defined, and by adopting such practices, producers may increase productivity by $5-$7 per ewe.

Effective worm control does not necessarily mean just controlling or eliminating worms, it means doing so cost-effectively. Products are now available that allow excellent long-term worm control, and these products may have a use in prime lamb flocks. However, history and common sense indicate that excessive worm control in the short-term is likely to be unsustainable in the long-term, due to the rapid build-up of resistance. It is therefore important that we understand both the benefits and any costs associated with the various strategies available to prime lamb producers to control worms. Both the type of product to use and when to use it are important questions to answer.

But it is likely that any ‘best practice’ will include the regular WEC monitoring of both ewes and lambs to determine drench frequency and monitor the overall program. Such monitoring will allow producers to develop an appropriate program for their own flock.

**Acknowledgements**

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**References**


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