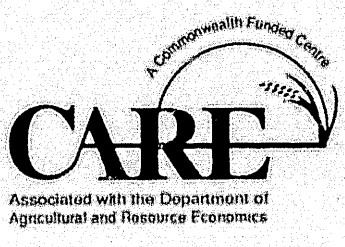

A Stochastic Analysis of Drought Management Strategies in The Western Division of New South Wales

by

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Abstract

This paper presents the initial results of a study investigating the financial implications of farmers' drought management strategies for enterprises in various regions of Australia. The *RISKFARM* whole-farm stochastic budgeting model is used to analyse financial and production data provided by farmers on Merino sheep enterprises in the Cobar West area of New South Wales. Stochastic dominance techniques are used to compare cumulative distribution functions of different strategies under risky conditions. The results suggest that conservative stocking is conducive to favourable cash flows. This is also likely to be consistent with pasture and land conservation objectives.

* NSW Agriculture

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1. Background to the Study

In August 1992, the Minister for Primary Industries and Energy, Mr Simon Crean, announced a new National Drought Policy, agreed between Commonwealth and State Ministers for Agriculture.

The broad thrust of the new policy is a phasing out of transport and fodder subsidies during drought, and an emphasis on self-reliance and better drought preparedness by farmers. The rationale for this new direction is that drought is not a natural disaster, it is a normal feature of the operating environment for Australian agriculture and is just one of many risk factors to be dealt with by farmers (Crean 1992).

The objectives to be achieved by the new policy include:

- encouraging Australian primary producers to adopt self-reliant approaches to managing climatic variability;
- maintaining and protecting Australia's agricultural and environmental resource base during periods of extreme climate stress; and
- ensuring early recovery of agricultural and rural industries, consistent with long-term sustainable levels.

The new policy has brought a sharp response from some commentators. Johnson (1992) described the new policy direction as switching away from "dealing with the symptoms of lack of rain to its implied cause: lack of foresight, poor preparation and inept management and planning". He went on to comment that "anyone who swallows the joke about droughts not being a natural disaster has never obviously experienced one first hand".

During our discussions with farmers and farm advisers, it was suggested that some farmers relied upon freight and fodder subsidies in times of drought, enabling them to stock more heavily than would be the case if the subsidy safety net were not in place. It could be inferred that the provision of subsides deterred farmers from relying upon their own resources and judgements to care for their stock and land, and was a disincentive for investigating alternative methods for managing climatic risk.

On the other hand, some noted that stocking rate *per se* was not the critical issue. Rather, the timeliness of decisions to alter stock numbers was an important determinant of both profitability and sustainability. It is possible to devise strategies which benefit from the subsidy, and stock heavily for short periods, and are also compatible with the sustainability of soils and pastures.

Given that subsidies are to be phased out under the new policy, the implications of alternative drought management strategies in a subsidy free environment will be investigated in this study.

2. Scope of the Project

Part of the new National Drought Policy included an allocation of $0.7 million per annum for three years to the Land and Water Resources Research and Development Corporation (LWRRDC) for a co-ordinated R&D effort related to drought. Part of this allocation has been used to fund this project along with equal funding from the Rural Industries Research and Development Corporation (RIRDC).

The project is a collaborative effort between the Centre for Agricultural and Resource Economics (CARE) at the University of New England and the NSW and WA State Departments of Agriculture.

There is a problem of definition attached to the term 'drought'. In the National Drought Policy Report (1992), it was noted that, statistically, severe drought might only occur once or twice in a farmers working life. Some believe that these droughts are so severe, it is not possible to prepare for them without adopting such conservative practices that the farm business becomes unprofitable. Discussions with farmers and NSW Agriculture staff have revealed that the term can encompass normal or slightly below normal rainfall and feed supply, and that perhaps the term 'drought' should be reserved for severe nutritional deficits.

It was also noted by staff at NSW Agriculture (Cobar), that drought in terms of nutritional deficit may be caused by factors other than a lack of rain. For example, competition from feral animals and kangaroos may lead to feed shortages in the Western Division.

As this project is analysing drought in a subsidy free environment, the effects of severe drought (defined as droughts which occur once or twice in a lifetime) will not be examined. Rather, we will examine shorter term droughts of 12 months duration which have a quantifiable impact upon feed supply and livestock production and necessitate some action by the farmer. Under the new drought policy, droughts of longer duration may still attract subsidies through the 'exceptional circumstances' provision.

Several farming zones and farming systems will be examined in NSW and WA. Feasible drought and risk management strategies will vary between farming systems, so a case study approach in each zone is warranted.

The findings of a pilot study carried out in the Western Division of NSW are reported in this study. The results presented here illustrate an analytical approach and represent interim results rather than a complete modelling analysis.

Although the project focus will be drought management, it is envisaged that it will encompass risk management in the broader sense. Traditional drought management strategies suggest tactical and strategic responses such as the timing of farm

operations, hand feeding of stock, irrigation of crops, management of stock numbers and cropping area decisions. However, there are other risk management tools which can help maintain farm financial viability during periods of poor cash flow. For example, Kaine, Wright and Lees (1993) have undertaken work which suggests that the maintenance of a cash buffer fund, such as an IEED, can have a substantial beneficial impact upon the financial performance of the farm.

One aim of this project is to investigate a range of risk management tools in the context of managing the total risk associated with the farm business. Traditional drought management techniques will be examined, but broader risk management tools and the concept of managing total as opposed to partial farm risk will also feature.

Another important component of the study will be the dissemination of the research findings. Project results will be incorporated into a suitable educational training kit which can be used by State Departments of Agriculture, farm advisers, accountants, banks and other 'key change' initiators in the Australian rural sector.

The goal is not to be prescriptive and recommend the 'best' drought strategy for each region. Rather, the financial implications of alternative strategies will be discussed, providing more information upon which decision makers can base their decisions. It is also expected that some decision makers will be exposed to new risk management tools and a better understanding of risk.

It is important to recognise that if all farmers in a region follow the same strategy this could have detrimental macroeconomic effects. For example if all farmers chose to sell stock early this may depress prices. In many instances individual farmers may do better by employing a mixture of strategies thereby providing the flexibility to respond in a number of ways to drought.

3. The Western Division of NSW

The Western Division of NSW covers an area of 31 million hectares which represents 40 per cent of the land area of NSW (see Figure 1). Rainfall is variable and unreliable to the extent that 'drought' is regarded as an unavoidable feature of the region (Marwick 1991).

Agricultural activity in the area is dominated by Merino sheep breeding. Self-replacing Merino flocks are most profitable in more open, better pastured areas due to ewe and weaner sales and the higher prices received for the fine wool they produce. In the less productive (poorer) country, which often has scrub encroachment, wethers generally constitute a higher proportion of total flock numbers. Wool production per animal ranges from 4 to 8 kilograms per year with wethers often cutting 1-2 kilograms more than ewes. Average wool diameter varies around 23-25 microns.

Cattle production is also a significant enterprise in the Western Division. The average herd size is about 150 head. Other enterprises include feral goats for meat and cashmere, dryland cropping on the eastern fringe of the region and lake bed and flood plain cropping.

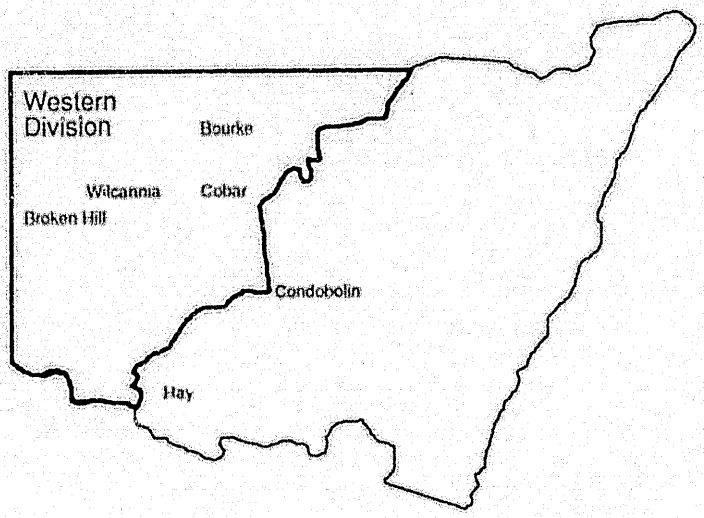

Figure 1. The Western Division of NSW

The area is further characterised by the sensitivity of the vegetation to both drought and grazing pressure. Sustainable and profitable pastoral production is heavily dependant upon desirable perennial rangeland grasses and forbs (O'Shea 1991). Holding stock on this vegetation for extended periods will decrease the vigour of these plants. This problem is exacerbated by heavier stocking rates and during periods of drought.

The issue is further complicated by the invasion of woody weed species, which have a detrimental effect on the profitability of grazing by reducing the growth of perennial pasture species. It has been estimated that between 1931-40 and 1972-81, the sheep carrying capacity of the Cobar region has declined by 30 per cent due to woody weed encroachment (Muir 1992).

The need to protect valuable pasture species means that grazing management is critical. Early destocking and/or supplementary feeding has been advocated as the key to both pasture management in general and drought management in particular. The maintenance of perennial pastures is viewed as an excellent insurance mechanism against drought (O'Shea 1991).

Despite this fact, investigations in the Cobar and Wilcannia areas revealed that appropriate grazing practices were not always observed. It must be remembered that the definition of an 'appropriate' stocking level is something of a moving target. What is a conservative stocking level during a good season may be too heavy during a dry season. Close observation on the effects that grazing is having on pasture composition is a good indicator of suitable grazing pressure (Muir 1992).

Anecdotal evidence pointed to the fact that graziers with a higher debt burden erred on the side of higher stocking rates. They were of the opinion that it was necessary to run more sheep to provide more profit to meet debt servicing requirements. Others felt that running 20 per cent less stock than the generally accepted 'average' stocking rate

was more profitable. This strategy allegedly improved weaning rates, provided higher wool cuts and allowed stock to be carried longer into a drought before destocking became necessary.

Other common drought risk management techniques used in the area included selling dry sheep (but maintaining a core breeding flock where possible), agistment, supplementary feeding, enterprise diversification, the timing of lambing and sheep sales to match pasture availability, changing the livestock mix and feral animal control.

The purpose in this study is to investigate the financial implications of some of these drought management strategies, while explicitly accounting for riskiness in other key production parameters such as yields, prices and interest rates.

4. Method

RISKFARM is a whole-farm stochastic budgeting program which utilises the @RISK statistical software. It is being developed at the Centre for Agricultural and Resource Economics (University of New England) and the NSW Agriculture Agcost Unit, Parkes. The model uses a stochastic simulation process which allows risk to be represented through the probability distributions of selected financial outputs. In agricultural economics, such simulation is often the only way to come to grips with the inherent dynamic and stochastic nature of bioeconomic systems (for example Walker and Helmers 1984).

RISKFARM uses a combination of physical and financial data provided by farmers and/or farm advisers to assess the effects of alternative farm and non-farm production and investment decisions. The model emphasises the medium-term to allow comparison of alternative management strategies and financial structures, rather than intra-year tactical decision-making. Reports generated annually for the five year model horizon are year-end profit and loss statements, cash flow statements, balance sheets and financial ratios.

Stochastic variables in RISKFARM include product yields and prices, expenses, interest rates and livestock production parameters such as weaning rates. The model also has the capacity to examine the effects of using specific financial options such as Income Equalisation Deposits. Future interest rates and prices are selected from normal distributions based on linear regressions using historical data. At present, these data are of a national nature, however the scope for using regional data is being investigated. Weaning rates, death rates and yields are selected from triangular distributions specified by the farmer and/or farm adviser.

The financial and production inputs for the Cobar West region were specified by a diverse group of graziers in the area. The use of this Local Consensus Data technique allowed the knowledge and experience of local graziers to be pooled to develop a detailed picture of a 'typical' property and enterprise in their area (Murphy and Date 1989).

The final property details used in the model drew on their personal experiences, *Farmcheque* information and data collected from the graziers by the NSW

Agriculture's *Western Uplands Landsafe Project*. Meetings with graziers over an eighteen month period established the base property data and also elicited the main drought management strategies and effects of such strategies in the Cobar West region.

The results of these meetings have been validated by various financial advisers and studies in the Western Division of New South Wales (for example, Walker and Helmers 1984, Curran et al 1993, Hoadley and Milham in process, and Woods 1992). These strategies were then modelled in RISKFARM to assess the financial implications of the alternative management decisions.

In the Cobar West analysis, a drought shock, with substantial effects on farm production parameters, has been used with the majority of impacts occurring in the second year of the model timeframe. To model a drought, production and price variables were altered to reflect actual drought impacts on the farm system under the agronomic circumstances which would occur under each drought management strategy. These production and price effects were elicited from the co-operating graziers and staff at NSW Agriculture, Cobar.

This drought shock would not be classified as a severe drought which warranted 'exceptional circumstances' provisions under the new National Drought Policy. Rather, it can be viewed as only a fairly severe drought arising from the cumulative effect of two dry years such as can be encountered in the Western Division every five years or so.

A drought simulated in year two of the model allows the production parameters of the farm time to adjust to the impacts of different drought strategies. The financial impacts of a selected strategy can then be analysed for the drought year and for three years after the drought. For example, the time lag to build back to the target flock size by natural increase and the effects in terms of wool cut and stock available for sale can have a significant impact on future cash flows.

The @RISK simulations were run using Monte Carlo sampling in which variates are randomly sampled from probability distributions specified in the model to compute risk profiles for critical outcomes. Using this method, iterative simulations allow the construction of a cumulative distribution function (CDF) for the outcome (Milham 1992).

For each of the selected strategies, net cash flow was selected as the simulation output for the five year period. Strategies were ranked using the cumulative distribution functions of net cash flow in year two and again in year five. This allowed strategies to be compared in the short and medium term. It should be stressed that these CDFs are not designed to recommend the best drought strategy for the area but are rather a tool which allow financial comparison of different strategies with given assumptions.

5. Drought management strategies in the Cobar West area of New South Wales

In general terms, many risk management strategies are an issue of holding reserves of one type or another. Strategies to manage drought risk could include reserves of water, feed, cash or tradeable livestock.

The Cobar West study has identified the major drought management strategies in the area as conservative stocking, agistment and selling. In addition, a base model which maintains stocking levels in the drought until forced sales occur is also modelled. It should be noted that these four options are by no means the only alternatives available, but are those perceived to be the most common and widely used. In the study group of graziers there was a diversity of opinion as to their preferred strategies. For example, some saw the agistment option as less preferable in the long term and practised conservative stocking and selling strategies while others viewed agistment as an alternative which had worked for them in certain circumstances. Farmers may also adopt a mixture of strategies.

Other strategies included the production of fodder crops if irrigated river flats or lake beds were available, feeding of base breeding flocks in sacrifice paddocks with less erodable soil, and 'opening the gates' to let stock roam over the entire property.

Severe drought and the wool crisis in the early 1990s encouraged the option of shooting sheep, a strategy subsidised by the flock reduction scheme for a time. It was interesting to note that the graziers involved in this study, while having a range of stocking rates from the conservative (1 dse (dry sheep equivalent) per 4.6 ha) to base or 'average' (1 dse per 3.8 ha), all agreed that some graziers who were stocking at higher rates (up to 1 dse per 2.5 ha) were unlikely to be viable in the long term.

For details of the different assumptions made to model each strategy in normal and drought years, refer to Appendix 1.

6. Results

Results have primarily been analysed in terms of net cash flow. In particular, net cash flow at the end of year five is of interest to assess the medium term financial implications of the alternative strategies.

Results are presented in graphical form showing the standard deviation, trend in mean and 5/95 percentile bands for each of the strategies net cash flow (refer to Figure 2). The cumulative distribution functions of net cash flow for each of the strategies in year two and year five are shown in Figures 3 and 4. These results are analysed below in terms of the different assumptions for each strategy in drought and non-drought years as summarised in Appendix 1.

Risk implications of drought strategies

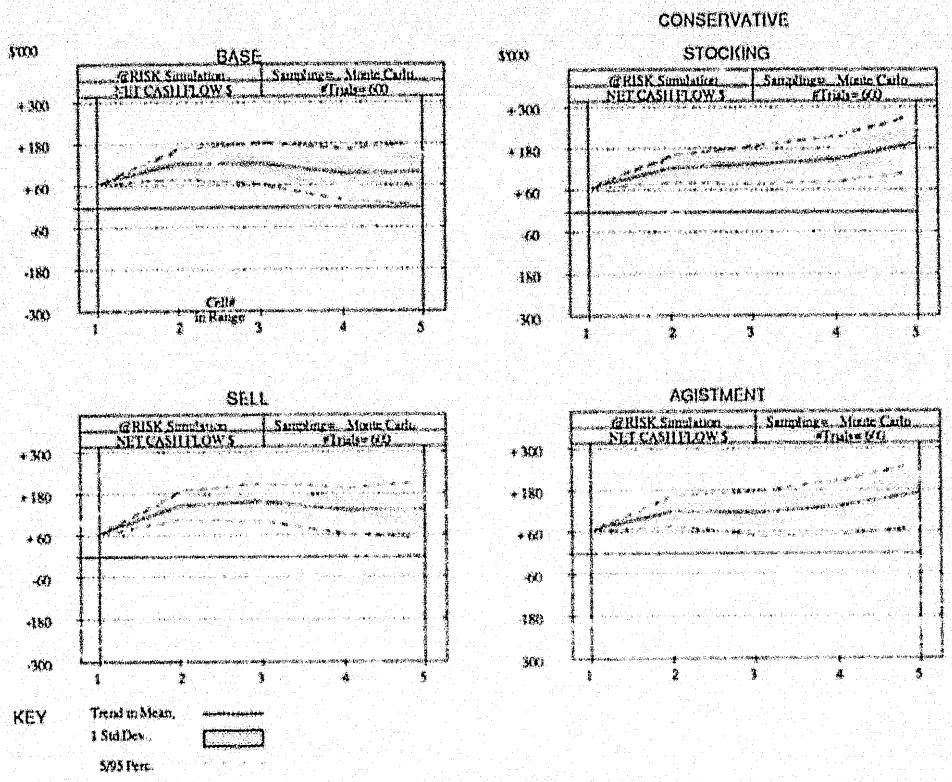

Figure 2 Variability in Net Cash Flow

Variability in net cash flow provides a measure of the risk inherent in each of the strategies modelled. Reference to Figure 2 indicates that the conservative stocking and sell strategies provide the smallest standard deviation in net cash flow for the four future years modelled. The standard deviations in years 2 to 5 for each of the strategies in order of increasing risk are provided in Table 1.

Table 1 Standard deviation in net cash flow ($'000)

Strategy	Year 2	Year 3	Year 4	Year 5
Conservative stocking	23.96	32.28	39.95	47.97
Sell	24.70	32.09	39.68	49.12
Base	26.02	34.78	43.04	57.60
Agistment	27.22	36.51	47.20	56.71

The conservative stocking strategy shows the least variability because of the assumption that wool yields, death rates and weaning rates show less variation than the other three strategies (see Appendix 1). This assumption is based upon the increased feed available under a lower stocking regime. The sell strategy also shows low cash flow variability. However, this is largely a result of the fact that flock numbers do not recover to the same level as for the other strategies after the drought. Therefore, the stochastic effects of price and production variables are operating over a smaller number of sheep, leading to a smaller degree of performance variability.

The base and agistment strategies are the most risky in terms of cash flow. This is a result of greater variation in wool yields and weaning and death rates (refer to Appendix 1). These differences in livestock production parameters were consistent with the opinions of graziers and NSW Agriculture staff involved in the study.

Year two results (the drought year)

Figure 3 shows that the sell strategy has first degree stochastic dominance in terms of net cash flow in the drought year. In this strategy, sales include not only a large proportion of young animals and all wethers, but also half of the breeding flock. In addition, for the breeders, a higher price per animal is received in the drought year because stock are sold early and include not only cast-for-age ewes but also better quality younger ewes.

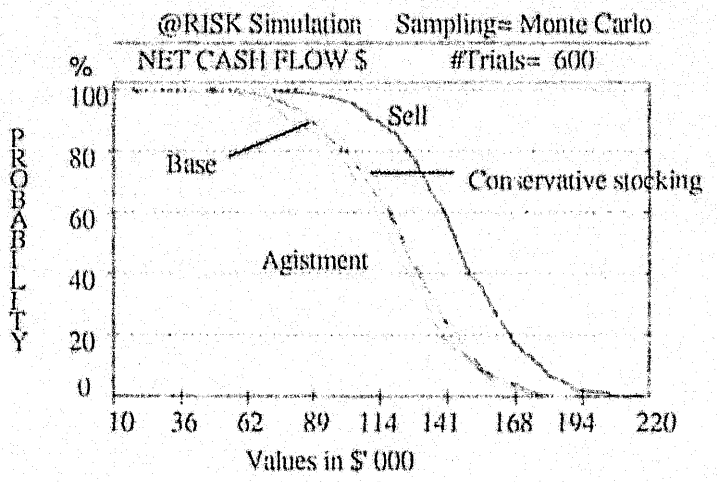

Figure 3 Year Two Net Cash Flow Cumulative Distribution Functions

Other advantages of the selling strategy include the flexibility and security of access to cash surpluses, the maintenance of pastures and decreased risk of land degradation in drought due to the lower stocking rate. For the sell strategy, timing is crucial. One grazier stated that in the long term, selling early is preferable to selling late.

Figure 3 also indicates that the agistment strategy is the least preferred option for short term net cash flows in a drought period. This strategy assumed agistment at a distance of 700 km for 2500 ewes (25 decks) at $0.70 per deck per kilometre with no subsidies ($24 500 transport costs). Agistment costs were $0.20 per animal per week for 32 weeks ($16 000). All these costs were incurred in the drought year which resulted in the relatively poor short term cash flow performance of this strategy.

Advantages of agistment were stated to be the maintenance of the breeding flock structure and numbers with no purchases necessary at high post-drought prices, numbers returning to full capacity as soon as the drought breaks and maintenance of genetic capital.

Disadvantages included the possibility of bad management (eg lice, worm infestations) and/or below optimal feed conditions at the place of agistment with subsequent high death rates and low weaning rates. If ewes lamb while on agistment, lambs must either be sold (if a market is available) or transported home thereby increasing costs. For the agistment strategy therefore, availability of good agistment and the length of the drought were crucial. For this model, reasonable agistment was assumed with no increase in death rate. Weaning rates for the agistment strategy did not fall to the same extent as for the base model during the drought year (see Appendix 1).

In Figure 3, the base and conservative stocking models were both between the sell and agistment strategies in terms of net cash flow at the end of year two but were fully differentiated by year five. By year two, these two strategies were fairly similar in terms of net cash flow because the base model's higher sales and wool cuts in normal years, due to the higher stocking rate, have been partially offset by forced sales and higher death rates in the drought year. In comparison, the conservative stocking model, while having lower cash inflows in normal years, displayed a less significant drought impact as more stock could be kept on and death rates were lower. This meant that the conservative stocking model did not have a substantial decline in cash flows in the drought year.

Year five results

For the years after the drought, the assumptions are the same as in the base year (year one of the model), except for a higher animal price for the year immediately following the drought (see Appendix 1).

From Figure 4, it can be seen that in the medium term, the conservative stocking strategy was stochastically dominant in terms of net cash flow when account is taken of production and price risk. The CDF for this strategy is furthest to the right indicating a higher probability of achieving a particular cash flow level (eg the 50% probability value is $192 135). This is a result of lower death rates, higher weaning rates and higher wool yields per head in both normal and drought years. These assumptions can be attributed in part to better conservation of feed, with pasture butts being maintained above a critical level which allows stock to maintain condition

The next most preferred strategy in the medium term is the agistment strategy. The advantages of an instant return to full stocking in terms of high possible sales and yields in the immediate years after a drought are evident as a continuing increase in net cash flow in years three, four and five. As noted above however, the relatively high weaning rates and wool yields and the low death rates during agistment are critical to the superior cash flow performance of this strategy.

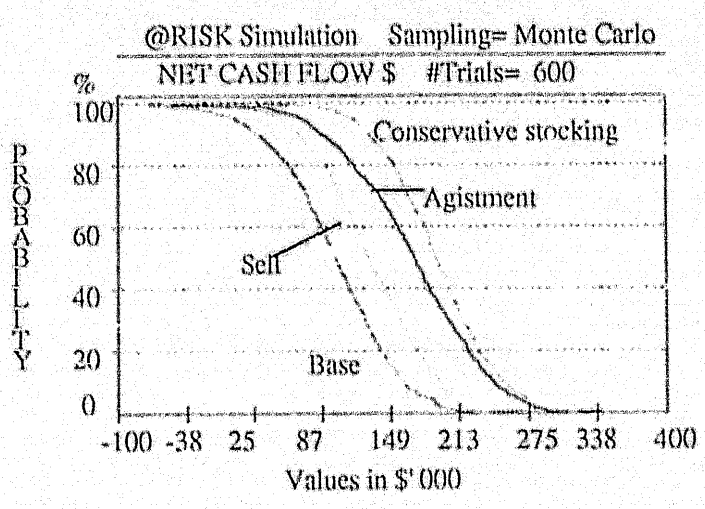

Figure 4 Year Five Net Cash Flow Cumulative Distribution Functions (CDFs)

The sell strategy ranks third in terms of the year five cash flow CDF. There is only a slow return to the target breeding flock with so few breeders after the drought and replacements coming from natural increase only. This means that there are fewer animals to generate cash flow in years three, four and five. Under the sell strategy, by year five the expected breeding flock size is still only 3877. The option of purchasing after the drought may enhance the outcome.

Other considerations for this strategy may be the use of the livestock election taxation provisions to smooth taxable income. The use of an Income Equalisation Deposit in the year of sale with proceeds being withdrawn to purchase stock after the drought may further enhance the medium term cash position for the sell strategy.

In Figure 4, in the medium term the least preferred option was the base strategy. This strategy had higher stocking levels to generate income in the normal years. However, in the drought years, the failure to either sell early or agist resulted in a decline in feed condition and in flock performance. This was reflected in an increased death rate, significantly decreased weaning rate and a decline in wool cuts. In addition, more breeders had to be sold at the low drought prices. In the medium term, the major result was a significantly reduced breeding nucleus and fewer replacement animals. The financial implications are a lower income from wool and less income from animal sales in the medium term.

Conclusion

The results presented here are consistent with the opinions of graziers and advisers familiar with the Western Division of NSW. To date, only individual strategies have been analysed. Future work will examine the implications of adopting a mixture of strategies. It will also be instructive to investigate in detail the use of more general risk management tools such as IEDs and livestock taxation elections.

The results support the notion that conservative stocking strategies are both financially and environmentally robust in the Western Division. However, this result is sensitive to the assumptions made, in particular the extra wool cut achieved under a lower stocking rate. One grazier noted that, in some cases, invasion by feral animals and the risk that surplus or carry over feed can dry off and blow away may erode the advantages of a conservative stocking regime .

The advantages of a conservative stocking regime are also sensitive to the timeframe selected. Modelling a drought impact highlights the advantages of this strategy but if, for example, ten good years were modelled the base model may well be the best.

The livestock and interest rate data used in the model were based upon historical information. The cash flows reported do not reflect the current low wool prices and interest rates. However, the relative differences between the strategies will still be captured.

The other purpose of this pilot study was to adapt the analytical capability of the basic RISKFARM model to deal specifically with drought management issues. This has been achieved in part, yet further model development will be required to examine other farming systems. It may also be necessary to update the historical data to reflect regional conditions.

APPENDIX 1. Summary of Drought Strategies

Expected values (or means)	Base normal year	Base drought year	Conservative stocking normal	Conservative stocking drought	Agistment normal	Agistment drought	Sell normal	Sell drought
Target breeder flock	5000	3060	4000	3500	5000	5000	5000	2500
Target wether flock	625	0	500	0	625	0	625	0
Market/sale price ewe/wether	$10.06	$5.06	$10.06	$5.06	$10.06	$5.06	$10.06	Ewes $10.06/ Wethers $5.06
Market/sale price young animals	$16.34	$11.34	$16.34	$11.34	$16.34	$11.34	$16.34	$11.34
Wool yield wethers[a]	7 kg/head (6-7-8)	5.5 kg/head (4.5-5.5-6.5)	7.5 kg/head (7-7.5-8)	6 kg/head (5.5-6-6.5)	7 kg/head (6-7-8)	5.5 kg/head (4.5-5.5-6.5)	7 kg/head (6-7-8)	5.5 kg/head (4.5-5.5-6.5)
Wool yield breeders[a]	6 kg/head (5-6-7)	5 kg/head (4-5-6)	7 kg/head (6-7-8)	5.5 kg/head (4.5-5.5-6.5)	6 kg/head (5-6-7)	5.5 kg/head (4.5-5.5-6.5)	6 kg/head (5-6-7)	5.5 kg/head (4.5-5.5-6.5)
Death rate[a]	10% (6-10-14)	25% (21-25-29)	8% Breed(6-8-10) YA&Wthrs (5-8-11)	14% Breed(12-14-16) YA&Wthrs (11-14-17)	10% (6-10-14)	10% (6-10-14)	10% (6-10-14)	10% (6-10-14)
Natural increase[a]	75% (60-75-90)	40% (25-40-55)	80% (65-85-90)	60% (45-65-70)	75% (60-75-90)	55% (40-55-70)	75% (60-75-90)	55% (40-55-70)
Variable costs breeders	$12.50	$12.50	$12.50	$12.50	$12.50	$20.60	$12.50	$12.50

a: Numbers shown in parenthases are the minimum, most likely and maximum values of the triangular distributions from which the expected value is derived.

Major assumptions applicable to all strategies are:

- Nil debt
- Partnership tax structure with averaging and 4 years income prior to year 0; $50 000, -$50 000, -$50 000, $50 000
- Area of property - 33 461 ha ($14/ha market value)
- All sales prices of breeders and wethers in the post-drought year have a mean of $14.99. For young animals the mean of the normal distribution is $21.34 (ie both are $5 above normal prices).

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