Decision support for farm business strategy: An example for sheep breeding

W.J. Parker[1], A.E. Dooley[2] and C.K. Dake[2]

[1] AgResearch (Ruakura), Private Bag 3123, Hamilton
[2] College of Sciences, Massey University, Private Bag 11222, Palmerston North

Abstract The uptake and application of decision support models by New Zealand farm businesses has been disappointing. This has been attributed to overly-complex models, lack of access to required computing resources, too much emphasis on accuracy, poor understanding of user-needs and their decision-making processes, and a lack of integration with the wider farm system. While a multitude of planning models have been written for farmers, most have been developed outside the context of business strategy or scenario formulation. A spreadsheet-based planning model was developed to address past shortcomings in relation to the strategic question, 'Which sheep breed should I farm?' The farmer-oriented model requires them to define future levels of performance in performance traits and costs and prices for breeding options. This might include continuing to progress the existing breed, adopting cross-breeding or breeding-up to a new breed. The model design allows user-flexibility but minimises output by restricting all data inputs and model solutions to a single screen or sheet of A4 paper. The profitability of alternative breeding strategies is compared through gross margins (GMs), and the sensitivity of these to production and price for key variables (e.g. lambing percentage and lamb price) are provided in 3x3 tables. Risk is incorporated through user-estimates of the probability of minimum, most likely and maximum values, and this enables an approximate distribution of GMs to be derived. Thus, the model focuses on the key bioeconomic factors influencing future sheep breed profitability (and hence strategy selection) and simplifies inputs and outputs, but in doing so maintains user-flexibility, and is based on software which is routinely available to farmers.

1. INTRODUCTION

The uptake and application of decision support models by New Zealand farm businesses has been disappointing [Pollock & Hurley 1997, McCall, 1999 *pers. comm.*]. This has been attributed to overly-complex models, lack of access to required computing resources, too much emphasis on accuracy, poor understanding of user-needs and their decision-making processes, and a lack of integration with the wider farm system [Cox 1996, Paine 1997]. Prior experience with decision support tools for farmers indicates that where these deal with farm strategy (as opposed to management operations) they should be intuitively simple to use and focus on the factors critical to success for the change under consideration [McCall *et al.* 1989]. The decision aid should enable the farmer to evaluate alternative future scenarios in order to determine the farm policy which gives the 'best' long-term fit with the external environment and which best meets his/her aspirations [Parker *et al.* 1997]. Because medium to long-term forecasting, of product prices in particular, is notoriously difficult, complex simulation models are unlikely to be superior in developing strategy than simple spreadsheet models that demonstrate the effect of key performance parameters on production and profit.

This paper presents a spreadsheet-based planning model that attempts to address past shortcomings. It was designed to help farmers conceptualise and quantify a sheep breeding strategy.

INPUT TABLE:			
		BREED A	BREED B
Farm area	HA	240	240
Ewe numbers	EWES	1949	1949
Lambing	%	160.0	185.0
Ewe repl. rate	%	22.5	22.5
Ewe deaths	%	4.0	4.0
Hogget deaths	%	2.5	2.5
Lamb deaths	%	3.0	3.5
Rams to ewes	%	1.0	1.0
Ram repl. rate	%	25.0	25.0
Ram price	/HEAD	$ 350	$ 350
Ram wool	KG/RAM	4.40	7.00
Ram wool price	/KG	$ 3.00	$ 2.70
Cull ewe sales	/HEAD	$ 50.00	$ 40.00
Ewe wool	KG/EWE	4.40	7.00
Ewe wool price	/KG	$ 3.00	$ 2.70
Hogget wool	KG/HGT	3.10	4.90
Hgt wool price	/KG	$ 3.25	$ 2.90
Ave lamb sales	/HEAD	$ 50.75	$ 42.10
Lambs shorn	%	0.0	50.0
Lambs wool	KG/LAMB	0.00	1.20
Lamb wool price	/KG	$ -	$ 3.00
Shearing cost	/HEAD	$ 1.85	$ 1.85
No. shearings	/YEAR	1.0	1.5
Animal health	/HEAD	$ 1.50	$ 2.00
Interest rate	%pa	7.00	7.00
Stock units -ewes	SU	1.3	1.3
-hoggets	SU	1.0	1.0
-rams	SU	0.9	0.9
Hogget lambing	%	85.0	100.0
Hogget lamb price	$/HEAD	$ 46.40	$ 38.70
Capital values			
-ewes	$/HEAD	$ 40.00	$ 32.00
-hoggets	$/HEAD	$ 50.00	$ 40.00
-rams	$/HEAD	$ 280	$ 280

Sensitivity	**Value**	BREED A	BREED B
Lambing %	1	100%	100%
Wool Wght	2	100%	100%
Lamb $/hd	3	100%	100%
Wool $/kg greasy	4	100%	100%
Interest Rate	5	100%	100%

Breed A Sensitivity Inputs		**Low**	**Likely**	**High**
Lamb $/hd	Range	41.53	46.14	50.75
Wool $/kg greasy	Range	2.60	3.00	3.30
Lamb $/hd	Probability	20%	50%	30%
Wool $/kg greasy	Probability	25%	50%	25%
Breed B Sensitivity Inputs				
Lamb $/hd	Range	34.60	38.45	42.30
Wool $/kg greasy	Range	2.40	2.70	3.00
Lamb $/hd	Probability	20%	50%	30%
Wool $/kg greasy	Probability	25%	50%	25%

OUTPUT TABLE:	(sheep enterprise only)		
		BREED A	BREED B
Total SU:		3001	3001
Stocking rate:	SU/HA	12.50	12.50
Gross Margin:	$ TOTAL	178752	185936
GM/EWE:	$/EWE	91.71	95.40
GM/SU:	$/SU	59.57	61.96
GM/HA:	$/HA	744.8	774.7
Wool production	KG TOTAL	9883	17796
Wool/su	KG/SU	3.3	5.9
Wool/ha	KG/HA	41.2	74.2
Ewes' lambs sold	TOTAL	2575	3030
Hoggets' lambs sold	TOTAL	371	434
Cull ewes sold	TOTAL	360	360
Wool sales	$ TOTAL	29997	49116
Wool sales/su	$/SU	10.00	16.37
Wool sales/ha	$/HA	125.0	204.7
Sheep sales	$ TOTAL	165946	158799
Sheep sales/su	$/SU	55.30	52.92
Sheep sales/ha	$/HA	691.4	661.7

GM Sensitivity Tables (GM/HA)

BREED A		Lamb $/hd	
Wool $/kg greasy	41.53	46.14	50.75
2.60	608	668	728
3.00	624	685	745
3.30	637	697	757

BREED B		Lamb $/hd	
Wool $/kg greasy	34.60	38.45	42.30
2.40	638	697	755
2.70	661	720	778
3.00	684	742	801

			BREED A	BREED B
Average			689.73	725.40
Minimum			607.68	638.45
Maximum			757.30	800.61
Probability:	<=	650	20.0%	5.0%
	650	700	50.0%	27.5%
	700	750	22.5%	37.5%
	750	800	7.5%	22.5%
	>	800	0.0%	7.5%

Row Input	3
Col Input	4

Select "Sensitivity" on the "Tools" menu or CTRL-R to run the sensitivity tables after selecting Row and Column Input values.

Figure 1: The one-page input and output template for evaluating sheep breed options.

2. MODEL DESIGN

The model was formatted on Microsoft Excel which is readily available to farmers. Spreadsheets are likely to be used already for other purposes (e.g. recording) and are relatively straightforward to use if presented in a template format. A single-page template comprising an input and an output table was designed to minimise and simplify data entry (Figure 1). The inputs describe farm and flock attributes (e.g. area, death rates by class, lambing percentage, wool weights, ewe:ram ratio), management practice (replacement rate, shearings per year, hogget mating) and costs and prices associated with two sheep enterprise situations. These are labelled Breed A and Breed B, and could, for example, represent the current flock (A) and a future 'target' flock (B). These data are used to develop (off-screen) a livestock reconciliation and gross margin, from which the output table is derived. The cost of capital invested in livestock is usually the only difference in fixed costs between breed options, and can be estimated from the capital value per class ($/head) at 1 July and the lending rate on borrowed funds.

The gross margin (GM, $), expressed per ewe, SU or hectare, was calculated as:

$$GM = GR - (DC + OC)$$

where:
GR = Gross revenue from the sale of products
DC = Direct costs (shearing, animal health, breeding)
OC = Opportunity cost of livestock capital.

Future product prices are not discounted because they primarily reflect erratic movements in international market prices rather than domestic inflation. Similarly, in the current economic environment of low inflation, annual changes in the farm input price index are small and therefore do not have a substantial influence on the GM when a 3-5 year planning horizon is being considered. Product prices and costs, and thus their relativities, are instead estimated for the year when the status quo for the new policy is reached. Secondary and tertiary data (industry forecasts, consumer trends, personal communications) and the user's own intuition, combined with 'What if?' analysis enable the likely profit response surface to be estimated for various price-product combinations. The output also includes a GM sensitivity analysis based on the specified product and price distribution (see Figure 1 for the variables that can be changed).

3 MODEL OPERATION - INPUTS AND INTERPRETATION

The model can be run on an Excel spreadsheet from Windows 3.11, Microsoft Excel version 5.0 or later versions. Data entry cells are highlighted in colour. The remaining cells are protected from data entry. In the ensuing sections each component of the spreadsheet model is described.

3.1 Input Table

The only part of the spreadsheet requiring inputs is presented on the left-hand side of Figure 1. The respective values are entered by the farmer/consultant for each breed policy (or for a comparison within a breed, different levels of costs and prices). The majority of inputs are self-explanatory.

Farm area (effective for grazing) is used to calculate returns per hectare. Ewe numbers, lambing percentages (mixed-age ewes and hoggets), deaths (lambs, hoggets and ewes), rams to ewes, and ram replacement rates are used to create a status quo stock reconciliation. The number of lambs and ewes sold, rams purchased, and numbers shorn are derived from the stock reconciliation, built off-screen from the values provided for the input table. Wool production, shearing costs and wool returns are calculated using the input values for wool yields, price per kg (greasy), proportion of animals shorn and frequency of shearing.

Stock numbers are also used to calculate the total SUs farmed and the cost of capital. The SU conversion factors for ewes, hoggets and rams are entered by the user. This allows breed specific SU factors to be entered (e.g. larger framed and heavier ewes can be entered at a higher value than the "standard" 55 kg ewe [Parker 1998]). The number of SUs wintered for each of the policies is shown at the top of the output table. Ewe numbers can be altered for the two policies until the number of SUs wintered is the same, or at the required number, for each policy. At the same time the number of ewe hoggets (tied to ewe numbers by the replacement rate) and rams (through the ram:ewe %) is adjusted automatically.

The capital value of ewes (at opening) is calculated as 0.8 times the price received for cull ewes, while that for ewe hoggets and rams is 1.25 times the capital value of ewes, and 0.8 times the purchase price paid of rams, respectively. These are the long-term industry relativities between livestock categories. The "tying" of values reduces the number of inputs required, but the multipliers could be customised to a particular case if required.

3.2 Sensitivity analysis input tableau

A 2 x 2 sensitivity analysis can be run for any two variables selected from the list of five variables shown (top left: lambing %, wool weight, lamb price, greasy wool price and interest rate). Each of these variables has been allocated a number. To complete a sensitivity analysis, the range and probability values, and row and column input numbers are entered.

The 'low', 'most likely' and 'high' values for the two variables selected are entered in the tables for each breed. An example is shown in Figure 1. The probability of each of the three values occurring is then entered. These are entered as a decimal, but shown as a percentage (i.e. 0.3 for 30%), unlike the other inputs where the percentage value is entered (e.g. 160 % lambing entered as 160). If the percentage values in a row do not add to 100% an error message is shown. The user can define any combination of probabilities as long as they sum to 1.0.

As noted earlier the aim was to minimise the number of inputs. The price for hogget lambs was thus tied to the mixed-age ewe lamb price for the purpose of the sensitivity analysis. In the example, the entered mixed-age ewe lamb price for Breed A is $50.75 and the corresponding price for the progeny of hoggets is $46.40 (91.4% of the mixed-age ewe lamb price). The cull ewe price is also tied to the mixed-age ewe lamb price. Similarly, the hogget and mixed-age ewe lambing percentage, and wool production and wool prices for rams, hoggets and lambs are all tied to the value entered for ewes. These linkages, as noted previously reflect typical industry relationships, simplify the inputs necessary to complete the sensitivity analysis, and preserve the farmer's focus on the critical factors influencing the GM.

3.3 Breed comparison output

The output table shows the stocking rate, gross margin and production values for the breed comparison. Total SUs and the stocking rate per hectare are shown. If a fixed annual feed consumption is assumed the SU conversion factors need to be adjusted for each breed until an equivalence in total SU is attained [Parker 1998].

The gross margin ($) is expressed in several ways: per farm (total), per ewe, per stock unit (SU), and per hectare (ha). The relationship between per ewe and per SU returns is contingent on the SU conversion factors and whether or not hogget lambing is adopted. Production values and ratios are derived from the GM template and the livestock reconciliation off screen.

3.4 Sensitivity table outputs

The sensitivity analysis shows the GM/ha for each combination of values specified in the sensitivity input table. For example, at a mixed-age ewe lamb price of $46.14 and a ewe wool price of $3.00 per kg (with the associated hogget lamb, cull ewe, and ram and hogget wool prices tied as explained previously) the GM for Breed A is $685/ha (Figure 1).

The average GM is calculated from the 'low', 'most likely' and 'high' values and the probability of each occurring for the two nominated variables. If the distribution is normal for both sensitivity variables, (i.e. the probability of achieving the 'low' value is the same as achieving the 'high' value, and the difference between the 'most likely' and the 'high' value and the 'most likely' and the 'low' value is the same), then the average GM/ha will be that for the 'most likely' values. However, if the distributions are skewed, as with the lamb price distribution in the example, the average GM may not equate to the 'most likely' value (i.e. $685 vs. $690/ha for Breed A). The maximum and the minimum gross margin per hectare ($757 & $608/ha) provide the distribution range for the GMs/ha generated by the sensitivity analysis. In the example, 22.5% of the values lay between $700 and $750/ha.

3.5 Lamb price calculation tables

Input tables are available in the spreadsheet to calculate the expected average lamb price, if required. They do not have to be completed in order to run the GM calculation or the sensitivity analysis.

3.6 Hidden tables

The calculations for the summary template are completed off-screen. This involves the completion of a stock reconciliation and a gross margin from the input data.

The stock reconciliation is for a status quo situation and is completed from the data provided in the input table. Similarly, prices, costs and production parameters for the GM are read from the input table. The number of ewes shorn is the total number of ewes less half the losses. All rams and hoggets are shorn. The number of lambs from mixed-age ewes that are shorn is calculated from the lambs born less losses times the nominated percentage shorn. Hogget lambs are assumed not to be shorn. The cost of capital is calculated from the opening livestock reconciliation values as explained previously.

4 MODEL APPLICATION: AN EXAMPLE SCENARIO ANALYSIS

4.1 Flock case study

4.1.1 Inputs and assumptions

The model was used to estimate the GM for two sheep breeds: Texels (Breed A) and Coopworths (Breed B) (Figure 1). Some of the data used to model these flocks were derived from Leslie [1999].

The Texel and Coopworth ewes were of similar weight (ca. 70 kg), and reared a similar weight of lambs to weaning, therefore they were assumed to be the same SU equivalents (1.3 per ewe) [Brookes *et al.* 1998]. Hogget mating was practised in both flocks. A higher price was received for Texel lambs as these were heavier than those of the Coopworth, and a greater proportion were able to be sold at weaning (December) when seasonal lamb prices tend to be higher. Texel wool, which is finer than that of the Coopworth, also received a higher price [Gavigan & Everitt-Hincks 1998]. The Coopworth flock, however, had a higher lambing percentage and heavier wool weights than the Texels. Coopworth ewes were shorn once every eight months (1.5 times per year) because of the greater staple length of their wool. Animal health costs for the Texels were less because of the reduction in drench costs associated with the early sale of lambs. The total utilised feed supply, and hence SU carrying capacity of the case farm was fixed at 3000 SU (12.5 SU/eff. ha wintered) for each breed.

A sensitivity analysis with lamb and wool prices was completed to compare the likely future GMs for the two flocks. The relative values should hold assuming future production increases in both flocks occur at a similar rate. Values used in the sensitivity analysis were ca. ± 10% of the 'most likely' value. The distribution for wool prices was normal, whereas that for lamb prices was skewed toward higher values.

4.1.2 Results

The Coopworth flock would return a $30 higher GM ($775 cf $745)/ha at current prices: for likely future costs and prices the difference was $35 ($725 cf $690). A 10% increase in lamb prices would have a similar effect on both flocks, increasing the GM/ha by $60 and $50, respectively, for the Texel and Coopworth flocks. An increase in wool price would impact more on the Coopworth flock, increasing GM/ha by $23/ha compared to $15/ha for the Texel flock.

The Coopworths out-performed the Texels for all lamb and wool price combinations. Differences between the two flocks ranged from $27/ha (low wool price, high lamb price) to $47/ha (high wool price, low lamb price). The probability distribution also showed the Coopworths are likely to achieve a higher return per hectare than the Texels: 70% of the former GMs/ha were $700 or less compared to only 32.5% for the Coopworths.

At current prices, sheep sales income represents 84.7% and 76.4% of total income (sheep sales plus wool income) for the Texel and Coopworth flocks, respectively. The Texel lambing percentage, or lamb and cull ewe prices would need to increase by 4.2% and 4.5%, respectively, to 167% or $53.03 (for mixed age ewes), in order for the same income to be generated as the Coopworth flock. Similarly, the model enables the user to quickly establish that wool prices or wool weights would need to increase by 24% to $3.72/kg or 5.46 kg/ewe, respectively, to breakeven with the Coopworths.

5 CONCLUDING REMARKS

The spreadsheet model described in this paper seeks to help farmers integrate the primary drivers of sheep farm profit, through a limited number of inputs, so that 'What if?' questions can be answered with respect to possible future scenarios for sheep farming. The use of a standard spreadsheet, a one-page layout and the ability to observe how changes in input values affect productivity and the GM simplifies the use of the software for the farmer. The spreadsheet model could be distributed to farmers via disc or the Internet. The advantage of using Excel as the platform software is that it is widely available to farmers and farm management consultants.

Benefits from improved decision-making with respect to the introduction of new sheep breeds because of access to the decision aid include:

- more rapid uptake of breeds or their crosses that will meet future market requirements;
- more effective use of the genetic material available in existing and new breeds;
- an improved understanding of how breed changes can impact on farm productivity, especially the need for adjustments to the stocking rate and/or seasonal calendar of events.

The model has received positive endorsement from a small sample of farmers and consultants and is to be made available to farmers through the Meat New Zealand internet site.

ACKNOWLEDGEMENTS

We thank Meat NZ for financial support for this project and the case farmers for their input.

REFERENCES

Brookes, I.M., K.I. Lowe, and D.J. Garrick, Modelling the feed requirements of cross-bred sheep. *Proceedings of the New Zealand Society of Animal Production* 58, 165-169, 1998.

Cox, P.G., Some issues in the design of agricultural support systems. *Agricultural Systems* 52, 355-381, 1996.

Gavignan, R.G. and J.M. Everitt-Hincks, The economics of alternative wool production systems. *Proceedings of the Southern North Island Sheep & Beef Cattle Farmers' Conference* 7, 49-54, 1998.

Leslie, D., Cross breeding means management changes. *The NZ Farmer*, March 25, 13, 1999.

McCall, D.G., P.R. Marshall, and K.L. Johns, An introduction to StockPol: A decision support model for livestock farms. *Proceedings of the International Conference on Decision Support Systems for Resource Management*, Texas A&M University, USA, 27-30, 1989.

Paine, M.S., Doing it together: Technology as practice in the New Zealand dairy sector. *PhD Thesis*, Wageningen University, The Netherlands.

Parker, W.J., The use and misuse of the stock unit systems. *Proceedings of the New Zealand Grassland Association* 60, 243-248, 1998.

Parker, W.J., N.M. Shadbolt, and D.I. Gray, Strategic planning in grassland farming: Principles and application. *Proceedings of the New Zealand Grassland Association* 59, 191-197, 1997.

Pollock, S. and E.M. Hurley, Computer software use by farm consultants studied. *New Zealand Rural Business* 2, 37-38, 1997.