A Farmer Decision Tool for Simulating and Optimising Lamb Production

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Abstract: Farm study groups are an effective means for putting the results of scientific research into practice by farmers. One such group, the Northern King Country Farm Study Group, identified that increasing the number of lambs produced per ewe made it difficult to maintain average lamb weaning weight. Managing this requires decisions to match ewe numbers, ewe and ram breeds, timing of mating, allocation of ewes and lambs to paddocks, and timing of sale, to pasture availability. A decision support tool, "BestBreed", was developed to allow the farmers in the group to explore lamb production and sale value resulting from different management policies. In this way, farmers could identify options for increasing returns from their ewe flocks. This paper describes the design of the software, especially the user interface and the model functionality. Problems arose identifying the most useful inputs that could practically be entered by farmers with little experience in using spreadsheet software. The user interface therefore had to present the input requirements in a way that was clear and logical to the farmers, and to validate entered data. Another issue arose with deciding on the amount of functionality to provide. Initial requests to increase functionality made BestBreed more difficult to understand; a more usable tool resulted when some features were subsequently removed. Our experience with designing this tool and training farmers in its use provided valuable lessons for effective design and use of future decision support software for farmers.

Keywords: Decision support systems; Spreadsheet model; Extension; Sheep; Farm study group

1. INTRODUCTION

Research into agricultural systems results in increased knowledge about the responses of those systems to different management interventions. However, translation of this knowledge, typically held by scientists, into learning packages and procedures to aid farmers in managing their farms is non-trivial [Passioura, 1996; Brooksbank, 2000]. One approach which has received much attention internationally is the use of software decision support systems (DSS) [Matthews et al., 2000]. DSS are software which are intended to capture scientific knowledge and allow farmers to use that knowledge in decision making on-farm. Experience shows, however, that the vast majority of DSS projects fail to produce much benefit for farmers [Cox, 1996; Lynch et al., 2000]. The main reasons cited for this are that DSS tools do not address perceived farmer needs, and are developed without participation from farmers [Campbell, 1999; Newman et al., 2000]. This consequently reduces farmer buy-in, and subsequent uptake of these tools.

An alternative methodology for making the results of scientific research available to farmers is the study group approach. In AgResearch, this approach has been used since the 1980s [Sheath and Webby, 2000]. Over time, farm study groups have focused on specific farm management issues. More recently still, a combined approach has been developed that links the farm study group approach with DSS "learning tools". The focus of these tools is on farmer learning rather than use in routine decision making. This paper describes the design and implementation of a learning tool, "BestBreed", as part of a farm study group project, and discusses the strengths and weaknesses of this approach to DSS use.

2. FARM STUDY GROUP

The Northern King Country Farm Study Group [Webby and Paine, 1997] was established as a farm monitoring project in 1992 [Webby and Sheath, 1991] and continued as a study group project from 1995 onward [Sheath et al., 1999]. As a result of these earlier projects, the group had identified improving weaning weights of multiple-born lambs as the best opportunity for increasing profitability of their mixed sheep-beef enterprises. Increasing the number of lambs produced per ewe (i.e. ewe prolificacy) had made it difficult to maintain high lamb weaning weights because of the increased demands for feed, the supply of which was limited by pasture available on farm. The "Feeding and breeding to wean heavier lambs" study group project (1999-2001) was subsequently established to look at options for achieving better lamb growth.

Particular options for managing this situation were identified as:

- Improving ewe nutrition pre-lambing.
- Use of fertiliser to increase pasture quantity and quality.
- Improving pasture quality [Lambert and Litherland, 2000; Lambert et al., 2000].
- Use of green feed crops for summer feed.
- Tactical use of breeding cows to improve pasture quality for lambs.
- Use of composite breed ewes.
- Use of specialist meat sires.
- Precise feeding to match pastures to animals.
- Early weaning.

It is evident from this list that sheep-beef enterprises are complex systems, requiring multiple animal, pasture and other management decisions to be made at different times of the year. These decisions are overlaid onto the seasonal pattern of weather, pasture growth, and pasture quality, and success depends on matching animal requirements to these seasonal patterns.

3. DECISION SUPPORT MODEL

As one way to cope with the complexity of the management decisions and the scientific information available, the group decided to develop a decision support tool. The "BestBreed" software simulated lamb production and sale value resulting from different farm configurations specified by the farmer. In this way, farmers could identify options for increasing returns from their ewe flocks. BestBreed was not an adaptation of an existing research model, as discussed by Cox [1996], but was purpose-built for use by the farmer group.

3.1 Scope

The model was built to the following specifications:

- The system was a lamb production system from ewe pregnancy scanning to weaning.
- The model would be used by the farmers approximately monthly.
- Feeding and breeding had been identified as the key management areas.

ScanningData			Total Fetuses	Total Ewes Scanned	Ewe Weighing Date	Lambing Date	Overall Scanning %	Total EwesTo Allocate	Start Date
			10900	6000	Sep1	Sep2	182%	5700	Sep1
Breed Code	Ewe Breed	Ram Breed	Stock Class	Ewes Scanned	Ewe LW Sep1	Lamb LW at Birth Sep2	Scanning %	EwesTo Allocate	Allocation Priority
1	Crossbreed Ewe	Coopworth	Dry 1	300	55.0		182%	0	Don't Allocate
			Single 1	1000	71.0	5.5		1000	Low
			Twins 1	4200	75.0	4.5		4200	High
			Triplets 1	500	65.0	3.5		500	High

Figure 1. StockData input sheet. The shading indicates areas for user input. Depending on the time of year, this sheet records ultrasound scanning or lamb birth information.

Paddocks	Total Area	Average Cover		
	780.0	1269		
Paddock Name	Paddock Area	Pasture Cover Sep1	Maximum Priority Allowed	Okay?
Barkers	20.0	1269	High	Okay
Matua	20.0	1269	High	Okay
Stream	20.0	1269	High	Okay
Ridge	20.0	1269	High	Okay
Pohutukawa	100.0	1269	High	Okay
Back Ranges	100.0	1269	High	Okay
Derries Road	100.0	1269	High	Okay
Spring	100.0	1269	High	Okay
House	100.0	1269	High	Okay
Sixteen	100.0	1269	High	Okay
Tomo	100.0	1269	Low	Okay

Figure 2. Paddock input sheet. The shading indicates areas for user input.

- A "half month" was chosen as the model time step, representing a balance between useful frequency of output, resolution of management decisions, and scale of available biological data.
- The model was coded in Visual Basic using Microsoft Excel 97. This allowed the model to be developed quickly. It was also believed that this would make the model easier to learn for farmers already familiar with Excel.
- The biological functions were based on relationships developed for growing sheep in a previous model, StockPol [Marshall et al., 1991], and extended using additional data on the effects of lactation on ewe maintenance requirements [Geenty and Rattray, 1987], and ewe and lamb intake [Rattray et al., 1982; Freer and Christian, 1983; Woodward et al., 2000].

The lamb production system operates as follows. Prior to lambing, ewes are weighed, and scanned by ultrasound to determine how many fetuses they are carrying (i.e. 0, 1, 2 or 3). At this time they are grouped into mobs (i.e. dry, single, twin or triplet) and put into paddocks ("set stocked"). In most cases dry ewes are sold prior to lambing. After lambing, the lambs and their mothers graze together until weaning, at which time the lambs are separated from their mothers, and may be further grown before being sold.

3.2 Model Inputs

The most complex aspect of the model was coping gracefully with the large number of inputs required to allow the farmers to specify their farm systems. A list of inputs is given in Table 1. Input sheets (e.g. Figures 1 and 2) were shaded to indicate where user input was required. Once farm information had been entered, this could be saved.

Table 1. List of input sheets in the model, and information required to be entered on each sheet. * = information required for each paddock in each month.

Input sheet	Information required
MyBreeds	Ewe breeds Ewe numbers Ram breeds
StockData (Figure 1)	Lambs or fetuses per ewe Ewe start weights Lamb start weights Lambing date Start date
Paddocks (Figure 2)	Paddock names Paddock areas Paddock start covers (amount of pasture)
ME	Pasture metabolisable energy content*
ROG	Pasture rate of growth*
Cattle	Pasture cover remaining after cattle grazing*
Allocation	Number of ewes and lambs in each paddock
Schedule	Weaning date Meat price in each carcass grade

3.3 Model Functionality

In its simplest form, the model simulated grazing and liveweight gain of ewes and lambs from pre-lambing through to weaning (Figures 3 and 4). First, the number and birth weight of lambs surviving lambing in each paddock was calculated. Second, pasture growth, pasture intake of ewes and lambs, milk produced by ewes, and liveweight gain of ewes and lambs were simulated through time for each paddock. Third, at weaning lambs were assigned to meat grades and their total carcass value calculated (Figure 5). A range of biological variables were reported so that farmers could evaluate the performance of various aspects of their system (e.g. lamb growth, pasture availability) at different times through the season (Table 2).

The model also allowed optimisation of one or more of the following variables:

Results		Total Ewes	Total Lambs Weaned		Optimiser Progress	Total Value	Average Lamb LWG
		5700	8615			$321,479	0.260
Paddock Name	Stock Class	Number of Ewes	Number of Lambs Weaned	Stocking Rate	Final Ewe LW Dec2	Final Lamb LW Dec2	Paddock Lamb LWG
Barkers	Single 1	300	276	15.0	58.9	8.6	0.035
Matua	Twins 1	300	480	15.0	48.0	13.7	0.101
Stream	Twins 1	75	120	3.8	74.0	31.2	0.294
Ridge	Twins 1	75	120	3.8	74.2	31.2	0.294
Pohutukawa	Twins 1	750	1200	7.5	58.2	28.3	0.262
Back Range:	Twins 1	750	1200	7.5	60.8	29.8	0.278
Derries Roac	Twins 1	750	1200	7.5	58.2	28.3	0.262
Spring	Twins 1	750	1200	7.5	60.8	29.8	0.278
House	Triplets 1	500	975	5.0	58.6	29.5	0.286
Sixteen	Twins 1	750	1200	7.5	60.8	29.8	0.278
Tomo	Single 1	700	644	7.0	68.7	34.6	0.319

Figure 3. Results summary sheet.

- Total numbers of ewes on the farm.
- Ewe genetics (growth rate, fecundity, milk production).
- Ram genetics (growth rate).
- Allocation of ewes and lambs to paddocks.

A genetic algorithm [Goldberg, 1989] was coded into the model to iteratively adjust one or more of these variables, as selected by the user, in order to maximise the total value of the lambs at weaning. Although the optimisation option was easy to use, in practice this facility made the model more difficult to understand, so that farmers preferred to run the model as a simple simulation, without optimisation.

Table 2. List of output sheets in the model, and information reported on each sheet. * = information reported for each paddock in each month.

Output sheet	Information reported
Results (Figure 3)	Number of ewes in each paddock Number of lambs weaned Stocking rate Final ewe weight Final lamb weight Average lamb weight gain per day Total lamb value at weaning
Lambing	Lambs born per ewe
HM	Paddock herbage mass (amount of pasture)*
EweLWG	Daily weight gain of ewes*
EweLW	Weight of ewes*
LambLWG	Daily weight gain of lambs*
LambLW (Figure 4)	Weight of lambs*
Payout (Figure 5)	Number and dollar value of lambs in each carcass grade

4. RESULTS

4.1 Participation in Model Design

In the project evaluation survey, 9 of the 12 farmers indicated that they felt they had opportunity to contribute to the design of BestBreed. When the farm study group met, approximately every 3 months, progress with the model was reviewed, and new requirements, changes or fixes were noted. Early versions of the model were fitted using the farmers' data from the 1999-2000 season, and model development continued until an advanced version of the model was available for use in the 2000-2001 lambing season.

Although BestBreed was purpose-built for the study group, rather than being derived from a research model, it did end up being a fairly substantial piece of software, partly due to the complex nature of the lamb production system, but also to meet the farmers' expectations of functionality. However, improving functionality compromised the model's ease of use, and a more usable tool resulted when some features were subsequently removed.

4.2 Handling Model Inputs

The farmers in the project routinely collected and recorded key pasture and lamb performance data from their farms. The easy entry of this data was a key requirement of the model. Techniques that were used to make the model easier to use therefore included logical sequence of input requirements (Table 1), highlighting of spreadsheet cells that required data entry (Figure 1), using spreadsheet functions to validate certain data items as these were entered (Figure 2), validating inputs (in Visual Basic) when the model was run and using dialogue boxes to indicate incorrect or inconsistent entries, and a farmer-oriented instruction manual prepared by the group coordinator. Even with these measures, the number of inputs required was daunting for some of the farmers. Also, it was not possible to lock the spreadsheet to prevent accidental changes to the formatting of the input cells, or entry of non-numeric values (e.g. spaces). This tallies with overseas studies that have found that farmers are not generally familiar with computer use [Hamilton et al., 1991].

4.3 Confidence in Outputs

An issue which, perhaps surprisingly, did not cause much concern was the reliability of the model outputs. This may have been partly because some of the model biology was based on functions refined from an existing commercial software package, StockPol [Marshall et al., 1991], which was well known to the farmers in the group.

The farm data from the first season of the study group was used in 2000 to check the model biological predictions, and as a result, changes were made to the lamb liveweight gain functions. These predictions were further tested in 2001 and indicated that the ewe liveweight responses were also inaccurate. These also were subsequently adjusted. The adjusted model produced realistic predictions of ewe and lamb growth.

4.4 Uptake of the Model by Farmers

Despite efforts to include the farmers in design of the model and continued encouragement for them to use it, uptake by farmers was modest, at best. Based on the project evaluation survey, only 1 farmer indicated that he used the model monthly, and a further 5 indicated that they used it once or twice per year. Not all of the farmers felt confident

LambLW

Paddock Name	Jul1	Jul2	Aug1	Aug2	Sep1	Sep2	Oct1	Oct2	Nov1	Nov2	Dec1	Dec2
Barkers						5.5	5.6	6.4	7.7	10.7	10.1	8.6
Matua						4.5	6.4	8.4	10.4	13.9	14.2	13.7
Stream						4.5	10.0	14.4	19.8	24.3	28.0	31.2
Ridge						4.5	10.0	14.4	19.8	24.3	28.0	31.2
Pohutukawa						4.5	9.9	14.3	19.5	24.0	26.5	28.3
Back Ranges						4.5	9.9	14.3	19.5	24.0	27.3	29.8
Derries Road						4.5	9.9	14.3	19.5	24.0	26.5	28.3
Spring						4.5	9.9	14.3	19.5	24.0	27.3	29.8
House						3.5	8.9	13.1	18.4	22.8	26.4	29.5
Sixteen						4.5	9.9	14.3	19.5	24.0	27.3	29.8
Tomo						5.5	11.9	16.8	22.4	27.2	31.1	34.6

Figure 4. Lamb liveweight results sheet.

Payout

Lambs Weaned	Average CW	Total Value	Average Lamb Value
8615	12.7	$321,479	$37.32

Grade	CW Range	Schedule (c/kg) Dec2	Lambs in Grade Dec2	CW in Grade	Value by Grade
A	-9.0	200	8.9%	4097	$8,194
YL1	9.1-11.5	295	9.2%	8624	$25,441
YL2	11.6-13.2	295	32.6%	35081	$103,489
YM1	13.3-14.9	300	29.0%	35048	$105,145
YM2	15.0-17.0	300	8.3%	11185	$33,555
YX1	17.1-18.0	300	0.6%	875	$2,625
YX2	18.1-21.2	300	0.2%	274	$821
PL1	9.1-11.5	295	0.2%	176	$519
PL2	11.6-13.2	295	1.7%	1846	$5,447
PM1	13.3-14.9	300	5.1%	6185	$18,555
PM2	15.0-17.0	300	3.6%	4794	$14,381
PX1	17.1-18.0	295	0.5%	716	$2,112
PX2	18.1-21.2	290	0.3%	411	$1,191
PHH	21.3-	285	0.0%	2	$5
			100.0%		

Figure 5. Lamb carcass production results sheet.

with computer technology. Of the 12 farmers, 6 did not have access to Microsoft Excel 97 on their computers. This was an unforeseen drawback of having developed the model using Excel.

However, in the evaluation farmers responded strongly that the project had given them more confidence in changing the way they managed their farms, and had allowed them to improve farm profitability—for them the project had achieved its goals. This is an indication that the strength of this approach does not necessarily lie in getting all of the farmers to use the model but rather in exposing them to the thought processes associated with the model. All farmers were trained in the use of the model and completed exercises using information from their own farms. This alone may have been a sufficient learning exercise to influence their thinking in the way they managed ewes and lambs.

5. CONCLUSIONS

Our experience with designing this tool and training farmers in its use provided valuable lessons for effective design of future decision support tools. The key lesson was that farmer benefit from the DSS was enhanced by its being developed and used within a group learning context. This allowed farmers to have input into the model design and function and to see that it related closely to the issues they were grappling with.

6. ACKNOWLEDGEMENTS

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