Proof of Concept: Farm Genetic Plan for Commercial Enterprise

A project completed in fulfilment of the Kellogg Rural Leadership Programme

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Executive Summary

The New Zealand government wishes to double exports by 2025. To do this they wish to increase exports from agricultural sectors to $64 billion. To help, the government has invested in Primary Growth Partnership Programmes to advance science and farm system changes. This includes improving farm management systems.

The genetic and genomic potential in the New Zealand red meat sector industries are vast and often untapped by the commercial farmer. Two key issues overlooked by the industry are;

1. Understanding and utilisation of breeding values by the commercial farmer is limited, and
2. The ability to benchmark own key production indicators against the genetic potential of sires is lacking in farm management systems.

Here a farm genetic plan for commercial enterprise is explained and tested on three commercial farmers. The model aims to quantify the genetic merit of the commercial flock, align the genetic merit of the flock with key performance indicators, and identify and evaluate options for improvements and/or changes within the commercial operation.

Ram team/purchases and ewe population structure was combined with Sheep Breeding Limited breeding value data to estimate genetic merit of rams, ewes and lambs within a commercial flock. Estimates of genetic merit of key traits; weaning weight (WWT), carcass weight (CWT), number of lambs born (NLB) and survival (SUR) were reported. Performance data from the commercial flock was used to calculate production statistics for reproduction (lambs tailed per ewe mated and survival from pregnancy scanning to tailing) and growth (to weaning and slaughter). Production statistics were compared against the estimates of genetic merit; tailing percent with NLB, survival with SUR, growth to weaning with WWT and growth to slaughter with CWT.

Meetings were set up with each farmer to discuss the model, clarify inputs and explain results. Feedback was sought on the model, gathering of data, result presentations and overall thoughts. The idea of a "genetic plan for commercial enterprise" was well received. All farmers were enthusiastic about the whole process. Gathering of historical data was difficult and not complete for all farms. None of the farmers knew actual ram teams used, information had to be sourced from the breeding company involved. This proved to be one limitation of the model, however, all farmers were happy with assumptions used to fill in gaps.

The main recommendation suggested by all three farmers was, that for first time users a consultant or qualified person should be used. Interpretations of the results varied and incorrect generalisations were made that could be corrected by the consultant before any decisions are made by the farmer. Overall, all t farmers enjoyed and benefited from the exercise, with a willingness to perform the exercise again the next year.

The next steps of this project are to refine the model and develop it into an online programme/application for use by consultants, breeders and commercial farmers. Finally, there is the potential to modify and extend this model to the deer and beef cattle industries.

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1. Introduction

To help double exports by 2025, there is a need to look at how we can better exploit the genetic potential available in seed stock. Work has begun with the Farm^{IQ} and Red Meat Profit Partnership Primary Growth Partnership programmes. However, a missing link is the alignment of key production indicators with the genetic potential of the sire team/whole flock/herd. The aim of this project is to design a farm genetic plan, which aligns Sheep Improvement Limited index/breeding values with farm production data. Ultimately prompting farmers to think about their genetic teams, how they buy and how they best utilise these in their farming enterprise. The outcome of this project could also be implemented in our beef cattle and deer sectors.

2. The research problem and rationale

New Zealand relies on their red meat sector for export earnings. The government has set a goal of increasing exports to $64 billion by 2025 from all agricultural sectors. The government has implemented the Primary Growth Partnership (PGP) programmes to help realise this target. Those PGPs aimed at the red meat sector including Farm^{IQ} and the Red Meat Profit Partnership show great potential in trying to help align the value chain, promote a collaborative strategy and promote implementation and uptake of best farm practices. However, within their projects there is no big push in promoting a "genetic plan" in farm management decisions.

New Zealand's red meat sector is well supported by world class genetic programmes run by breeders with support from genetic evaluation systems. Genetics is cumulative and permanent and can be an untapped resource, unrealised by farmers. This can be through limited understanding of animal breeding, or unknown genetic potential held within flocks/herds.

Farmers benchmark a number of key production statistics, including lambing percentage, weaning weight, days to slaughter, carcass weights and earnings before interest and tax (EBITs). Performance is often attributed to fertiliser, pasture species and breed (as maternal versus terminal). There is a real opportunity in benchmarking these key production indicators to the genetic potential of the flock/herd. Consequently, raising awareness of and exploitation of the genetics in improving overall farm production systems.

3. Literature review

Current industry performance

Since 1990 in the sheep, beef, dairy cattle and deer industries there has been a dramatic lift in production per animal, and except for the dairy industry, with a concurrent decrease in livestock numbers (Table 1). Sheep numbers have nearly halved since 1990, however, an extra 27 lambs are born per 100 ewes, there has been a 26% increase in average lamb carcass weight and a doubling of the amount of lamb sold per ewe (Table 1; Beef + Lamb, 2012; 2016; MPI, 2016a). Wool production and for the beef cattle, average steer weight has stayed at similar levels. Dairy cattle have had a 45% increase in the amount of milk solids per cow. These increases can be attributed to better farm management practices, better pastures but also better genetics (Mackay et al 2012).

Table 1: Change in livestock numbers and productivity in New Zealand between 1990 and 2015 (provisional).

	1990-91	2004-05	2014-15p	Change since 1990
Livestock Numbers (million)				
Sheep	57.85	39.88	29.48	-49%
Beef Cattle	4.59	4.42	3.58	-22%
Dairy Cattle	3.44	5.09	6.37	85%
Deer	0.98	1.71	0.91	-7%
Production				
Lambing % (ewe)	100.4%	119%	127%	+27 lambs
Av lamb carcass wgt (kg)	14.35	17.5	18.1	26%
Lamb sold (kg/ewe)	9.76	16.4	19.5	100%
Wool Prodn (kg/head, greasy)	5.28	5.5	5.2	-2%
Av Steer wtg (kg)	297	318	302	2%
Milksolids per cow (kg)	260	308	377	45%

Beef + Lamb 2012; Beef+ Lamb 2016; MPI, 2016a

Breeders of genetic livestock have been focusing on genetic gain in their flocks/herds since domestication of livestock began around 7,000-9,000 years before present. More recently, genetic gain has been achieved with the help of animal evaluation systems, e.g. Sheep Improvement Limited (Young & Amer, 2009), Breedplan (Beef cattle; Barwick & Henzell, 2005) and DeerSelect (Archer et al, 2005). For the sheep industry, there was a significant lift in the genetic merit of breeder's flocks since the implementation of the Sheep Improvement Ltd (SIL) genetic evaluation system in 1999 (Young & Amer, 2009). The introduction of SIL moved flocks from individual within flock evaluations to a larger across flock evaluations that were more accurate. This was improved also with the introduction of the Central Progeny Test, which provided greater flock connectedness and a larger across-flock and breed evaluation (SIL-ACE). These impacts can be seen in Figure 2, where the establishment of SIL increased rate of genetic gain for Dual Purpose flocks from 29 cents/year to 54 cents/year, and the establishment of SIL- ACE increased this to 84 cents/year (Young & Amer, 2009).

There is no lack of genetic potential available in any of the red meat sectors, for commercial farmers to exploit. With the advancement of genomic technologies, there will again be a jump in the level of genetic potential available. It is up to the industry to put in place farm systems to exploit this.

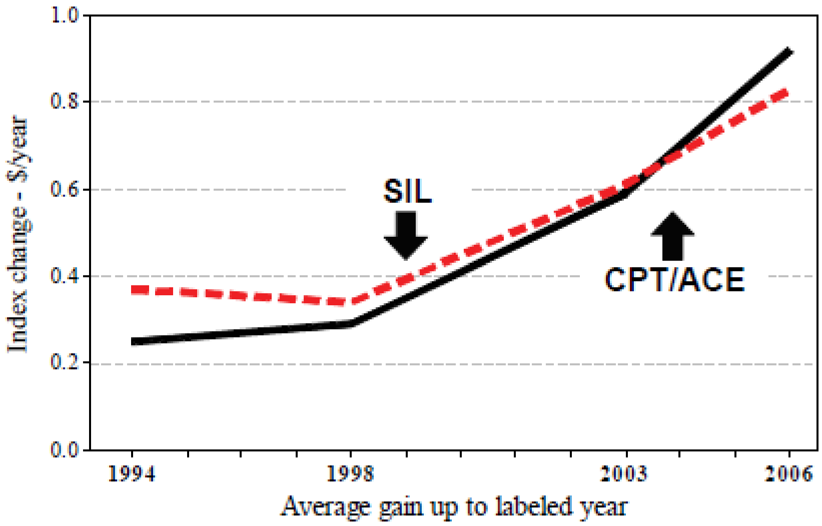

Figure 1. Average rate of gain in SIL-ACE overall indexes for Dual Purpose (solid line) & Terminal Sire (dashed line) sheep. Times that SIL & CPT/ACE were established are indicated. Reproduced from Young & Amer, 2009.

Future industry performance

The goal of doubling primary export sector exports to $64 billion by 2025 was announced in 2012. Currently the outlook for 2020 is a forecast of $44 billion. (MPI, 2016a). To reach the goal of 2025 the primary sector exports will need to grow at 9.5% per year from 2016. Currently between 2012 and 2016 New Zealand has been tracking at 3.3%. To reach the forecasted $44m by 2020 it is forecasted that all agricultural sectors will increase their export revenues, except the meat & wool sector which will decrease by 3% to $8,804m (MPI, 2016a). This has been attributed to beef prices decreasing plus herd size decreases and stabilization of dairy herd sizes (i.e. lower dairy cow slaughter rates).

To help increase NZ export earnings, MPI is investing in Primary Growth Partnership (PGP) Programmes (total investment $727m) to advance science and farm system changes to boost productivity and profitability by producing products that align with consumer demand (MPI, 2016a). Expanded, the farm systems change will look at; learning from the best farmers, understanding what makes farmers/farms successful, develop common investment methodology (partnerships within rural sector i.e. with banks, farm advisors) and encourage sharing of best practice and ideas. Annual benefits to the rural sector through PGPs is expected to be $6.4b.

Two programmes aimed at the red meat sector have been implemented. These are Farm^{IQ} and the Red Meat Profit Partnership (RMPP). Farm^{IQ} (www.farmiq.co.nz), partnering with Silver Fern Farms, Landcorp Farming Limited and Tru-Test, had the aim to grow the red meat sector by 50% by 2025 via designing, piloting and implementing a demand-driven, integrated red meat value chain. The seven year PGP was established in 2010. The RMPP had a focus on adoption of best practice on farm and between farm and processor (www.rmpp.co.nz). Alongside Beef + Lamb New Zealand, six meat companies, two banks plus other stakeholders in the sector are working together. It has been estimated that the potential economic benefit to New Zealand from this programme by 2025, will provide $880m per annum in additional on-farm revenue (MPI, 2016b). The seven year programme commenced in 2013.

The Farm^{IQ} PGP has identified problems relating to; costs of establishing breeds, products and markets; a fragmented supply chain and absence of consistent inventory measurement and management tools across the value chain. (FarmIQ, 2013 – Appendix 1). The RMPP has identified problems with the lack of collaboration in the current competitive sector and issues around farmer learning, retention of high-calibre people, extension of best practice and implementation of positive practice change (RMPP, 2014 – Appendix 2).

These two PGP programmes are aligned, and there have been several positive outcomes. The Farm^{IQ} System farm management software (FIQ-FMS, Farm^{IQ}, 2016a); genomic estimates for lamb eating quality in Terminal sheep flocks (Farm^{IQ}, 2016b); RMPP survey to refine appropriate extension design (RMPP, 2015); establishment of a software platform and code of practice for data transfer “DataLinker” (Cooke et al 2013), and many others.

The FIQ-FMS, allows the flow of data from the value chain back to the farm, as well as recording general farm management activities, land environment planning and Health and safety plans (Farm^{IQ}, 2016a). The system, apart from integrating with Silver Fern Farms, has also been integrated with CashManager Rural financial management software and Farmax feed budgeting software. The FIQ-FMS is also involved in the RMPP code of practice for data sharing and ultimately with the DataLinker project.

What is missing to help NZ reach MPI goals?

The genetic potential available in New Zealand for the red meat sector industries (Sheep, Beef and Deer) are vast. With continued improvements in genetic and genomic technology the rate of genetic gain will lift again. The ultimate point of success is when this genetic potential has been realised by the commercial farmer. It is generally accepted that the commercial operation is ~2-4 generations (6-8 years) behind that of the breeder (Van der Werf, 2000). The opportunity lies in improving the ability of the commercial farmer to maximise the genetic potential in the seed stock they already have.

The FIQ-FMS is not the only farm management software tool available for farmers, however, it has the potential to be one of the most all-encompassing software packages. Given this, it has the ability to provide reports on a wide range of animal, paddock and forage production key performance indicators to support key farming decisions. Farm^{IQ} partnership farmers, have already shown that using the comprehensive FIQ-FMS has lifted productivity (Farm^{IQ}, 2016b). Though the Farm^{IQ} programme has one project specific to genetics, it is missing within its FIQ-FMS a key performance indicator relating to the genetic potential of the sires bought each year.

The RMPP survey of over 1000 farmers, found that of the farm systems and practices farmers believed increased productivity, animal breeding and genetics was one of the top five (RMPP, 2015). However, a survey of 12,000 sheep and beef farmers (971 respondents; 94 ram breeders, 844 commercial), found that only 22% of commercial farmers used breeding values (BVs), and only 59% of the ram breeders (Corner-Thomas et al 2013). The low use of BVs by the commercial farmers could be attributed to either their non-acceptance of BVs as a farm management tool or they trust their Breeder to make genetic gains and to make available appropriate rams (Corner-Thomas et al 2013). The reasons for low use of BVs by breeders was not explored further by the authors. With changes in technology there is a potential drop of non-recording breeders, as the leading breeders move further away from the average breeder.

Summary

The genetic potential available for New Zealand red meat sector industries is vast. Farmers recognise that genetics is within the top five farm systems and practices important to the farm enterprise. However, only a small percentage of commercial farmers are using BVs when picking their sires. For the government to realise a doubling of primary exports by 2025, they are investing in PGP programmes and have a number of PGP's in place for the red meat sector. Specifically, FarmIQ and RMPP are promising. In summary, the industry are still overlooking the following two key issues;

1. The understanding and utilisation of breeding values by the commercial farmer is limited, and
2. The ability to benchmark own key production indicators against the genetic potential of sires is lacking in farm management systems

This report, investigates the potential of a model for estimating genetic gain on three commercial enterprises. The report discusses the ease of use, outputs and feedback provided by the three farmers. Finally, this report provides recommendations on its implementation into industry, with the primary aim of becoming a tool that covers the above outlined key issues.

4. Methodology

Beef + Lamb Genetics (BLG) had also identified a similar gap in the red meat sector. Jude Sise of AbacusBio (Dunedin) was commissioned to outline a framework for development of a farm genetic plan tool for sheep (Sise, 2016). A model was developed for testing (see below). Further testing was required to assess the model, its effectiveness, shortcomings and potentials, under a range of commercial farming scenarios. Three commercial farmers were approached to test the model. The commercial farms approached were those thought to keep accurate records and known sire team history. Feedback on the process, reporting and usefulness of the project was sought from the test farms.

Model overview

An excel model was built with the view to:

1. Quantifying the genetic merit of the commercial ewe flock,

2. Aligning the genetic merit of both ewes mated and lambs born with key performance indicators, and
3. Identifying and evaluating options for improvements and/or changes within their operation

Model set up

To estimate the genetic merit of the flock, information was required on where rams are sought from and what rams are bought each year. This information was used to predict the merit of ewes within the flock and lambs born each year. The accuracy of the estimates is dependent on the knowledge of rams used each year. Ram data was captured from:

1. Knowledge of the stud flock purchased from.
2. Known ram individuals within the ram team (flock, tag and birth year).
3. Age distribution and number of rams purchased and mated.

Assumptions were made, where rams are unknown, or homebred rams are used.

Assumption 1. Where rams were unknown, rams were assumed to be purchased from the top 30% of rams within the same age cohort of the stud flock.

Assumption 2. Homebred rams were given an estimated merit based on the average merit of the lambs born within their cohort (birth year).

Additional ewe information to define the ewe flock population structure and merit estimate were:

1. Number of mixed age (MA), two tooth (2tth) and hogget ewes mated to maternal or terminal rams
2. Number of replacements kept from hogget ewes
3. Oldest ewe age group kept
4. Hogget and ewe death and cull rates (assume as 5 and 8%, respectively, if unknown)

Merit estimates

The initiation year was set as 2005, where all ewes mated and lambs born were assumed to have a genetic merit of 0. The genetic merit of the ewe flock was updated in subsequent years according to;

Ram Team:

- Merit estimates for the ram team which were calculated from the ram usage profile, with the merit estimates for home bred rams taken as the average merit of lambs born within their cohort.

Lambs born and/or retained:

- Merit estimates for all lambs born were taken as the average merit of all lambs born, taking into account any portion sired by terminal rams.
- Impact of terminal ram usage was taken into account for merit estimates of the lambs weaning weight and carcass weight traits.
- Merit estimates of ewe lambs retained as replacements was taken as the average merit of maternal sired lambs born within each cohort. It was assumed that there was no additional selection pressure (i.e. weight, born as a twin, pregnant as a hogget) applied to these ewe lambs.

Ewe flock:

- Merit estimates of the ewe flock were adjusted each year according to the average merit of lambs entering the flock as replacements, and also the death and cull rate of older ewes.
- Allowances were made for any ewes purchased. The genetic merit of these ewes were taken as the average of the contributing flock using the same model.

It was assumed there was no preferential mating between rams and selected ewes.

Annual production data

Production data from mating to slaughter was requested from the test farmers for the years 2010 to current. This included,

Mating data

- Number of 2tth, MA and hogget ewes mated.
- Number of pregnant ewes purchased or sold
- Average date rams joined

Lambing data

- Number of lambs tailed (separated for those born to a hogget or older ewe)
- Number of foetuses scanned (separated for those born to a hogget or older ewe)

Weaning and carcass data

- Average weaning date
- Number of lambs weaned
- Number of lambs slaughter pre weaning
- Average carcass weight
- Average kill date

Production targets

- Tailing/docking %
- Survival %
- Growth rate from birth to weaning
- Growth rate from weaning to slaughter
- Growth rate from birth to slaughter

The following criteria were calculated from the supplied data;

Tailing % separate for hogget ewes and older ewes, as number of lambs tailed divided by number of ewes mated adjusted for any ewes bought or sold pregnant.

Survival % as the difference between number of foetuses scanned and number of lambs tailed.

Average birth date as the weighted average, where average time to conception was 9 days and gestation length was 147 days.

Age at weaning difference between average weaning date and average birth date.

Growth to weaning was standardised to a 90-day growth rate, where average lamb birth weight was assumed to be 4.5kg and adjusted for any lambs sold pre-weaning.

Age at slaughter difference between average slaughter date and average birth date.

Growth to slaughter (from birth) was estimated from birth to average age at slaughter, using average carcass weight adjusted to a live weight where dressing out percentage was assumed to be 43%.

Growth to slaughter (from weaning) was estimated from weaning, adjusted to 90 days, to average age at slaughter, using average carcass weight adjusted to a live weight where dressing out percentage was assumed as 43%.

Outputs

The model produced genetic merit estimates for each years ram team, ewe flock and lambs born for weaning weight, carcass weight, number of lambs born and survival. These estimates could be compared graphically against growth to weaning (weaning weight), growth birth/weaning to slaughter (carcass weight), lambs tailed per hogget or older ewe (number of lambs born) and survival from pregnancy scanning to lambs tailed (survival) and the production targets.

Testing the model

This involved three stages;

1. Gathering of initial set up data from farmers including; flock structure, rams bought/used and production statistics.
2. Setting up of the model for each farmer based on flock structure and where the rams are sourced from.
3. Meeting with the farmer, to finalise the production statistics and present the results for feedback.

Farmers were targeted, based on knowledge of their farming enterprise. Farmers were limited to those that knew what rams were used/purchased for at least the past three years. Also limited to those farmers that were thought to only sourced rams from a single stud flock of each production system, one maternal and/or one terminal stud flock.

Points 1 and 2 have been outlined in the above section (model overview). Data was sourced for 2010 to 2016. Once models were setup, a meeting was arranged to sit down with the farmer to present the results. These meetings were generally for one to two hours and involved clarification of the inputs, discussion of the outputs, and discussion on the overall process, usefulness and recommendations for improvements. The three farmers were;

Farmer 1. Based in Kaituna, Masterton, this enterprise consisted of a 1000ha hill country property running 12,500 stock units. Utilise both a maternal (breed: Highlander) and terminal (breed: FocusPrime) sheep production system. Production targets include 160% lambing, greater than 80% survival, target growth rate to weaning of 310g/day and target growth rate from weaning to slaughter of 150 g/day.

Farmer 2. Based in Ormondville, Dannevirke, this enterprise consisted of 1121 effective ha hill country property running 11,600 stock units. Utilise both a maternal (breed: Highlander) and terminal (breed: FocusPrime) sheep commercial production system. Also run Multiplier flocks for both breeds, using elite rams from stud flock to produce unrecorded ram lambs for sale. The Highlander multiplier flock was used for this exercise. Production targets include 160% lambing, greater than 80% survival in the 2tth and MA ewes, and 90% lambing and greater than 80% survival in hogget ewes.

Farmer 3. Based in Whanawhana, Hastings, this enterprise consisted of 1641 effective ha hill country property running 18,000 stock units. Utilise both a maternal (breed: Highlander) and terminal (breed: FocusPrime) sheep commercial production system. They also run FocusPrime breeding and multiplier flocks. The commercial Highlander flock was used for this exercise. Production targets include 150% lambing in the 2tth and MA ewes with 85% survival from pregnancy scanning to tailing. For the hoggets 110% lambing and 80% survival. Growth rate targets include 280 g/day between birth and weaning, 220 g/day between birth to slaughter and 200 g/day post weaning.

For both Farmer 1 and 2 the exercise was carried out with the owner-operator, while for Farm 3 (also an owner-operator business) the exercise was performed with the farm manager. Both Farmer 2 and 3 were hit by bad weather events during 2014 and 2015 lambing which affected tailing % and survival rates. The 2016 lambing has also been affected, at time of writing figures were not yet available.

5. Results and discussion

Model set up

The following paragraphs outline the setup of ewe flock structure and ram mate teams for each farmer.

Farmer 1.

- Ewe flock information: 4,050 2tth and MA ewes to Maternal sires and 3,183 MA ewes to Terminal sires. Tailing 10,800 lambs, retain 1600 hoggets as replacements with oldest maternal age of 7 years.

- Ram team information: Maternal ram team on average consisted of 48 sires spread evenly across ram ages (hogget, 2tth, 4tth and older) with 12 new hoggets purchased each year from Highlander flock 4631. Terminal ram team on average consists of 33 sires spread evenly across ram ages (2tth, 4tth and older) with 11 new 2tths purchased each year from FocusPrime flocks 4588 and 3658. Ram purchase information was available for 2013 to 2016 mating periods. Actual mate teams were unknown. No homebred rams are used. For 2006 to 2012, rams were assumed to be purchased from the top 30% of the stud flocks 2tth rams available.
- Assumption – model currently set up for only one stud flock per breed type. The terminal sires were bought from two stud flocks. However, flock 3658 was formed from transferring a subset of ewes from 4588 in 2010. Since then both flocks have shared sires, hence these two flocks can be considered as one. Flock 4588 was used for estimating genetic merit as being the founder of the two flocks.

Farmer 2.

- Ewe flock information: 2,209 2tth and MA ewes and 1,964 hogget ewes to Maternal sires. Tailing 7,029 lambs, retain 780 hoggets as replacements with oldest maternal age of 4-5 years.
- Ram team information: Maternal ram team for 2tth and MA ewes on average consisted of 25 hogget sires. These are provided as elite hogget rams from the Highlander flock 4631 yearly for use in the Multiplier flock. The hogget ewes are mated to 65 rams born from the multiplier flock. Actual ram team information was available for 2012 to 2016 mating periods for the 2tth and MA ewes. For 2006 to 2011, rams were assumed to be purchased from the top 30% of the stud flocks 2tth rams available.

Farmer 3.

- Ewe flock information: 1,723 2tth and MA ewes to Maternal sires and 3,785 2tth and MA and 1,160 hogget ewes to Terminal sires. Tailing 7,770 lambs, retain 1100 hoggets as replacements with oldest maternal age at mating of 8 years.
- Ram team information: Maternal ram team on average consisted of 17 MA sires (2tth, 4tth and older). These are sourced as ex-elite rams used in the Highlander stud flocks (4591 and 4631). Approximately 66 terminal sires are used each year, these are from the Multiplier FocusPrime flock and are a mix of hogget, 2tth and 4tth rams. Ram

purchase information was available from 2013 to 2016 mating periods, actual mate teams were unknown.

- Assumption – model currently set up for only one stud flock per breed type. The maternal sires were from two stud flocks. However, the majority (79%) were from one flock (4631). Both flocks are closely aligned and hence these two flocks can be considered as one. Flock 4631 was used for estimating genetic merit as contributing majority of the rams.

Example of genetic merit

The following figures are visual examples of what the genetic merit of the ram teams used each year for Farmer 1. Figure 3 and 4 show the average genetic merit of the ram teams used each year (between 2010 and 2016) for the maternal and terminal production systems. The traits weaning weight (WWT) and carcass weight (CWT) were used for both maternal and terminal systems, and number of lambs born (NLB) and survival (SUR) for maternal system. Can clearly see a change in the maternal ram team genetic merit in 2013. This is the first year information on ram purchases were known for farmer 1. Prior to 2013, it was assumed rams were purchased from the top 30% 2tth rams from the stud flock.

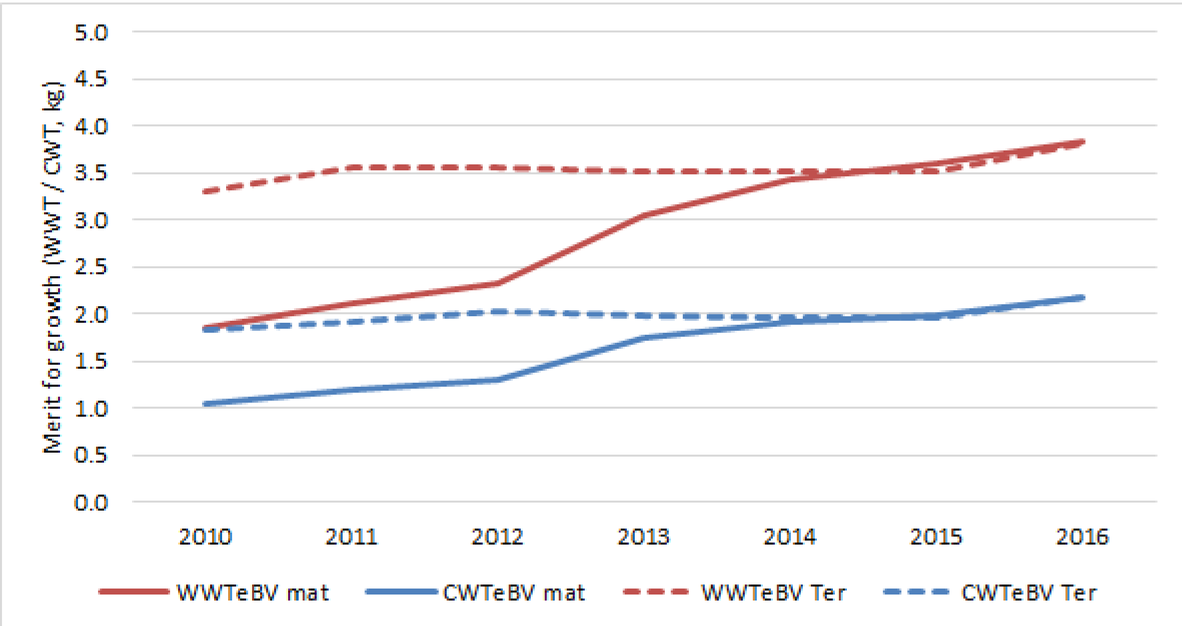

Figure 3. Average breeding value for weaning weight (red) and carcass weight (blue) for the maternal (solid lines) and terminal (dash lines) ram teams used each year at Farm 1 between 2010 and 2016. Note 2013 was first year individual rams used were known.

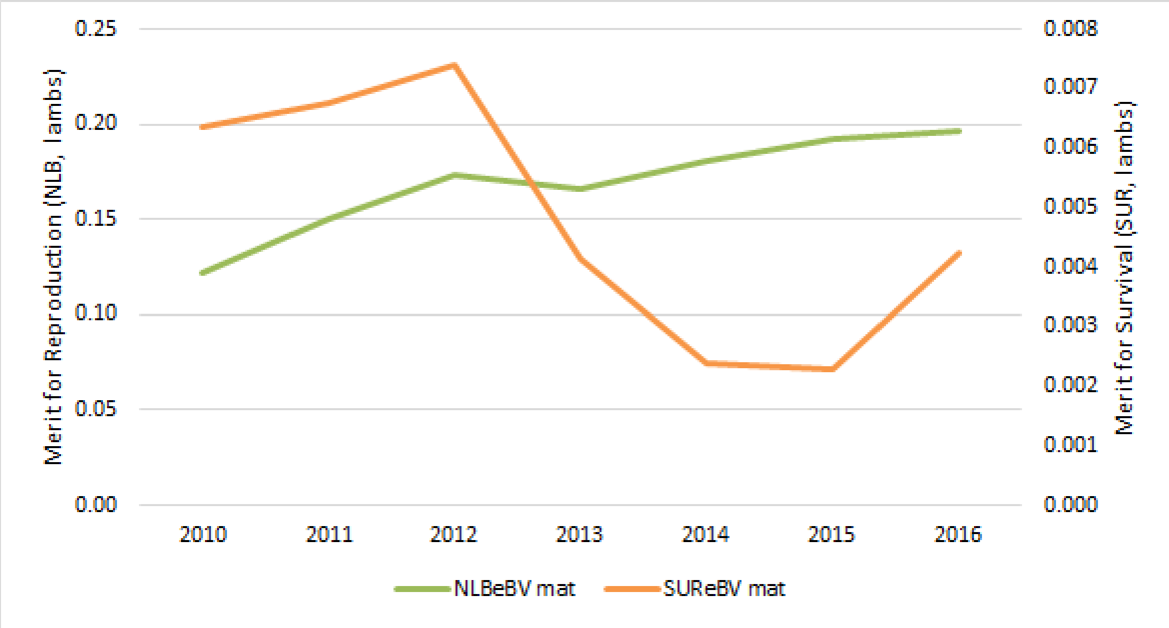

Figure 4. Average breeding value for number of lambs born (green) and survival (orange) for maternal ram teams used each year at Farm 1 between 2010 and 2016. Note 2013 was the first year individual rams used were known.

The estimated merit of the ewe flock and the lambs born each year consequently flowed through using the ram team information above. For example, figure 5 shows for Farmer 1, the average genetic merit of maternal rams mated, maternal ewes mated and maternal lambs born each year (between 2010 and 2016) for carcass weight. As expected the genetic merit of new lambs born each year is in-between the rams and ewes mated line. The ewes merit is modified each year by the portion of ewe replacements and the resulting age structure of the ewe population following deaths and culls.

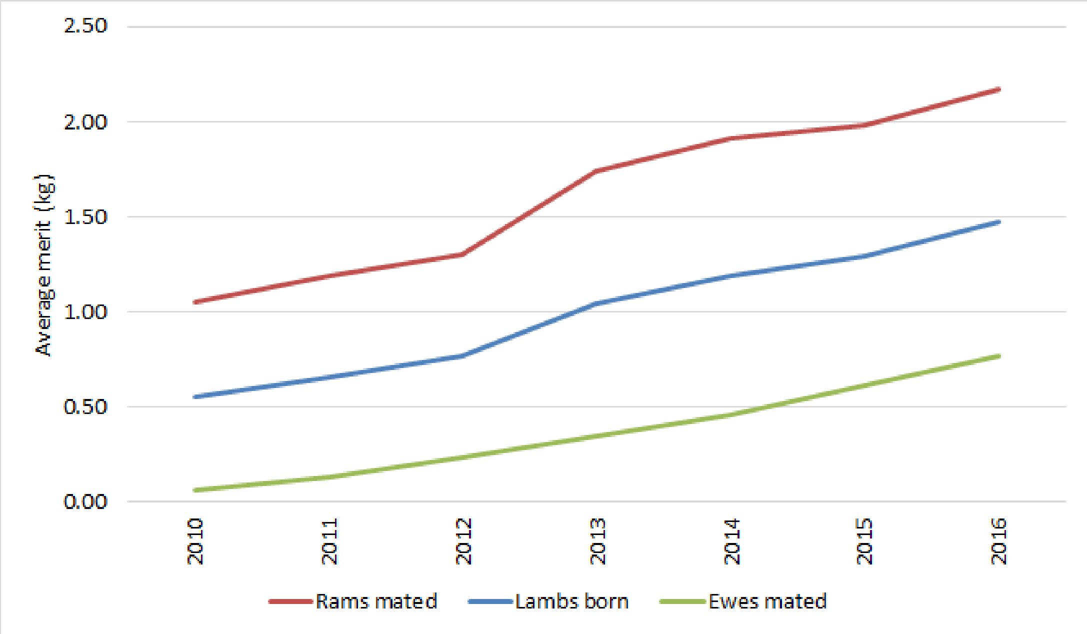

Figure 5. Average genetic merit of maternal rams mated (red), maternal ewes mated (green) and lambs born (blue) each year for carcass weight on Farm 1 between 2010 and 2016.

Outputs

Production data was supplied from the farmers' own worksheets and/or from their farm management databases.

- Data for Farm 1 is shown in appendix 3. The reproduction data was provided from the farmers worksheets. For the traits, tailing and pregnancy scanning, data was available for 2010 to 2016. The average weaning date and carcass date and weight was specified from the FarmIQ database, data was available for 2011 to 2015.
- Data for Farm 2 is shown in appendix 4. All information was provided by the farmer's own worksheets. Reproduction data for tailing and pregnancy scanning was available for 2010 to 2016. Weaning and carcass data was unavailable.
- Data for Farm 3 is shown in appendix 5. Information was provided by the farmer from Farmax. Data was available from 2011 to 2016. Hogget ewes were first mated in 2013.

Example outputs

The following are examples of some of the visual outputs produced by the model. Figure 6, shows the lambing performance of the 2tth and MA ewes compared to the ewe flock genetic merit of NLB for Farmer 2. For 2016, tailing results were unknown at time of data collection.

The average ewe flock merit (2tth and MA) for NLB has increased at a rate of 0.009 lambs/year. The actual performance has decreased, however, scanning % has been increasing at 0.004 %/year (equal to 0.004 lambs/year). Difference in direction of change between NLB and actual tailing was due to bad weather events during lambing for 2014 and 2015. Figure 7, shows the survival of lambs born to hogget ewes between pregnancy scanning and tailing compared to the average hogget ewe flock genetic merit for SUR for Farmer 2. For 2016, tailing results were unknown. The average ewe hogget flock merit for survival has increased at a rate of 0.0005 lambs/year. Actual survival has decreased at -0.0097 %/year (equal to 0.0097 lambs/year). Difference in direction of change between SUR and actual survival was due to bad weather events during lambing for 2014 and 2015 season.

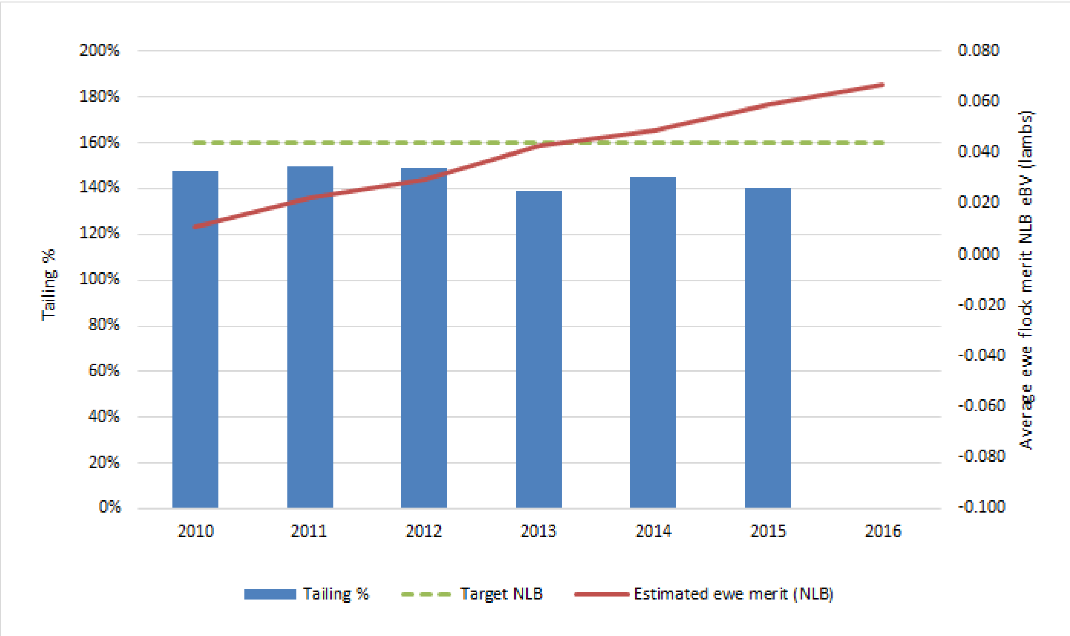

Figure 6. Comparison of number of lambs tailed per year (blue bars) against the average ewe flock merit for number of lambs born (red line) for the 2tth and MA ewes for Farm 2. The production target of 160% is plotted (green dash line).

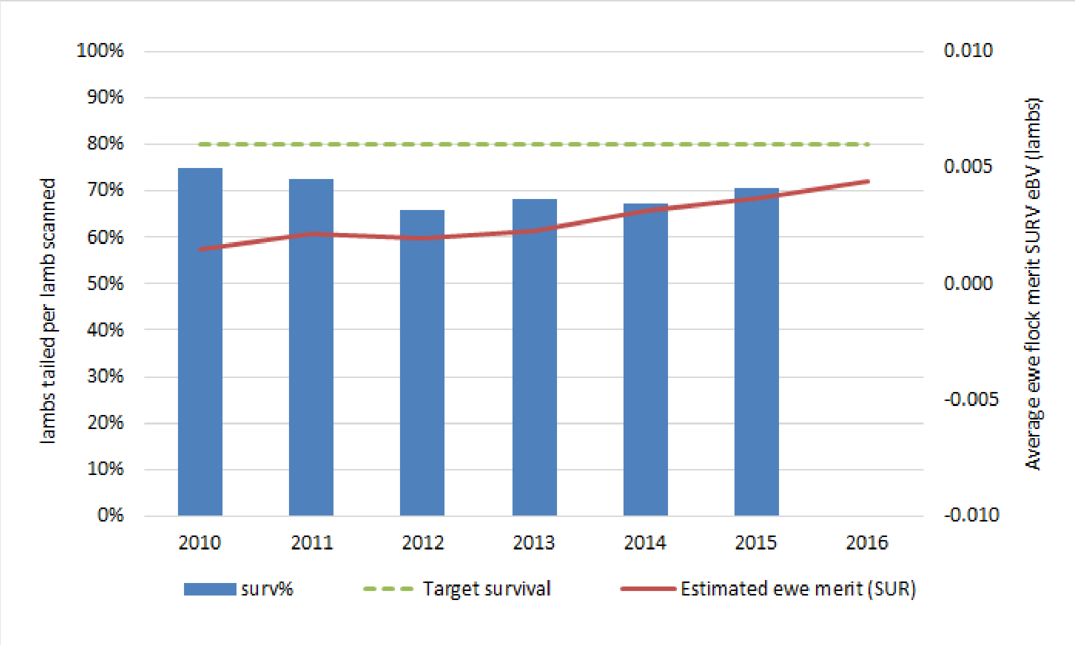

Figure 7. Comparison of survival per year (blue bars) against average hogget ewe flock merit for survival (red line) for the hogget ewes for Farm 2. The production target of 80% is plotted (green dash line).

Below are examples of growth production traits. Figure 8, shows the average daily growth rate for all lambs born each year between birth and weaning adjusted to 90 days for Farmer 3. This has been compared to the average lambs born genetic merit for weaning weight. The average genetic merit of lambs born has been increasing at 0.20 kg/year. Growth rate to weaning, adjusted to 90 days was increasing at 16 g/day/year. Average actual weaning weight adjusted to 90 days (not shown) has increased at 1.3 kg/year. A combination of realising genetic potential and lower stocking rates due to lower lambing performance from poor weather events during lambing generated the jump in performance for 2014 and 2015.

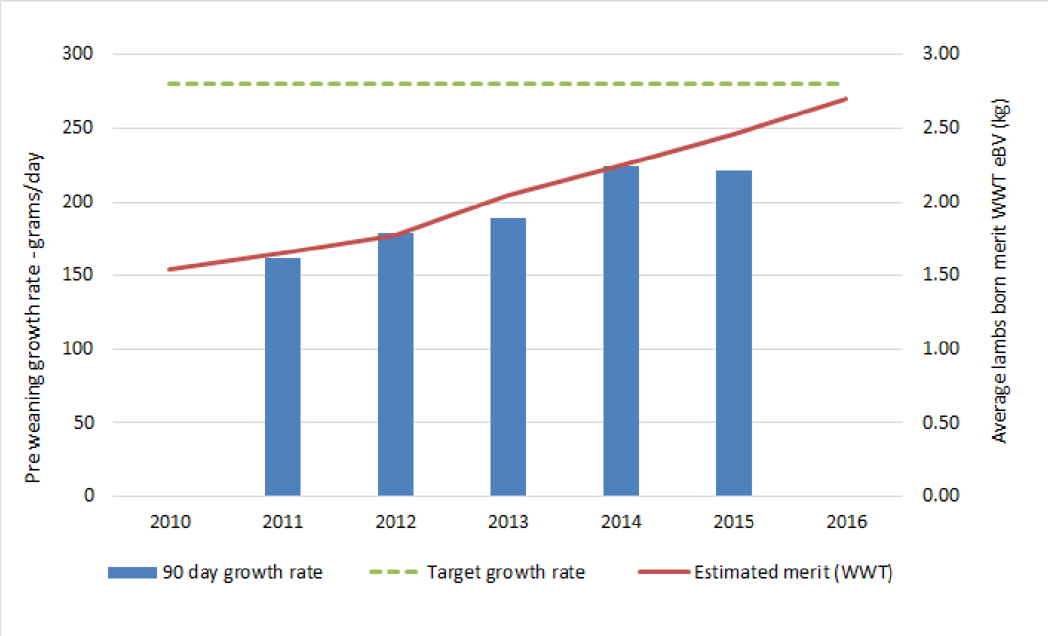

Figure 8. Comparison of growth rate to 90 days per year (blue bars) against average lamb born merit for weaning weight (red line) for Farm 3. The production target of 280 g/day is plotted (green dash line).

For growth rate post weaning to slaughter, there was a noticeable difference for Farmer 3. Average carcass weight has increased from 17.1 kg for 2011 born lambs to 19.5 kg for 2015 born lambs. While average age at slaughter has increased by approximately 30 days. Compared to figure 8 above, for the later years (2013 to 2015), the increase in growth rate to weaning has been offset by a slower growth rate post weaning to slaughter (figure 9). For the lambs the average genetic merit for carcass weight has increased at 0.12 kg/year. Despite the difference seen, farmer 3, was happy with these results, in the big picture scheme, based on both environmental events and consequently management response in the previous few years.

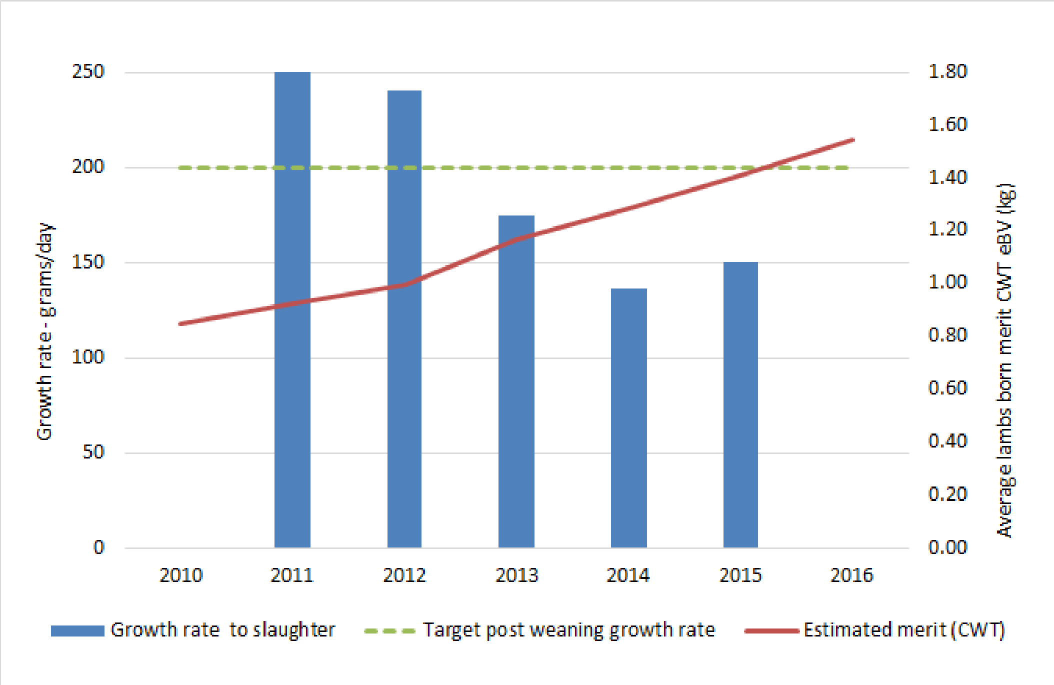

Figure 9. Comparison of growth rate from weaning to slaughter per year (blue bars) against average lamb born merit for carcass weight (red line) for Farm 3. The production target of 200 g/day is plotted (green dash line).

Feedback

The response by all farmers during the whole exercise (initial contact to presentation of results) was enthusiastic. All farmers had a good understanding of genetics, with farmer's 2 and 3 involved as a breeder for stud and/or multiplier flocks.

Inputs

All farmers found the initial set up as a huge task. Farmers 1 and 3 were using a farm management programme (FarmIQ and Farmax, respectively), however, had to revert back to spreadsheets especially for earlier (approx. pre 2014) data. One farmer mentioned that they thought they had good systems in place for data recording, but found as they were hunting for data that this was not the case. All farmers, liked that the exercise refreshed their views on how their flock was performing with actual production records.

All farmers had no knowledge of actual rams used each year. Information on potential ram teams had to be sourced from purchase invoices or from spreadsheets from the stud breeder on ram teams sent. None of the farmers provided hogget and ewe death and cull rates, all used the assumption provided.

This highlights the difficulty of obtaining accurate data, even with sophisticated farm management systems. One farmer was sceptical of the weaning and carcass data obtained from the FarmIQ database, a third party had helped with extraction of this data. There was the potential that if the farmer himself had extracted the data this may have allowed for inaccuracies to be fixed. This emphasis the risk that direct importation from farm management systems into the model with no checking, could introduce more errors. This risk needs to be calculated and allowed for.

All farmers understood the implications of assumptions made on ram teams and consequently the estimated genetic merit of ram teams, ewe flock and lambs born each year. However, there was no indication from the farmers that they would in future start recording the rams used each year. Once the model is set up, a check could be put in place each year for farmers to input new ram purchases and to check which rams were still retained from the previous year. This may decrease some of the inaccuracies.

Outputs

After the visit with farmer 1, the survival production graphs were added in. All farmers were happy with the production statistics graphed. The use of graphs was commended as an easier way for them to understand the genetic merit, especially of ram teams, rather than the actual BVs often presented at sale time in a table. The scaling of graphs was confusing, in some graphs the red line depicting the average genetic merit of lambs or ewes was below the production bars. This gave an impression that the farmer was performing better than the genetic potential. Once explained that scales were not aligned these incorrect assumptions were discarded. Describing the graph in rate of change over time, helped, especially for reproduction and survival traits as this showed actual performance was in line with genetic potential in most cases.

For the growth traits, comparison of weaning weight genetic merit with growth rate to weaning was acceptable, as both are relative to a 90 day weight. There was difficulty in deciphering the graphs on growth rates from birth or weaning to slaughter. On first instance, it was expected with an increasing genetic merit for CWT there would be a correlated rise in growth rates to slaughter. This was not the case for farmer 1 or 3 (farmer 2 did not provide weaning or carcass information), where growth rates were stagnant or decreased. Though both weight and age at slaughter is taken into account, factors concerning management decisions to fit price schedules/contracts and pasture growth curves can influence post weaning growth. Looking at these growth graphs together plus taking into account actual performance, management decisions and reproduction statistics helped form a complete picture that the farmer could understand.

Final thoughts

All farmers agreed that the model and results need to be presented for the first time by a qualified consultant/person. The consultant was required to explain the inputs required, the model and its assumptions and the outcomes. Generalisations and ideas were made by all farmers, which the consultant could explain/fix quickly before any decisions are made.

All farmers ended the session with an action plan for improving the genetic potential of their flocks. Farmer 1 and 2 identified individual BVs and which direction (positive or negative) they wished to push these, they were to approach their breeder with these requests. Farmer 3, identified potential changes needed in the terminal multiplier programme in order to achieve better rams for use in the commercial flock. Finally, all farmers wished to repeat the exercise the following year.

Other recommendations suggested were; separation of the maternal and terminal production systems to see how they perform on their own; a fleece weight genetic merit graph, though no actual weights are measured on farm; and a graph of the overall index value (relevant SIL industry index) of the ewe flock versus industry average. This last recommendation was a result of farmer 1 and 2 selling ewe hoggets not retained to other farms as replacements. The graph would help as a point of differentiation when selling.

Implementation

To implement this model for use to the industry three key issues need to be addressed; format, ease of use and delivery. The model was initially set up in an excel spreadsheet which was appropriate for the initial testing. The model should be developed as a standalone programme or online application. As graphs are key to the outputs, use of an application on a cell phone would be limiting for visuals, on a tablet or computer this would be less of an issue.

Key components of the genetic plan include importation of data. Linkage with farm management software via RMPP DataLinker would allow input of weaning, slaughter and potentially ram team/purchase information. Checks are required, to ensure the correct information is downloaded.

Thought is required about inputting of historical data. The use of the “cloud” has been developed recently for most farm management software, however, historical data has not necessarily been converted to this storage base. All farmers found the task of retrieving data time consuming, searching through files for several hours over multiple nights. This could be a limiting factor in the uptake of the new application.

Once historical data is in, year on year input of new ram teams, mating information and production statistics can be done easily through linkage with farm management software and/or flow of simple set up screens. Updated breeding values for rams used can be automatically downloaded through a link to SIL. A customised dashboard to select preferred report outputs and a “help” section will allow users to view and interpret results.

All farmers suggested that the programme should be delivered with a consultant for the first year. This is to ensure that inputs and interpretation of the results are correct. In subsequent years farmers could update the model through the application themselves, or chose to set the process as a yearly task to perform with the consultant. Continued use may need to be prompted by Beef + Lamb NZ, a farm management programme or consultant. This would ensure its use, but also provide reminders on how to use and interpret results.

The genetic plan model aligns well with the aims of the RMPP, especially development of benchmarking models and linking of industry partners for flow of information. It is suggested that RMPP is approached to help develop the next stage of this model into a usable application.

Limitations

There are a few limitations to both this study and the model that were not addressed during this project. During the testing of the model one factor that was not assessed was the impact of buying in or selling of pregnant ewe’s pre lambing. None of the three farmers used this practice in their farming enterprise. Buying or selling of pregnant ewes would affect the genetic merit of the ewe flock and lambs born and the production statistics of each farm. The genetic merit of bought in ewes is dependent on the structure and what rams are used by the seller. Both selling and buying in of ewes would influencing the reproduction and weaning/slaughter performance of the farm.

From the beginning it was known the model would require refinement before being developed into a software programme. There were limitations in what could be achieved in an excel spreadsheet. The following were identified as refinements/issues to consider;

- Ability to select rams from multiple flocks per breed type. Farmer 1 bought rams from two different terminal flocks. Farmer 3 bought rams from two different maternal flocks. In both cases the two flocks involved were from similar backgrounds, belonging to the same breeding company, plus had been breed under the same breeding objective. This allowed the use of one flock as the representative.
- Ability to separate out maternal and terminal systems. One farmer suggested this refinement to allow them to compare the two systems. At the production level the ability to do this comparison is available in FarmIQ. The benefit to add this comparison to the genetic plan would be to see how the production of terminal lambs compares to the estimate of terminal ram team and lamb genetic merit.
- Assumes ratio of ewes mated to terminal versus maternal rams is same over time. Production systems change over time, the portion of ewes mated to a terminal sire can depend on introduction of terminal ram usage and number of replacement ewe hoggets needed often based on lambing percent. The higher than lambing percent the more ewes can be mated terminally. One refinement already acknowledge is the ability to individualise each years mating – ewe flock structure, mating ratio etc.
- Linkage with farm management software and double checking of data input. As discussed above, farmer 1 was sceptical of data pulled from FarmIQ database. Data coming out of any farm management software will depend on how data was entered. Therefore checks will be needed.
- Risk of inaccurate data, production or ram team on resulting outputs and hence take home messages. It is crucial that the first time user is happy with their experience and interprets the results accurately. Help pages and use of consultants should be utilise appropriately to combat this.
- Forecasting future genetic merit of the flock based on current sire selection and mating decisions. Also the ability to compare current situation with other sire selection criteria or mating scenarios would provide benefit to decisions around sire team selections. Alternative scenarios could include, changing ram breeder, prioritising certain trait BVs, changing ewe lamb replacement rate and changing portion of ewes mated to a terminal sire.

6. Conclusions and Recommendations

Here, a model for estimating the genetic merit of a commercial enterprise was described and tested with three commercial farmers. The aims being to increase their understanding of and utilisation of BVs and to benchmark key production indicators against the genetic potential of the ram team, ewe flock and lambs born. All three farmers enjoyed and benefited from the exercise, with a willingness to perform the exercise again the next year. Results from the exercise were all three farmers had formulated a better understanding of the genetic potential in their flock and had plans on what rams they would like to use next year. The following recommendations arose from the completion of the exercise.

- Use of rate of genetic gain compared against rate of production improvement as an indicator of utilisation of the genetic potential available.
- Thought needs to be taken around explaining the comparison of CWT BV to growth rate to slaughter. Alternatively, is there another appropriate measure that could be used?
- A final page with a list of action points for the farmer to take to their breeder or to add to the farm management plan.
- Implementation – initially needs to be via a consultant or qualified person, to prevent incorrect interpretations being made. Also useful if consultant has access/knowledge of farm enterprise to help with model set up.

To increase productivity in a farming enterprise and hence the New Zealand industry, one of the tools available for use is the genetic merit of the ram team. It is known that sires can influence up to 80% of the genetic merit in a flock. They also have a huge impact in that the ewe lambs born from one years' ram team will be present and contributing to the flock for up to six or seven lambings. Farmers benchmark a number of production and financial key indicators, and often base farm management system/practice changes on these. This genetic model could become another key tool in the farm management tool box to help farmers improve their production systems.

The next steps of this project are; firstly, present the results and recommendations to Beef + Lamb Genetics and AbacusBio. Secondly, approach the RMPP to collaborate on the further development and implementation of the model into a working programme or application. Thirdly, the final format should be tested on the three farmers involved in this study and on some new farmers with various farming enterprises. Finally, the model should be modified and extended to the deer and beef cattle industries.

7. Acknowledgments

I wish to acknowledge Beef + Lamb Genetics and Jude Sise from AbacusBio who developed the initial model, and allowed me to test the model for this project.

Thanks also to Matt Wyeth, Grant Massie and Shane Tilson for taking part in testing the model and providing feedback.

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9. Glossary

Breeding Value (BV) – breeding values are the best estimate of the animal's genetic merit for a trait. They allow animals to be compared, without bias from environmental effects e.g. feed, flock, birth year, sex, birth rank. Breeding values are expressed in the units the trait is measured in, weight traits are in kilograms and survival trait is in number of lambs.

Cohort – animals born at the same time and similarly reared and treated

Dual Purpose/Maternal – a system where ewe lambs are retained as replacements for breeding.

Four tooth (4tth) – a sheep with first 4 permanent teeth, approximately between 2.5 to 3.5 years of age.

Genetics – the study of heritability, how characteristics of one generation are transmitted to the next.

Genomics – area within genetics that concerns the sequencing and analysis of the genome.

Hogget – a sheep approximately 8 to 18 months of age.

Homebred rams – Rams breed on commercial flock by using a stud or multiplier ram over the ewe flock (or a selected group of ewes within the flock) and male progeny kept based on physical characteristics. No performance or pedigree recording performed.

Index – a single figure that is arrived at by applying economic weightings to selected BVs and summing. An index provides a summary of overall economic breeding merit of an animal.

Mixed aged (MA) – any sheep 3 years and older.

Multiplier flock – Multiply the genetic material of the stud flock to pass on to the commercial farmer.

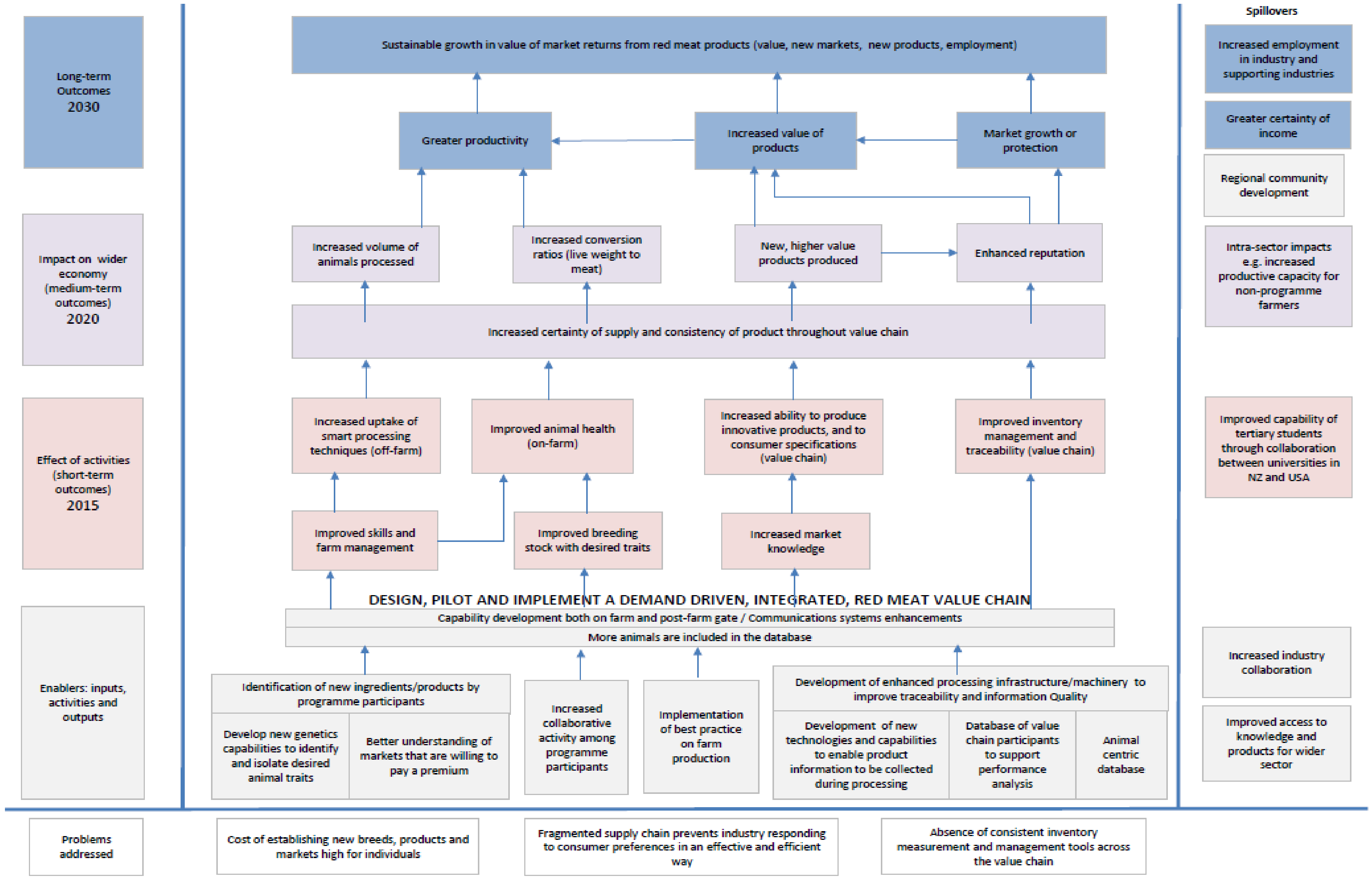
Stud flock – a group of animals specifically kept for selective breeding and genetic improvement. Animals are performance recorded and selected based on a breeding objective. The genetic superiority of these animals are dispersed down to the commercial sector (sometimes via a Multiplier flock) via sale of males.

Terminal – a system where all progeny are slaughtered.

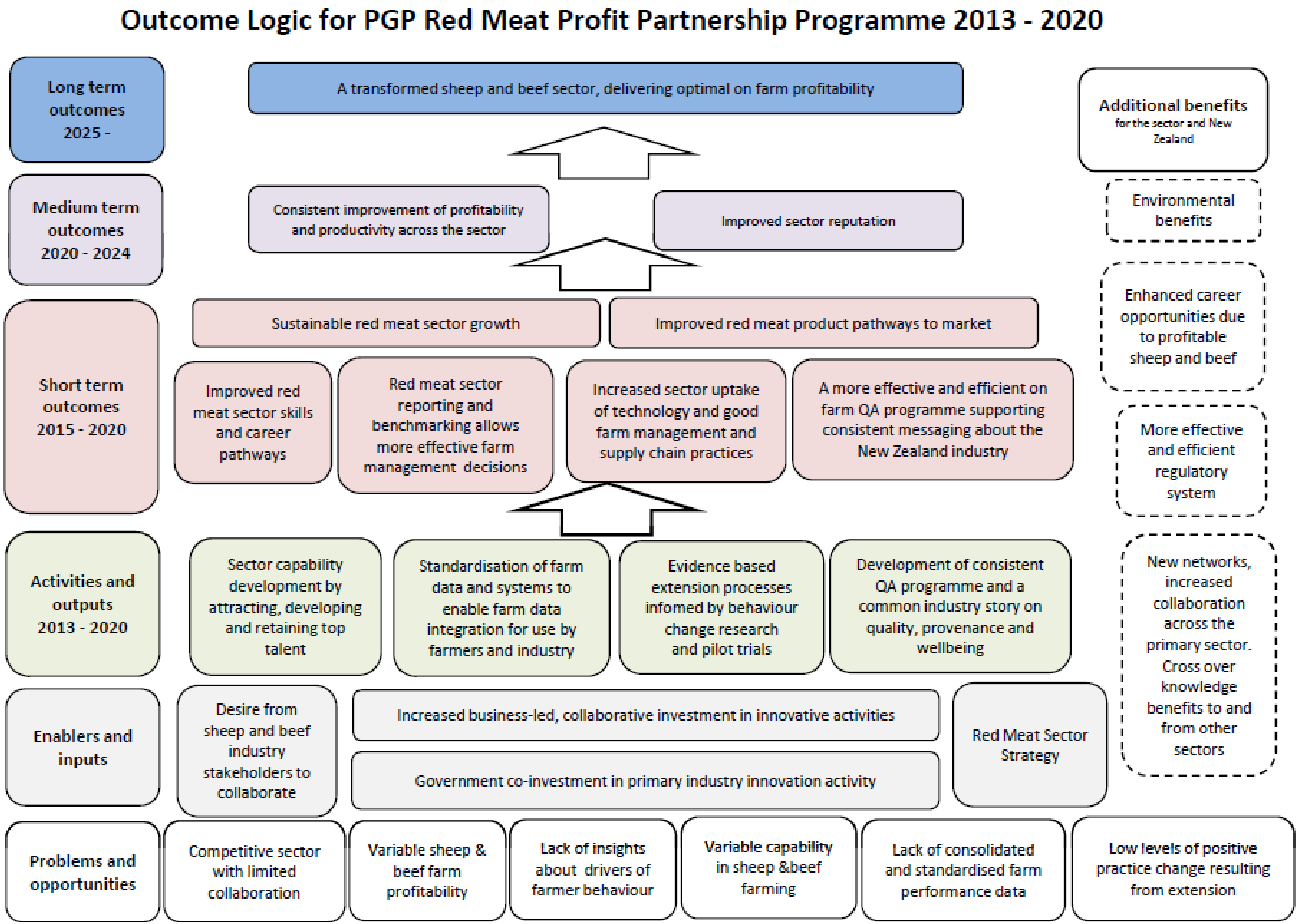
Two tooth (2tth) – a sheep with first 2 permanent teeth, between 18 and 30 months of age.

10. Appendices

Appendix 1: FarmIQ Outcome Logic Model. Reproduced from FarmIQ, 2013 (http://www.mpi.govt.nz/funding-and-programmes/primary-growth-partnership/primary-growth-partnership-programmes/farmiq/). Accessed 28th July 2016.



Appendix 2: Red Meat Profit Partnership Outcome Logic Model, Reproduced from RMPP, 2014 (http://www.mpi.govt.nz/funding-and-programmes/primary-growth-partnership/primary-growth-partnership-programmes/red-meat-profit-partnership/)



Appendix 3. Production data for Farm 1. Data shaded in blue or grey, supplied by the farmer. Data unshaded is calculated as outlined in methods. As of data collection, tailing was not completed for 2016 production season.

	Production Year						
Production Statistic	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
n mixed age ewes mated	7000	7,000	7,000	7,000	7,000	7,000	7233
date rams out	27/04/2010	27/04/2011	27/04/2012	27/04/2013	27/04/2014	27/04/2015	27/04/2016
Scanning	193%	194%	206%	204%	205%	213%	207%
n foetuses	13510	13580	14420	14280	14350	14910	14972.31
n tailed	9590	10,710	11,480	10,780	10,920	10850	
Tailing %	137%	153%	164%	154%	156%	155%	
Target NLB	160%	160%	160%	160%	160%	160%	160%
surv%	71%	79%	80%	75%	76%	73%	
Target survival	90%	90%	90%	90%	90%	90%	90%
average birth date		30/09/2011	30/09/2012	30/09/2013	30/09/2014	30/09/2015	30/09/2016
n tailed		10710	11480	10780	10920	10850	11399
n slaughtered pre weaning							
% present at weaning		*100%*	*100%*	*100%*	*100%*	*100%*	*100%*
Weaning date				15/12/2013	16/12/2014	02/12/2015	
Average weaning weight				28.9	28.4	26.3	
age at weaning				76.0	77.0	63.0	
i		*0.003429*	*0.003429*	*0.003429*	*0.003429*	*0.003429*	*0.003429*
Adjusted wwt		*0.01*	*0.01*	*28.91*	*28.41*	*26.31*	*0.01*
growth rate to weaning				*321.21*	*310.55*	*346.22*	
90 day growth rate				*380*	*363*	*495*	
Target growth rate	311	311	311	311	311	311	311
Average carcase weight	18.9	20.5	18	18.8	17.8	18.6	

Average kill date	25/03/2011	26/03/2012	06/03/2013	04/03/2014	06/03/2015	04/03/2016	
average age at slaughter		*178*	*157*	*155*	*157*	*156*	
Growth rate to slaughter		*242.6*	*238.0*	*253.0*	*235.0*	*248.4*	
Target growth rate (birth to slaughter)	270	270	270	270	270	270	270
days weaning to slaughter				79	80	93	
average growth rate (weaning to slaughter)				187	162	182	
Target post weaning growth rate	150	150	150	150	150	150	150

Appendix 4. Production data for Farm 2. Data shaded in blue, supplied by the farmer. Data unshaded is calculated as outlined in methods. As of data collection, tailing was not completed for 2016 production season. Data was not available for weaning and carcass weights.

	Production Year						
Production Statistic	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
n mixed age ewes mated	1531	1,721	2,152	2,316	2,147	2,209	2,034
date rams out	05/04/2010	05/04/2011	05/04/2012	05/04/2013	05/04/2014	05/04/2013	15/04/2016
n mixed age purchased pregnant							
n mixed age sold pregnant							
Scanning	185%	188%	180%	186%	187%	186%	188%
n foetuses	2832	3235	3873	4307	4014	4130	3945
n tailed	2265	2,581	3,206	3,219	3,113	3,092	
Tailing %	148%	150%	149%	139%	145%	140%	
Target NLB	160%	160%	160%	160%	160%	160%	160%
surv%	80%	80%	83%	75%	78%	75%	
Target survival	80%	80%	80%	80%	80%	80%	80%
n hogget ewes mated	1904	2002	1884	1945	2363	2357	1964
date rams out	05/05/2010	05/05/2011	05/05/2012	05/05/2013	05/05/2014	05/05/2015	05/05/2016
Scanning	115%	120%	129%	126%	128%	123%	129%
n foetuses	2189	2402	2430	2450	3024	2899	2533
n tailed	1637	1741	1601	1672	2032	2050	
Tailing %	86%	87%	85%	86%	86%	87%	
Target NLB	90%	90%	90%	90%	90%	90%	100%
surv%	75%	72%	66%	68%	67%	71%	
Target survival	80%	80%	80%	80%	80%	80%	80%

Appendix 5. Production data for Farm 3. Data shaded in blue, supplied by the farmer. Data unshaded is calculated as outlined in methods. As of data collection, tailing was not completed for 2016 production season.

	Production Year						
Production Statistic	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
n mixed age ewes mated	6962	6,879	6,952	6,832	6,470	5,592	5684
date rams out	25/03/2010	25/03/2011	01/04/2012	01/04/2013	01/04/2014	01/04/2015	06/04/2015
n mixed age purchased pregnant							
n mixed age sold pregnant							
Scanning		179%	175%	176%	182%	191%	198%
n foetuses		12345	12197	12024	11775	10680	11254
n tailed		9,903	8,640	9,222	8,343	6920	
Tailing %		144%	124%	135%	129%	124%	
Target NLB							
surv%		80%	71%	77%	71%	65%	
Target survival							
n hogget ewes mated				375	660	1159	1049
date rams out				20/04/2013	20/04/2014	20/04/2015	20/04/2016
Scanning				123%	131%	142%	136%
n foetuses				461	864	1645	1426
n tailed				337	693	850	
Tailing %				90%	105%	73%	0%
Target NLB							
surv%				73%	80%	52%	0%
Target survival							
average birth date		28/08/2011	04/09/2012	04/09/2013	05/09/2014	06/09/2015	
n tailed		9903	8640	9559	9036	7770	

n slaughtered pre weaning	0	0	0	0	0
% present at weaning	*100%*	*100%*	*100%*	*100%*	*100%*
Weaning date	18/12/2011	20/12/2012	18/12/2013	16/12/2014	21/12/2015
Average weaning weight	27.0	27.2	27.4	30.2	32.0
age at weaning	112.0	107.0	104.3	101.5	105.9
i	*0.003429*	*0.003429*	*0.003429*	*0.003429*	*0.003429*
Adjusted wwt	*27.01*	*27.21*	*27.41*	*30.21*	*32.01*
growth rate to weaning	*201.00*	*212.26*	*219.61*	*253.21*	*259.74*
90 day growth rate	*162*	*179*	*189*	*224*	*221*
Target growth rate					
Average carcase weight	17.1	17.9	18.2	18.8	19.5
Average kill date	05/02/2012	18/02/2013	13/03/2014	25/03/2015	19/03/2016
average age at slaughter	*161*	*167*	*189*	*201*	*195*
Growth rate to slaughter	*219.1*	*222.3*	*199.8*	*195.6*	*209.6*
Target growth rate (birth to slaughter)					
days weaning to slaughter	49.0	60.0	85.0	99	89
average growth rate (weaning to slaughter)	260	240	175	136	150
Target post weaning growth rate					