Final report

Investigating Flock Rebuild Strategies

Project code: **L.LSM.0032**

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Abstract

While the future export demand for Australian sheep meat is bright, there remains a significant missed opportunity at both the enterprise and industry level to supply more premium sheepmeat products to our customers, benefiting the whole supply chain. The decline in the national sheep flock needs to be reversed to capture this opportunity. A key element to this will be equipping sheep producers with the skills, confidence and ability to implement timely and beneficial flock rebuilding through employing strategies that are economically viable.

This project has focussed on providing sheep producers with the confidence and material on optimal pathway(s) to flock rebuilding. In particular, a range of differing strategies available (or potentially available) to sheep producers for rebuilding flock numbers are compared in terms of their projected flock growth capacity and financial impacts on the business over a period of 5 years. The effect of differing production zones, enterprise types and flock age profiles are also investigated, along with intangible barriers to flocks rebuilding.

Flock rebuilding strategies assessed as highly profitable and can also help rebuild numbers quickly mainly involve utilising more home-bred ewes or purchasing more ewes. Strategies on improving fertility and lamb survival, although profitable, do not have the same immediate flock rebuilding capacity. Purchasing young ewes in particular is a profitable strategy to rapidly rebuild stock numbers. Concerns regarding biosecurity risk and uncertainty of the merit of outside genetics when purchasing ewes are discussed in this report and weighed against other flock rebuilding options.

Some flock building strategies that increase reproductive potential (boosting ovulation rate and litter size), can be profitable. However, before these strategies are considered, recommendations on ewe condition score at joining, nutrition during joining and late pregnancy, ewe condition score pre-lambing, and lamb survival need to be met first.

Executive summary

Background

While the future export demand for Australian sheep meat is bright, there remains a significant missed opportunity at both the enterprise and industry level to supply more premium sheepmeat products to our customers, benefiting the whole supply chain. The decline in the national sheep flock needs to be reversed to capture this opportunity.

This project has focussed on providing Australian sheep producers in all regions and production segments with the confidence and material on optimal pathway(s) to flock rebuilding. In particular, a range of differing strategies available (or potentially available) to sheep producers for rebuilding flock numbers are compared in terms of their projected flock growth capacity and financial impacts on the business over a period of 5 years. The effect of differing production zones, enterprise types and flock age profiles are also investigated, along with intangible barriers to flocks rebuilding.

Objectives

These have been to:

- Develop flock rebuild scenarios that track inventory, cashflow, profit and loss and the overall balance sheet over a multi-year projection.
- Model the impact on strategies on exposure to variation in supplementary feed costs, purchase of stock and price received for sale animals and flock structure
- Model variation in benefit and costs for a range of production zones (pastoral, mixed farming, high rainfall), enterprise types and flock age profiles, real and simulated case studies
- Identify and report intangible barriers to flock rebuilding including

Methodology

These were to:

- Review in literature and audit results from the accelerated lambing trial conducted at Turretfield Research Centre by UofA components of reproduction opportunity (e.g. best practice twin lamb survival) and wastage (e.g. ewe loss at various ages)
- Model rebuild scenarios in detail (initial focus is dual purpose Merino, then a Maternal flock)
- Test sensitivity to supplementary feed costs, stock prices and different flock structure
- Extend the scenarios to multiple enterprise and flock types
- Extend the scenarios to cover high rainfall, mixed farming and pastoral conditions nationally
- Report the general and production system specific opportunities and challenges
- Review overall messages with an experienced consultant and leading producers from multiple production systems and zones

Results/key findings

Flock rebuilding strategies assessed as highly profitable and can also help rebuild numbers quickly mainly involve utilising more home-bred ewes or purchasing more ewes. Strategies on improving fertility and lamb survival, although profitable, do not have the same immediate flock rebuilding capacity. Purchasing young ewes in particular is a profitable strategy to rapidly rebuild stock numbers.

Some flock building strategies that increase reproductive potential (boosting ovulation rate and litter size), can be profitable. However, before these strategies are considered, recommendations on ewe condition score at joining, nutrition during joining and late pregnancy, ewe condition score pre-lambing, and lamb survival need to be met first.

Benefits to industry

Recommendations as a result of the findings of this project are as follows:

a. Flock rebuilding strategies involved retention of older ewes and purchasing in additional ewes are, in general, more profitable and allow more rapid rebuilding than any other methods investigated. These are the primary methods of flock rebuilding to promote to the red meat industry.
b. Joining of ewe lambs, although requiring more managerial input, monitoring and skill level to implement than retaining older ewes and purchasing additional ewes, has the capacity to have good profitability and also rapidly rebuild flock numbers.
c. The re-joining of once dry ewes within the same breeding season (assessed as dry at pregnancy scanning), is a profitable flocking rebuilding method across all flock types assessed and should be more actively promoted to industry. However, its impact on rebuilding flock numbers is modest relative to retaining older ewes, purchasing more ewes or joining ewe lambs.

Future research and recommendations

- Up-to-date benchmarks of reproductive performance across the key sheep regions, for the key breed/genotypes. This includes fertility, fecundity, and lamb survival rates by litter size
- Reproductive performance data from experimental flocks where once-dry ewes (assessed at scanning) are re-joined with the same breeding season and compared with the performance of ewes that were pregnant at first scan
- Detailed guidelines on optimal nutrition for non-Merino and Merino cross enterprises need to be made available. This is vital for sheep producers contemplating the use of strategies that increase little size

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1. Background

1.1 Need for flock rebuilding

1.1.1 Sheep numbers and market outlook

The Australian sheep industry has undergone profound change since 1990, with total sheep numbers shorn declining by 63% from a peak of 170 million a year just before the reserve wool price scheme finished in early 1991, to a low of 63.7 million in June 2020 (Figure 1). Wool production also declined over the same period, by a similar proportion.

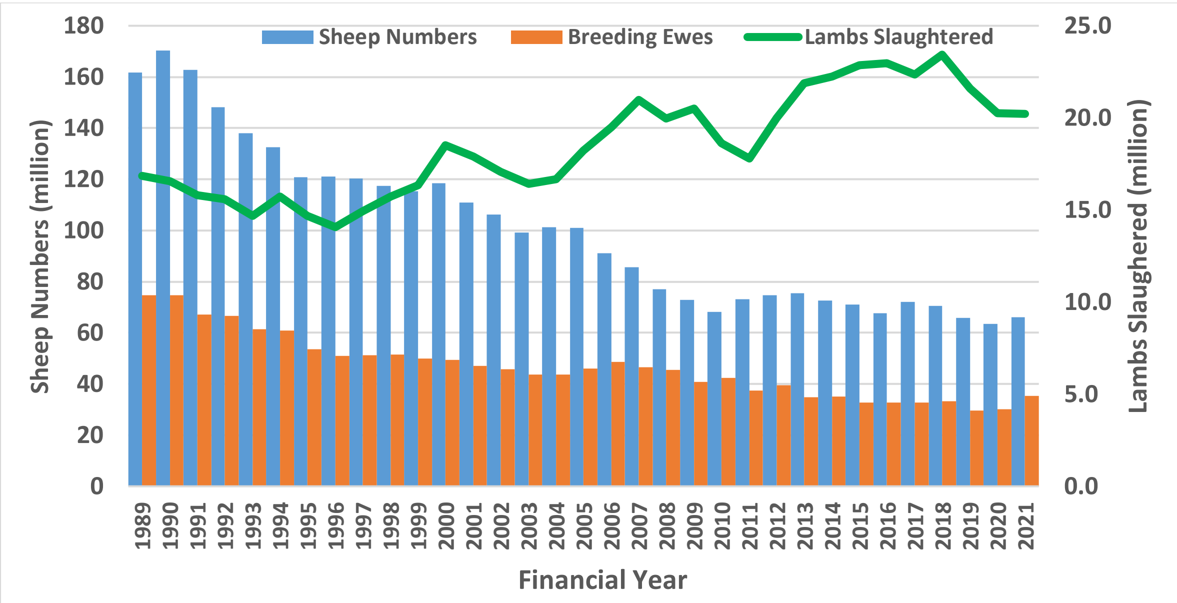

Fig. 1. Australian sheep population and lambs slaughtered from 1989 to 2021. (Australian Bureau of Statistics, 2021a, 2021b, MLA, 2021)

Lamb and mutton prices have increased markedly, especially in the last decade (Figure 2). Mutton prices in particular have increased relative to wool prices, even accounting for very high wool prices from 2017 to early 2020 (Figure 3).

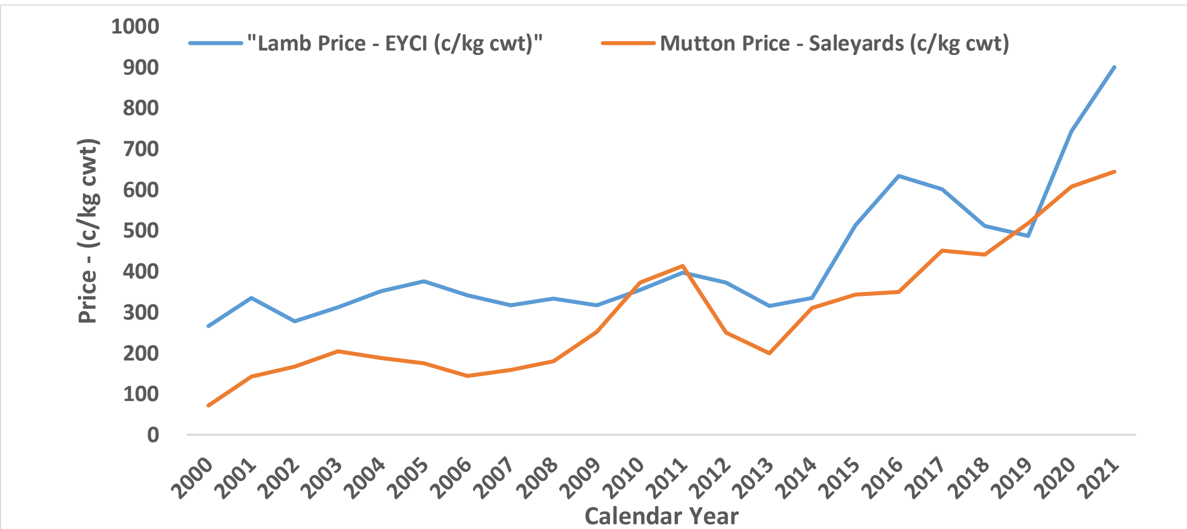

Fig. 2. Prices of lamb and mutton in Australia from 2000 to 2021. *Source: MLA's Market Information Statistics Database*

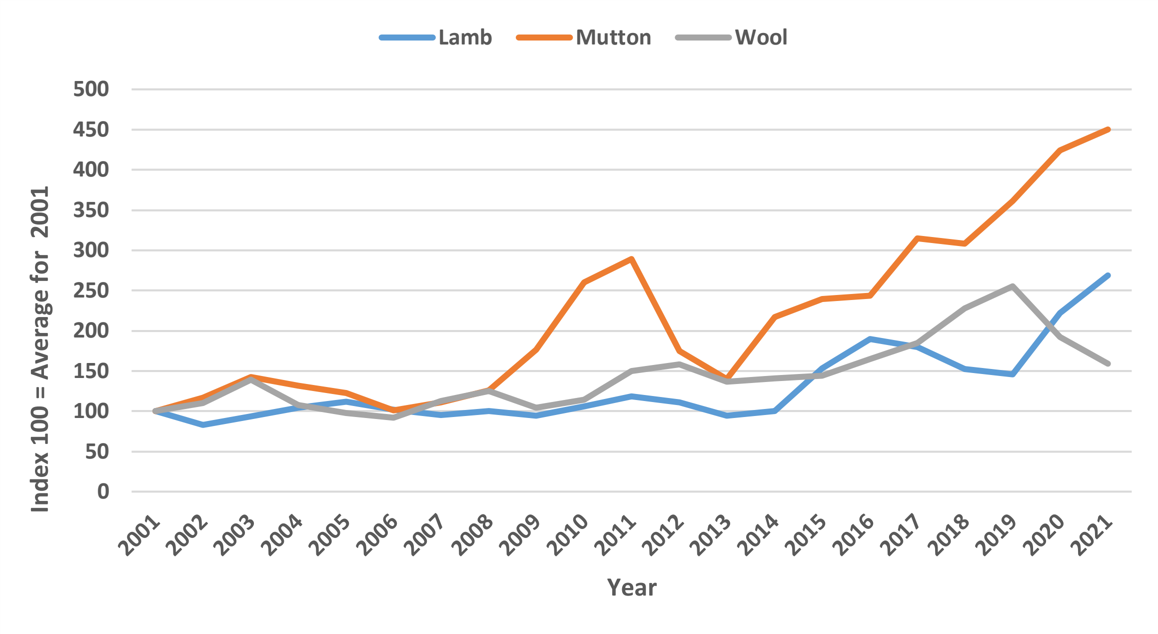

Fig. 3. Relative nominal prices of Mutton, Lamb and Wool, 2001 to 2021. *Sources: MLA's Market Information Statistics Database; Australian Wool Exchange*

Industry has responded via large changes in flock structure, with less wethers retained in most wool-oriented flocks beyond yearling stage. The proportion of ewes in the national flock (excluding lambs under 1 year) has increased from 55% in 1989-90 to 80% by 2007-08 (ABARE 2009) and remained high since (Figure 1). Despite the falls in breeding ewe numbers from a peak of 74.8 million in 1992 to a low of 35.7 million in 2020, Australia has increased and maintained the lamb slaughter numbers to over 20 million a year over the last decade (Figure 1).

Against this background of high prices and strong demand for sheep meat, Australian farmers have had to cope with a number of consecutive drought years, particularly in Eastern Australia from 2017 to 2020, with the historic low in sheep numbers in June 2020 influenced by many properties reducing stock numbers well below normal carrying capacity. Fortunately, with better seasonal conditions prevailing across most of Australia for the last year, there are clear signs of a national flock rebuild being underway.

The latest MLA & AWI wool and sheepmeat survey results for June 2021 indicate that of the 41,661,294 breeding ewes on hand in Australia (up from 35.5 million in June 2020), 74% are Merinos and 26% non-Merinos. (Note that of all breeding ewes on hand (1 year and older), on average, only 85% are mated). Of the Merino ewes to be mated, 70% are intended to be mated to Merino rams for wool production and 30% mated to non-Merino sires to produce meat lambs. Whilst the statistics indicate that Merinos still underpin the national flock, at current lambing percentages, the number of replacement Merino ewes being bred appears only sufficient to maintain the Merino population. This suggests that flock rebuilding is likely to mainly come from retention of older ewes and reduced culling of young ewe replacements. This is consistent with the MLA & AWI survey results cited above. With higher lambing percentages, self-replacing non-Merino flocks have the potential to more rapidly expand their flocks, but represent a much smaller proportion (a quarter) of the total national ewe flock than Merinos. For the next 5 years or more, it is thus inevitable that flock rebuilding will need to still rely heavily on an uplift in Merino and Merino-cross ewe numbers.

1.1.2 Demand for Sheep Meat and Supply

Export demand in particular for Australian lamb and mutton has been very strong over the last decade. This strong export demand for sheep meat and red meat in general is likely to continue for the foreseeable future (MLA, ABAREs Outlook 2021). In particular, the large negative impact of African Swine Fever on pork production in China and consequent high levels of meat imports to fill the deficit in domestic Chinese production is set to continue for some years to come. This in particular is causing shortages in global beef supply, which is likely to support higher beef and lamb prices in 2021 (Quilty, Global Agritrends 2021).

While the future export demand for Australian sheep meat is bright, there remains a significant missed opportunity at both the enterprise and industry level to supply more premium sheepmeat products to our customers, benefiting the whole supply chain. The decline in the national sheep flock needs to be arrested and reversed to capture this opportunity.

1.1.3 Achieving Flock Rebuilding

A key element to capturing the opportunity to supply more premium sheepmeat products to customers will be equipping sheep producers with the necessary skills, confidence and ability to implement timely and beneficial flock rebuilding through employing strategies that have been evaluated to be economically viable.

This project focuses primarily on providing the confidence and material on optimal pathway(s) and consideration for flock rebuilding to sheep producers. In particular, as a basis for recommendations, a range of differing strategies available (or potentially available) to sheep producers for rebuilding flock numbers are compared in terms of their projected flock growth capacity and financial impacts on the business (inventory, cashflow, profit and loss and the overall balance sheet) over a period of 5 years into the future. The effect of differing production zones, enterprise types and flock age profiles are also investigated, along with intangible barriers to flocks rebuilding (e.g. biosecurity concerns about buying in sheep).

2. Objectives

2.1 Development of flock rebuild scenarios that track inventory, cashflow, profit and loss and the overall balance sheet over a multi-year projection.

2.1.1 Factors considered in scenarios include:

a. Purchasing of ewes of varying ages (e.g. purchasing hoggets vs cull for age ewes)
b. Increased fertility (e.g. changed lambing times or supplementary feeding pre-joining to increase proportion in lamb) – *Note that this has been merged with c) immediately below*
c. Increased fecundity (e.g. changed lambing times, supplementary feeding pre-joining to increase proportion in lamb or from use of products to increase reproductive rate)
d. Increased survival of twin lambs (e.g. investing in scanning for multiples, investment in differential management, investment in small paddocks), but also increased survival of single lambs through reductions in dystocia
e. Increased growth of ewe lambs to facilitate joining
f. Improved management of dry ewes (i.e. managing ewes scanned dry)
g. Increased use of Merino rams over Merino ewes
h. Joining every 8 months – *Note this has been expanded to cover accelerated lambing systems*
i. Joining single bearing ewes during lactation to achieve lambing every 6 months – *Note this has been merged with h)*

j. Inducing a higher proportion of female offspring via use of sexed-semen or via dietary supplementation around mating time (feeding omega-6 fatty acids)

Further note – retaining breeding ewes longer (e.g. 5 ewe age groups rather than 4) and reducing the culling of ewe lambs, so more are available for flock rebuilding have also been included in the list of scenarios being considered. For comparison purposes only, the utilisation of excess pasture by running agisted stock or by making hay or silage has also been examined.

2.2 Modelling of impact strategies on

a. Exposure to variation in supplementary feed costs, purchase of stock and price received for sale animals
b. Flock structure
c. Cash-flow
d. Profit and loss
e. Balance sheet examples

**Please Note: Although modelling will be used to develop recommendations, the output of the project is not a tool or model.*

2.3 Model variation in benefit costs for

a. Range of production zones (pastoral, mixed farming, high rainfall)
b. Range of enterprise types and flock age profiles
c. Real and simulated case studies

2.4. Identify and report intangible barriers to flock rebuilding including

a. Struggling with making timely decisions
b. Acting too promptly when signs of dry seasons appear (e.g. selling of 4.5 year-old ewes during August 2020)
c. Lacking a positive outlook despite positive external conditions
d. Concerns around biosecurity when buying ewes

All objectives have been successfully met.

3. Methodology

3.1 Consideration of which flock rebuilding strategies to evaluate

3.1.1 Steps involved in conducting project

Step 1. The project team reviewed the list of flock rebuilding strategies initially proposed in the tender for the project and a further suggestion made to examine use of sexed-semen. This preliminary review was made based on knowledge of the project team, consulting literature (see Literature Review in next section) and also contacting Associate Professor Simon de Graaf at Sydney University for advice regarding the status and cost of sexed-semen technology.

The project team decided to evaluate a comprehensive list of strategies (see results), including some not originally listed (retaining more young ewe lambs, by culling less as well as the common practice of retaining more ewe age groups, but also alternative uses of excess pasture for comparison purposes only, being introducing stock on agistment and making and selling hay or silage). There is further discussion of each flock rebuilding strategy in 'Section 1.2.3. Review of Literature'

Step 2. A spreadsheet model was created to examine the potential of the various flock rebuild strategies to achieve an increase in flock numbers back to full capacity over a period of 5 years, from a starting point of 20% below optimum stocking rate. This was to simulate a property that for one or more reasons (drought, reduction in stock numbers to make way for increased cropping activity or other enterprises etc) is understocked and the owner/manager has chosen to rebuild sheep numbers. In doing so, the model was designed to examine and compare the consequences of the various flock rebuild strategies, in terms of tracking inventory, cash flow, profit and loss and also to present an overall balance sheet, projected across 5 years.

A number of parameters were calculated to summarise and compare these impacts, including Internal Rate of Return (%), Benefit/Cost Ratio and Net Present Value/Dry Sheep Equivalents ($) and NPV (on its own) calculated over a period of 5 years. None of these measures, on their own are sufficient to fully describe the relative profitability and utility of the various flock rebuilding strategies. A summary of the pros and cons of each economic measure is given in Table 1.

Table 1. The strengths and weaknesses of the economic measures of flock rebuilding strategies studied in the project

Economic Measure	Strengths	Weaknesses	Notes
NPV/DSE	Captures the profitability of the pathway	Does not demonstrate the relative impact on the flock rebuild (DSE numbers) Can't calculate in flocks that are not self-replacing	Re-joining dry ewes has a high NPV/DSE, but hardly contributes to DSE increases so could be misleading.
NPV or NPV/ha	Indicates total profit & relative scale of rebuild (higher profit often has higher DSEs)	Does not show the investment efficiency (profitability) aspect to the pathway	Purchasing ewes has high NPV but moderate NPV/DSE due to the large no. of DSEs involved
Internal rate of return (IRR)	Great metric for capturing the profitability of each rebuild option	Can't be calculated on many pathways that don't have an initial capital outlay (practice change vs investment)	
Benefit cost ratio (BCR)	Another metric for the profitability of different pathways	Can show quite different results depending on cost structure	Agistment has a moderate return with very low cost base and has a strong BCR, but it's NPV/DSE results are only moderate

The primary results stated in this report are NPV/DSE, and where not possible, BCRs are shown.

More detail on input assumptions, inventory, cash flow, profit and loss etc is given in Appendix 1.

The initial spreadsheet model focussed on a self-replacing dual-purpose Merino enterprise, producing 1st cross (Merino x Terminal Sire) lambs for the prime lamb market as well as pure Merino lambs for replacement purposes. This initial model, with altered price and productivity assumptions, was then used to simulate a self-replacing maternal flock focussed primarily on prime lamb production.

Step 3. These spreadsheets and their assumptions were reviewed with the Producer Reference Group (PRG), before modelling further enterprise types. A meeting was held with the PRG on Friday, 11 June 2021. Feedback received from the PRG was documented and considered at a debrief meeting of the project team. Almost all the feedback was acted on, with spreadsheet model assumptions being revised.

The Producer Reference Group included:
Jane Kellock, Farrell Flat, South Australia
David Cooper, Jamestown, South Australia
Elke Hocking, Elke Hocking Consulting, Lucindale, South Australia
Tim Leeming, TT and GJ Leeming, Coojar, Victoria

Further flock scenarios (varying genotype, production and regions) were created, to represent the majority of sheep enterprises run in Australia. The full list of flock scenarios is given below:
1. Self-replacing Dual-Purpose Merino flock
2. Merino wool focus
3. Merino - rangeland zone
4. Merino ewe x Terminal sire flock
5. Merino ewe x Border Leicester sire flock
6. F1 (e.g. Merino x Border Leicester) ewe x terminal sire flock
7. Self-replacing Maternal flock
8. Self-replacing cleanskin (agricultural & rangeland zones)

Step 4. The methodology and results of the project were appraised by Lee Beattie, of Lee Beattie Consulting Services, Hamilton, Victoria.

3.1.2. Utility of flock rebuilding strategies for different flock types

Table 1 summarises the flock rebuilding strategies that are applicable for the 9 different flock types examined. For example, strategies to increase fertility and fecundity do not contribute to flock rebuilding on the home property in Merino-cross production systems, as all female offspring are not retained as ewe replacements. However, some of these female offspring may be suitable for other producers to purchase for flock rebuilding purposes, rather than sold directly for slaughter. This is especially the case for female progeny of Merino by Border Leicester ewes.

Table 1. Applicability of flock rebuilding strategies to the 9 flock types investigated in the project

Flock Rebuild Strategy	Self-replacing Merino			Merino-cross			Self-replacing Maternal	Cleanskin	
	Dual Purpose	Wool Focus	Rangelands Zone	Merino x Terminal	Merino x BL	BLM x Terminal		Agricultural Zone	Rangelands Zone
1. Retain older ewes	Y*	Y	Y	Y	Y	Y	Y	Y	Y
2. Retain more young ewes	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Buy ewe hoggets	Y	Y	Y	Y	Y	Y	Y	Y	Y
4. Buy aged ewes	Y	Y	Y	Y	Y	Y	Y	Y	Y
5. Increasing fertility & fecundity	Y	Y	Y	N**	N	N	Y	Y	Y
5a. feeding energy pre-joining	Y	Y	Y	N	N	N	Y	Y	Y
5b. flushing with lupins	Y	Y	Y	N	N	N	Y	Y	Y
5c. Ovastim injection	Y	Y	Y	N	N	N	Y	Y	Y
6. Increase survival of twin lambs	Y	Y	Y	N	N	N	Y	Y	Y
7. Join ewe lambs	Y	Y	Y	Y	Y	Y	Y	Y	Y
8. Re-join dry ewes	Y	Y	Y	Y	Y	Y	Y	Y	Y
9. Increase Merino x Merino matings	Y	Y	Y	Y	Y	N	N	N	N
10. Accelerated Lambing – Type 1. Three lambings in 2 years. Managed as 1 flock	Y	Y	P***	N	N	N	Y	Y	Y
11. Accelerated Lambing – Type 2. Managed as two flocks, with mating opportunity every 4 months (Turretfield system)	Y	Y	P	N	N	N	Y	Y	Y
12. Use of sexed semen	Y	Y	Y	N	N	N	Y	Y	Y

*Y = Yes, applicable, **N = No, not applicable, ***P = Possible, but unlikely

3.1.3 Review of Literature

Traditionally, Australian sheep producers have relied on one or more of the following strategies (Strategies 1 to 4, please refer to Table 1) to rebuild or expand their flocks, either: retaining breeding ewes for longer or culling less young ewe replacements or purchasing in breeding ewes (usually either hoggets or cast-for-age ewes of 5-6 years of age).

There is no or very limited scientific literature available on the use of these strategies. Instead, assumptions on performance of ewes as they age and the relative performance of purchased ewes rather than home-bred ewes has been based on benchmarking data available to the project team.

5. Increasing fertility and fecundity

The standard practice on Australian farms is to mate ewes on an annual basis, with first mating at hogget age, although a considerable number of producers are now regularly mating ewe lambs. There are also a small number of producers now mating ewes more than once a year. Reproductive efficiency is normally measured annually on-farm by the number of lambs marked per 100 ewes joined to rams (marking percentage). However, marking% is a function of the key reproductive components of ewe fertility (ewes lambing of those joined to rams), litter size (lambs born per ewe lambing – also referred to as fecundity) and lamb survival (lambs surviving to marking or weaning of lambs born). Even more fundamentally, the reproductive potential of the ewe is set at the time of ovulation, with ovulation rate defined as the number of ova shed per ewe joined. Although ovulation rate is not a normal measurement recorded on farm, it has been extensively used by researchers to investigate reproductive potential and what factors affect it. In the context of either manipulating nutrition pre-joining and into the start of joining period or using a drug to boost reproductive rate, in the first instance the primary factor potentially improved is ovulation rate.

5a. Feeding supplements pre-joining. The live weight and condition score of ewes at joining time can be modified by the quantity and quality of the pasture grazed, as well as by feeding supplements. In the context of this flock rebuilding strategy, we have examined increasing ewe condition score by 0.5 of a score pre-joining by the feeding of high energy supplements, principally Barley grain, as excluding pasture, this is often the least expensive supplement available per unit of energy.

To help determine the size of the biological response achievable in reproductive rate to supplementing ewes pre-joining, past research on relationships between live weight and condition score of ewes at joining and reproductive rate have been examined.

A within-flock analysis of 21 Victorian ewe flocks (Saxon or Peppin Merino, Border Leicester x Merino or Perendale ewes) on the relationships of ovulation rate with liveweight, breed, season and plane of nutrition was conducted by Cumming (1977). In most cases studied, ovulation rate generally increased by 2.5 to 3.0% for each 1 kg increase in ewe liveweight at mating time. Increases in ovulation rate were generally less in flocks mated in spring (October-November), particularly in Border-Leicester by Merino ewes.

Although such within-flock associations studied between live weight and ovulation rate are of interest, they are essentially correlations, not ones of causation, as they are confounded with genotype and permanent environmental effects. Taking these limitations into account, Morley *et al.* (1978) concluded from analysing results from Australian and New Zealand data based on several breeds (Corriedale, a number of different Merino strains, Romney, Perendale, plus crosses of Border Leicester (BL) x Merino and BL x Romney) that an additional 1 kg in live weight at joining in autumn obtained through improved nutritional status will usually be associated with a 2 to 2.5% increase in ovulation rate (compared with 2.5% to 3.0% estimated from within-flock analysis; Cumming 1977), and probably 1.5 to 2.0% lambs born per ewe. In contrast, in Scotland, Scottish Blackface ewes were much more responsive, increasing by 6 to 7% in ovulation rate for each 1 kg increase in ewe mating weight (Morley *et al.* 1978, based on the results of Gunn and Doney 1975).

When liveweight changes are converted to condition scores, where 1 condition score is equivalent to 7-9 kg liveweight, a 0.5 increase in condition score (CS) is equivalent to 3.5-4.5 kg increase in liveweight and should be associated with an increase of 7.0% to 11.25% in ovulation rate and 5.25% to 9% in lambs born per ewe, based on the Morley *et al*. (1978) study. However, the authors stressed that the predictions were made for mid- to late-autumn joinings and situations where protein is not-limiting.

The predictions of Morley *et al.* (1978) are more conservative than advice provided more recently to Merino producers from the LifetimeWool website (www.lifetimewool.com.au), which cites 'the average response is about 20 extra lambs (born) per 100 ewes for an additional CS at joining', or 10 extra lambs born per 100 ewes for an additional 0.5 CS at joining. Variability of response is highlighted. In farmer case study flocks conducted as part of the LifetimeWool project, 50 high CS ewes (CS 3 and above) and 50 low CS ewes (CS 2.7 and below) were tagged and scanned for litter size. The extra foetuses scanned in the high CS ewes compared to the low CS ewes varied by 13-60%. However, the caution stated by Morley *et al.* (1878) against relying on simple within-flock analysis to relate live weight (and by inference, condition score) at joining with reproductive rates remains relevant.

To estimate whether extra ewe nutrition, especially feeding supplements pre-joining is economically beneficial, it is critical to estimate how much of potential increases in ovulation rate, foetuses scanned or lambs born at lambing are retained by lamb marking (or weaning) time. The project team has used lamb survival to weaning assumptions of 90% for singles and 60% for twin-born pure Merino lambs (and 90% for singles and 70% for twin lambs born to maternal composite ewes) to determine the final number of lambs weaned. These have been based on the typical lamb losses reported in the Hinch and Brien (2014) review of published Australian studies (10% for singles and 30% for twins), the estimated national lamb loss rate of 30% (with three-quarters from twin-births) in a report to Sheep Producers Australia by Trompf, Young and Bowen (2018) and in feedback from the project's Producer Reference Group.

An early evaluation of the economics of feeding supplements to Merino ewes before mating to increase fecundity was made by White and Bowman (1987). At the time, the authors concluded that it would be uneconomic in a Merino flock as a way of improving reproductive rate, with the costs/returns needing to change considerably before the practice became economic. Of course, costs/returns for sheep production systems have changed considerably since 1987, especially in relation to the value of sheep and lambs. Further, larger biological responses in ovulation rate have been obtained with legume supplements (such as lupins and field peas, see next section for references) than with lower cost cereal-based supplements such as oats and barley (Reeve *et al.* 1979).

5b. Lupin supplementation pre-joining. The first reports of significant flushing responses in ewes to lupin supplementation in Western Australia were published in the 1970s (Lightfoot and Marshall 1974 and Knight, Oldham and Lindsay 1975). Responses to 'flushing' of ewes around mating time were documented over a century ago in the United Kingdom (Heape 1899) and by numerous authors since (in particular by Coop 1966), but the large responses reported in the Western Australian studies (20% and more in ovulation rate) caught the widespread attention of researchers, especially in Victoria, where lower responses in ovulation rate (about 10%) and lambing rates were subsequently observed (Rizzoli *et al.* 1975, Brien *et al.* 1977, Reeve *et al.* 1979, Kenny *et al.* 1980). Lupin supplementation extended for at least 26-30 days in the early Victorian and the Western Australian studies, whereas Oldham and Lindsay (1984) in WA demonstrated that lupin supplementation only needed to be fed 6 days prior to oestrus to increase ovulation rate in the Merino.

Notwithstanding, large variations from -14% to +21% have been recorded in the number of lambs born in response to feeding lupins commercially in trials involving 22,800 Merino ewes in south-west WA, (Croker *et al.* 1985). Ewes were supplemented from 14 days before joining until day 17 of joining, totally 31 days. Most trials involved feeding lupins at 250 grams per head per day, but 10 trial sites also included ewes supplemented at 500 grams per head per day with the responses to higher quantities of supplement not being significantly different.

To investigate how management could be adapted to feeding lupins for only 14 days in a more commercial setting, Nottle *et al.* (1997) used the 'ram effect' and a joining period of 6 weeks to obtain an increase of 11 extra lambs weaned per 100 Merino ewes mated in the late spring-early summer in South Australia. More recently, as part of a larger trial ran in Victoria, New South Wales and South Australia, lupins fed to ewes (at 0.3-0.5 kg/head/day) at pasture as a supplement for 14 days (starting 1 week before joining to 1 week into the joining period) increased scanning rates by 8 to 21 lambs per 100 ewes on 5 of the 8 commercial farm sites participating (Gaunt *et al.* 2017).

In this current study, a conservative approach was initially taken (to produce preliminary results), requiring lupin supplementation to extend for 35 days in eastern Australia, based on research conducted in the 1970s and 1980s. However, for the final report, this has been revised down to 14 days of supplementation, based on the more recent results of Gaunt *et al.* (2017) and those of Nottle *et al.* (1997). Nonetheless, based on the available literature, large variation in the biological response to flushing with lupins needs to be expected and accounted for in deciding whether to adopt the practice on-farm.

5c. Use of 'Ovastim vaccination. Early research on vaccination against the hormone androstenedione to increase fecundity in sheep has been reviewed in an MLA Final Project Report by Refshauge and McFarlane (2017) and will not be repeated here. The initial commercialisation of an injectable product ('Fecundin') by Glaxo Australia Pty Ltd in the 1980s and more recently as 'Ovastim' by Verbac Australia, means that the product has been available for commercial use for a long time, but has only had limited adoption by sheep producers, with experiences of use of the technique somewhat mixed. The most comprehensive study on the use of vaccination against androstenedione in Australia is that of Geldard *et al.* (1984), which was based on trials on 10 properties in Victoria in 1982 (a drought year). They concluded immunising breeding ewes against androstenedione (using polyandroalbumin, Fecundin) resulted in an average increase of 23 lambs born per 100 ewes mated, due to an increase in multiple births. Twin births accounted for 93% of this increase in multiple births, with triplet births accounted for the remaining 7%. Immunisation was associated with a slight increase of 2% in non-pregnant ewes (Geldard *et al.* 1984), but Geldard (1984) reported that this increase did not occur if the start of joining was delayed by 3 weeks following the second injection of polyandroalbumin**.** The survival rates of offspring to marking time were, respectively 88% and 84% in control and treated sheep. These survival rates were based on collection of dead lambs from lambing paddocks and probably underestimate actual lamb losses and therefore overestimate survival rates. A lower survival rate in offspring from treated sheep would be expected, due to the higher proportion of twins and multiple births than singles compared to those from untreated sheep, given that neonatal mortality of twin-born lambs is 2 to 2.5 times higher than those born as singletons in the same flock (Hinch and Brien 2014).

Very similar results were obtained with Romney and Marshall Romney ewes in New Zealand, with immunisation with Fecundin increasing ovulation rates by 34-35% and predicted multiple birth rates (via X-ray) by 16-19% (Knight, Hall and Smith, 1988).

Based on available evidence, the project team decided to assume that the use of 'Ovastim' would, on average, increase the number of lambs born per 100 ewes mated by 20 lambs, then use existing lamb survival to weaning assumptions to determine the final number of lambs weaned.

6. Increasing survival of twin lambs.

The key study used as the basis to inform this flock rebuild strategy (Behrendt *et al.* 2011) was part of the LifetimeWool project. Conducted on 13 farms in southern Australia, the authors compared the lamb survival rates of single and twin lambs born to Merino ewes that were either in a condition score of 2.2-2.3 or 3.2 at lambing. Just focussing on the results of twin-bearing ewes with a full condition score difference at lambing, twins born to ewes in CS 2.2 had only a 57% survival compared with 71% survival to weaning in those born to ewes in a CS of 3.2 at lambing i.e. a 14 percentage-point difference. The project team, in investigating the impact of a 0.5 increase in Condition Score, from 2.7 to 3.2, assumed that one-half of the 14% increase in twin-lamb survival for a 1 CS increase in ewes at lambing reported by Behrendt *et al.* (2011) would be obtained i.e. 7%.

Later studies have been conducted to generate recommended ewe nutrition profiles for non-purebred Merino ewes. In a comparison of BLM and pure Merino ewes, the relationship between ewe condition score at lambing and survival of twin/multiple-born lambs to marking was similar in the 2 ewe types, with an increase of 1 condition score associated with 13 to 16 extra lambs marked per 100 foetues scanned. However, survival of single lambs born to BLM ewes did not vary with condition score, in contrast to survival of single lambs born to Merino ewes (Hocking-Edwards *et al.* 2019). Results from a study conducted on maternal composite ewes were generally similar, with twin/multiple lamb survival to weaning being 8-22% higher in ewes approximately 1 condition score higher at lambing, 3.6 vs 2.4 (Behrendt *et al.* 2019).

For the purposes of informing this flock rebuild strategy, it was assumed that the improvements in twin lamb survival from increasing ewe condition score at lambing from 2.7 to 3.2 would be similar in BLM and maternal composite ewes to those reported for lambs born to pure Merino ewes.

7. Increased growth of ewe lambs to facilitate joining.

Considerable research has been conducted overseas on the mating of ewe lambs (see review by Kenyon, Thompson and Morris, 2014) and an extensive review of that work will not be attempted here. Rather, some relevant Australian and New Zealand work (published and unpublished) is referenced, to outline the background to assumptions made by the project team about the likely performance of mating ewe lambs as a flock rebuilding strategy.

In work at Turretfield Research Centre in South Australia, Smith *et al.* (2012a) reported that Merino x SAMM ewe lambs, mated at 11 months of age, produced 0.54 foetuses for each ewe lamb mated (39% pregnancy rate). These results were averaged over 3 joining times, March, July and November. It is worth noting that when mated at the peak of the breeding season, in March, ewe lambs produced 0.7 foetuses for each ewe lamb mated. In a Western Australian study, pure Merino ewe lambs produced a weaning rate of 42% when mated between 8 and 10 months of age (Paganoni *et al.* 2014).

More recent, but unpublished information from producer experience is that the average age of mating of Merino ewe lambs is slightly over 8 months, with the average number of lambs born being 65% and the average weaning rate being 50%. Some Merino producers are achieving a weaning rate of approximately 70% from the mating of ewes lambs at 8 months of age (A. Thompson, personal communication).

For mating of maternal ewe lambs, the average age at joining across just under 100 farms is a little over 8 months, with an average number of lambs born per ewe lamb mated being 108%, with a weaning rate of 77%. Some producers joining maternal ewe lambs at 8 months of age are achieving a weaning rate of approximately 115% (A. Thompson, personal communication). An average weaning rate of 77% has been recently confirmed in a study of more than 11,500 maternal composite ewe lambs over 8 years that were mated at 8 months of age. Weaning rates also increased over the 8 years, from 2010 to 2017 (Thompson *et al.* 2021).

A review by Kenyon, Thompson and Morris (2014) recommended that regardless of breed or the genotype used, there are a number of practises a farmer can implement to maximise ewe lamb performance:

- Prior to breeding, ewe lambs should be vaccinated against abortive diseases and exposed to teaser rams for 17 days.
- Ewe lambs should be at least 35–40 kg, depending on breed, and at a body condition score of 3.0 when bred with mature rams at a ratio of 1:50–1:75. *These joining weights are considerably lower than the current Lifetime Ewe Management (LTEM) recommendation of 75% of mature body weight or standard reference weight i.e. for a 60 kg ewe, ewe weaners should be 45 kg minimum. Maternal composite lambs, mated at 8 months of age averaged a weaning rate of 77% (Thompson et al. 2021, cited above), with the average joining weight being 40.2 kg, almost 5 kg below the LTEM recommendation.*
- Throughout pregnancy it is important that the ewe gains total live weight at a rate of 100–150 g/day.
- During lactation ewe lambs need to be fed at a level that ensures they lactate to their potential while still growing themselves.

In research confirming the weight gain recommendation of Kenyon *et al.* (2014), Thompson *et al.* (2019) reported that regardless of live weight at the start of mating, ewe lambs gaining an extra 100g/day of live weight during the mating period increased their reproductive rate by about 20%. Live weight gain during mating, together with live weight at the start of mating together appear to be good predictors of reproductive performance from ewe lamb matings, with live weight gain in particular being more important in ewe lambs than reported in adult ewes (Thompson *et al.* 2019).

On the basis of the above published and unpublished information, the project team assumed that Merino ewe lambs of at least 8 months of age at the time of mating and mated in autumn, could produce a weaning rate of 50%. For maternal composite ewe lambs, the assumption was higher, at a weaning rate of 70%.

8. Improved management of dry ewes (i.e. managing ewes scanned dry).

The strategy modelled was to re-mate ewes that scan as dry, immediately following scanning. Surprising little direct literature is available on this subject, particularly when ewes that are scanned dry are re-mated within the same breeding season. Based on annual mating, the South Australian Merino Resource flock data was available to the project team, with relevant but unpublished results in a suitable form, collated as part of the published studies of Walkom *et al.* (2016) and particularly

Hatcher *et al.* (2018). In the latter, an empirical study was conducted where ewe hoggets, pregnancy scanned as dry (i.e. no foetus present) following their first mating opportunity were identified as a group. Along with their pregnant cohorts, these ewes subsequently had another 3 annual lambing opportunities. Compared to all the ewe hoggets scanned, the once-dry ewes subsequently only had a 7.6% lower weaning rate (averaged over 3 lambings). Similar results were obtained in research flocks run at the Trangie Research Centre by NSW DPI in the 1970s and 1980s (K. Atkins, personal communication).

Based on the available results from the scientific literature, a penalty of 8% in weaning rate was applied in this project for re-mating of once-dry Merinos, with a slightly higher figure of 10% applied to maternal composites.

10. Accelerated lambing.

For Merinos, the main study referenced is that of Smith *et al.* (2012b), conducted at Turretfield Research Centre over 4 years (2008 to 2011). The approach, an adaptation of the STAR lambing system described by Lewis *et al.* (1996) was to set up a split ewe flock, where ewes scanned as dry were given another mating opportunity (by swapping flocks) 4 months later. When results were calculated on an annualised basis, the system was able to produce 58% more lambs born (based on scanned foetuses) at 1.83 foetuses per ewe mated, when compared to the annual rate of 1.15 foetuses scanned, as established in extensive surveys of Merino flocks in South Australia (Kleemann *et al.* 2005).

This accelerated lambing system did not use any artificial breeding technology or drugs and utilised the long breeding season of the Merino sheep. The main issues experienced were in managing and cost-effectively feeding lambs from out-of-season lambings. Results for accelerated lambing with maternal flocks are available from studies by Neal Fogarty and colleagues, with a key recent reference being Fogarty and Mulholland (2013). These authors, similar to the experiences of Smith *et al.* (2012b) with Merinos, stress the importance for cost-effectiveness of using suitable genotypes and systems that do not rely on artificial breeding technologies and drugs.

The project team has erred on the side of caution in relation to supplementary feeding, assuming high amounts are required, particularly to sustain out-of-season lambing events.

12. Altering sex ratio.

a. Use of sexed semen. The key referenced study is a recent review by Vishwanath and Moreno (2018); although focussed on the bovine species, it provides an excellent summary on the state of the art of the technology of semen sexing for a range of species. For specific costs and efficiency of the technology for the sheep industry, we consulted Associate Professor Simon deGraaf at Sydney University, who has extensively researched the topic over many years, including with his predecessor, Professor Chis Maxwell, who helped pioneer the technology in Australia.

The cost of semen-sexing itself is around $32 a dose, but that cost needs to be added to the cost of artificial insemination. If a flock is not currently using AI, then the full cost of both AI and semen-sexing is incurred, making the approach unattractive financially, given that the benefits are more than outweighed by the costs, according the calculations made by the project team.

12b. Diet-induced alteration of sex ratio (by feeding ewes omega-6 fatty acids). Results are available from a series of studies conducted by researchers at Charles Sturt University – see Gulliver *et al.* (2013) and Clayton *et al.* (2016a, 2016b). Collectively, these indicate that the sex ratio achieved following omega-6 fatty acid supplementation for 6 weeks before and 3 weeks following conception was from 54.1% to 71.3% in favour of female offspring.

The project team decided, on the basis of these available results, that the technique provided too small a change in the sex ratio of offspring and was too unreliable to be economically evaluated.

13. Other options not economically evaluated.

A range of other strategies were considered as potentially able to contribute to flock rebuilding, but were not specifically economically evaluated, for a range of reasons discussed below.

Changing time of lambing. A decision on the timing of lambing has to consider a number of factors. These include the sheep's natural breeding season, the typical length of the pasture growing season (which determines the availability of adequate pasture at various times of the reproduction cycle and for growing out of young sheep) and the likely seasonal conditions at the intended lambing time.

For any particular sheep producing region in Australia, there is often a wide range of lambing times chosen by different producers, with the flexibility of lambing times greater with longer pasture growing seasons. The aims of the specific production system also influences the optimum lambing period, as shown diagrammatically in Fig 1.

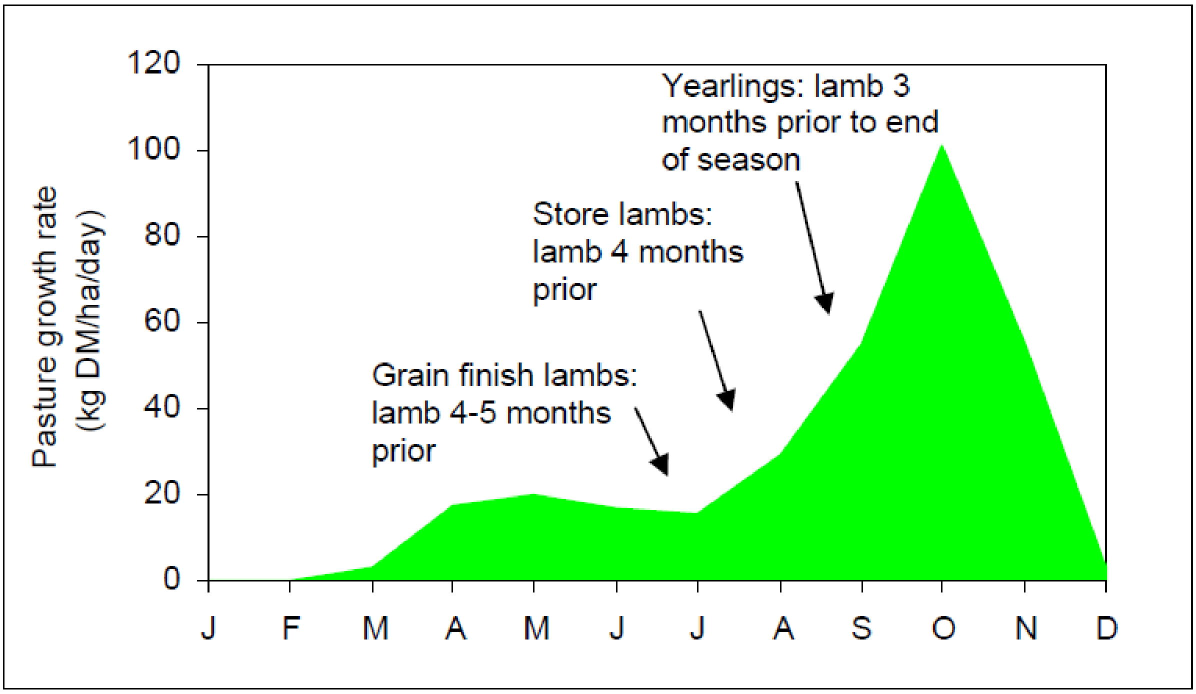

Figure 1. Guidelines for the optimum time of lambing can be related to the length of the growing season for a given pasture and environment (Warne *et al.* 2006).

The shorter the growing season, the earlier the optimum lambing time becomes. If lambing is scheduled earlier than May (thus commencing joining well before the summer solstice), this is generally outside the natural breeding season of some sheep breeds, although Merinos and Dorsets are less seasonal and can be successfully joined at most times of the year. However, all breeds naturally peak in ovulation rate in the autumn, so joining in the spring (and lambing in autumn) can compromise the potential weaning rate achieved compared to a later lambing. It is generally recommended for spring joinings (October-December) to use teaser rams, prior to joining with entire rams, to promote oestrus activity. However, if a producer is currently joining ewes in spring, even with utilising teasers, there may be scope to boost lamb weaning rates by up to 20% by delaying joining until after December. The project team decided not to economically evaluate changing to a later lambing time for boosting flock re-building, as such an evaluation is complex, involving a range of inter-related factors, as discussed above. Rather, the flock rebuilding options considered represent results likely to be achieved when averaged over a range of lambing times.

Use of Regulin. This pharmacological product, which contains the hormone melatonin, was developed originally as a method for advancing the breeding season in several species, including in sheep. Not only can the product promote oestrus activity and an end to anoestrus in some cases of highly seasonal sheep breeds, but it can also mimic the shorter daylength conditions of autumn and boost ovulation rates in sheep joined in spring/early summer (Kennaway, Dunstan and Staples, 1987; Haresign, 1992; Williams *et al.* 1992). The project team did not attempt to economically evaluate using Regulin in spring/early summer joined flocks as a flock rebuilding option. There was no particular reason for this, other than the number of options already being considered was extensive. It is suggested that the likely outcome of such an evaluation would be similar to using 'Option 5c. Ovastim Injection', also noting that boosting multiple births at an autumn lambing will dramatically increase ewe feeding requirements for late pregnancy and particularly lactation, with customised feeding of ewes according to litter size (as assessed by pregnancy scanning) highly recommended.

Flushing with green feed. Flushing with green feed (provided in various forms, such as Lucerne, fodder crops, irrigated pastures etc) is reported to be a more reliable flushing method than using lupin grain as a supplement. The main limitation under Australian conditions is that, apart from favoured areas where green feed is readily available at the chosen time of joining, for the great majority of sheep producing regions, joining is invariably carried out on dry or senescing pasture. Two MLA projects in recent years have investigated this subject - B.LSM.0051 'Flushing to increase conception' (Robertson, Clayton and Friend, 2015) and B.LSM.0053 'Participatory research evaluating and demonstrating the impact of green feed (particularly Lucerne) on sheep conception' (Gaunt *et al.* 2017). The project team decided not to economically evaluate these flushing methods as flock rebuilding options, as they are not readily available to the great majority of Australian sheep producers, or are not well-aligned with their current production systems.

Running smaller mob sizes. Researchers have recommended that mobs of ewes bearing twin lambs (based on pregnancy scanning results) should be run in smaller mob sizes during the lambing period. The effect of mob size is linear, with survival of twin-born lambs decreasing by between 1.9% and 2.5% per additional 100 ewes in the mob at lambing, regardless of breed (Lockwood *et al*. 2019a, 2019b, 2019c, 2020). The project team decided that this modest advantage was too small to economically evaluate as a flock rebuilding option on its own. It is however recommended as a management tool and could be used in conjunction with many of the flock rebuilding options that have been economically evaluated in this study.

Phenotypic culling, selection and genetic improvement approaches. Culling in commercial flocks on the basis of ewes being twice-dry at lambing (either pregnancy scanned as dry and/or lambed and lost) and retaining better reproductive performing ewes in the flock for 1 to 2 years longer are recommended as methods to improve reproduction rates (Lee *et al.* 2014, Hatcher *et al.* 2018) in the medium term (3 to 5 years), but are considered too slow to materially be used as effective flock rebuilding strategies that requires results preferably in a shorter time frame (2-3 years).

Likewise, the timeframes to generate more ewe replacements by genetic selection (from within-flock selection) for flock rebuilding are too long (greater than 5 years) to be considered in this project. Notwithstanding, when selecting rams, choosing those with high Australian Sheep Breeding Values for NLW (Number of Lambs Weaned), as part of an overall breeding goal, is good practice in helping to build long-term genetic improvement in reproductive performance of flocks.

The introduction of highly-fecund breeds or strains of sheep into a flock, either by crossing with rams or by purchase of ewes is another possible approach that could be considered. Examples are use of Booroola Merinos or MultiMeats (bred for homozygosity of the Booroola high fecundity gene), or Finnish Landrace. For enterprises where wool is a key contributor to financial returns, crossing with Finnish Landrace is unlikely to be attractive as fleece values will be dramatically reduced. Also, a recent trial including MultiMeat x Merino cross ewes, although reporting a 15% higher lamb marking rate than the next highest genotype compared (Border-Leicester x Merino ewes), the reproductive wastage was very high, at 44% of of foetuses scanned (Ransom, Brien and Pitchford 2021). Any plan to use this option needs to include additional management and ewe nutrition to improve lamb survival, particularly of twins and triplets. These could include pregnancy scanning to identify twin and multiple bearing ewes and drafting these into groups to allow for more targeted ewe nutrition according to their litter size during pregnancy and lactation. Provision of extra shelter at lambing time is also recommended. If introduced to a flock by crossing, the impact of high fecundity genetics will not be obtained until the third year after the initial mating, as female progeny (F1s) need to be born, grow out to hogget stage before being mated themselves, unless mated as ewe lambs.

4. Results

4.1 Economic ranking of flock rebuilding strategies

Table 2 provides the ranking (from 1 to 16) and Table 3 the values of the flock rebuilding strategies for each of the 9 flock types examined. The rankings are based on Net Present Value/Dry Sheep Equivalents ($), except for the Merino-cross flock types, which have been based on benefit/cost ratios.

Re-joining of ewes scanned dry (scanned after first mating opportunity - Strategy 8) ranked first for all flock types except a wool-focussed Merino flock. Retaining older ewes (Strategy 1) also ranked highly (1 to 5) across all flock types, as did – increasing survival of twin lambs (Strategy 6) and buying in ewe hoggets (Strategy 3). Ovastim injection (Strategy 5c) ranked within the top 3 strategies for Self-replacing Maternals and Cleanskin flock types and within the top 6 strategies for self-replacing Merino flock types. Buying aged ewes (Strategy 4) also ranked within the top 6 strategies for self-replacing Merino and Merino cross flock types. Finally, joining ewe lambs (Strategy 7) ranked within the top 6 for self-replacing Maternal and Cleanskin flock types.

Of the remaining flock rebuilding strategies, retaining more young ewes (Strategy 2), joining ewes lambs (Strategy 7) and increasing pure Merino matings (Strategy 9) for self-replacing Merino flock types were profitable, but returned less than the top 6 strategies. Feeding energy supplements pre-joining (Strategy 5a) was only marginally profitable for self-replacing Maternal and Cleanskin flock types, but below break-even for self-replacing Merino flocks. Accelerated lambing systems (Strategies 10 and 11) were barely break-even for self-replacing Merino flock types and were slightly unprofitable for self-replacing Maternal and Cleanskin flock types. Flushing with Lupins (Strategy 5b) was an unprofitable strategy for flock rebuilding, at least under an eastern state scenario. Under assumptions more applicable to Western Australian conditions, where lupin grain is only fed for a maximum of 20 days and a 6% improvement in lamb marking% is potentially achieved, the strategy becomes profitable but is still not amongst the top 6 flock rebuilding strategies. Finally, use of sexed semen was highly unprofitable (Strategy 12) in situations where artificial insemination is not the normal practice.

Table 2. Ranking of flock rebuild strategies on Net Present Value/Dry Sheep Equivalents (or on benefit/cost, in brackets)

Flock Rebuild Strategy	Self-replacing Merino			Merino-cross			Self-replacing Maternal	Cleanskin	
	Dual Purpose	Wool Focus	Rangelands Zone	Merino x Terminal	Merino x BL	BLM x Terminal		Agricultural Zone	Rangelands Zone
1. Retain older ewes	**2***	**1**	**3**	**(2)**	**(2)**	**(2)**	**4**	**4**	**5**
2. Retain more young ewes	12	11	**8****				11	12	**10**
3. Buy ewe hoggets	**4**	**3**	**7**	**(2)**	**(2)**	**(3)**	7	7	**8**
4. Buy aged ewes	**6**	**4**	**9**	**(4)**	**(4)**	**(4)**	8	8	**11**
5. Increasing fertility & fecundity									
5a. feeding energy pre-joining	**15**	13	**13**	N/A	N/A	N/A	9	10	**12**
5b. flushing with lupins	14	12	**11**	N/A	N/A	N/A	**6**	**6**	**9**
5c. Ovastim injection	**5**	**6**	**6**	N/A	N/A	N/A	**3**	**3**	**4**
6. Increase survival of twin lambs	**3**	**5**	**4**	N/A	N/A	N/A	**2**	**2**	**2**
7. Join ewe lambs	8	8	**15**				**5**	**5**	**7**
8. Re-join dry ewes	**1**	**2**	**1**	**(1)**	**(1)**	**(1)**	**1**	**1**	**1**
9. Increase Merino x Merino matings	11	10	**10**	**(12)**	**(10)**	N/A	N/A	N/A	N/A
10. Accel. Lambing – Type 1	13	**15**	**14**	N/A	N/A	N/A	**14**	**15**	**15**
11. Accel. Lambing – Type 2	9	**14**	**12**	N/A	N/A	N/A	**13**	**14**	**14**
12. Sexed semen use	**16**	**16**	**16**	N/A	N/A	N/A	**16**	**16**	**16**

*Top 6 strategies are emboldened and coloured in blue font, unless NPV/DSE is negative **Strategies with negative values are coloured in red font

Table 3. Net Present Value/Dry Sheep Equivalents ($) of flock rebuild strategies (or benefit/cost ratio, in brackets)

Flock Rebuild Strategy	**Self-replacing Merino**			**Merino-cross**			**Self-replacing Maternal**	**Cleanskin**	
	Dual Purpose	Wool Focus	Rangelands Zone	Merino x Terminal	Merino x BL	BLM x Terminal		Agricultural Zone	Rangelands Zone
1. Retain older ewes	**$153***	**$161**	**$66**	**(1.4)**	**(1.6)**	**(1.4)**	**$129**	**$131**	**$44**
2. Retain more young ewes	$18	$35	**-$6**				$16	$17	**-$26**
3. Buy ewe hoggets	**$115**	**$129**	**$18**	**(1.4)**	**(1.6)**	**(1.3)**	$98	$101	**-$2**
4. Buy aged ewes	**$92**	**$110**	**-$7**	**(1.1)**	**(1.2)**	**(1.1)**	$82	$84	**-$33**
5. Increasing fertility & fecundity									
5a. feeding energy pre-joining	**-$8****	$18	**-$81**	N/A	N/A	N/A	$71	$73	**-$45**
5b. flushing with lupins	$22	$31	**-$54**	N/A	N/A	N/A	**$99**	**$101**	**-$10**
5c. Ovastim injection	**$102**	**$98**	**$19**	N/A	N/A	N/A	**$149**	**$151**	**$51**
6. Increase survival of twin lambs	**$153**	**$105**	**$63**	N/A	N/A	N/A	**$162**	**$164**	**$84**
7. Join ewe lambs	$78	$59	**-$125**				**$115**	**$117**	**$21**
8. Re-join dry ewes	**$170**	**$155**	**$85**	**(4.0)**	**(4.0)**	**(4.3)**	**$171**	**$173**	**$102**
9. Increase Merino x Merino matings	$24	$40	**-$21**	**(0.8)**	**(1.0)**	N/A	N/A	N/A	N/A
10. Accel. Lambing – Type 1	$1	**-$12**	**-$87**	N/A	N/A	N/A	**-$36**	**-$20**	**-$64**
11. Accel. Lambing – Type 2	$7	**-$2**	**-$70**	N/A	N/A	N/A	**-$25**	**-$11**	**-$130**
12. Sexed semen use	**-$335**	**-$292**	**-$344**	N/A	N/A	N/A	**-$253**	**-$251**	**-$326**

*Top 6 strategies are emboldened and coloured in blue font, unless NPV/DSE is negative **Strategies with negative values are coloured in red font

The results are also shown in graphical form for 2 of the flock types, a self-replacing dual purpose Merinos (Figure 2) and a self-replacing maternal flock (Figure 3).

Figure 2. Net Present Values/Dry Sheep Equivalent (NPV/DSE - $) of flock rebuilding strategies for a self-replacing dual purpose Merino flock type. The top 6 strategies on rank are coloured in green. Strategies with negative values are coloured in pink.

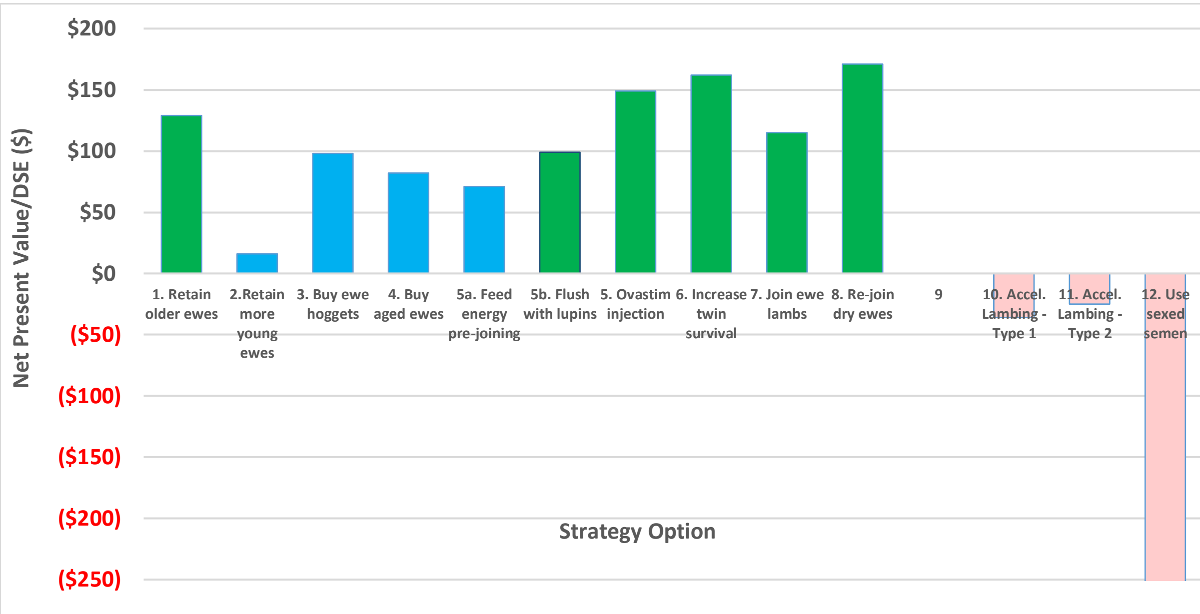

Figure 3. Net Present Values/Dry Sheep Equivalent (NPV/DSE - $) of flock rebuilding strategies for a self-replacing Maternal flock type. The top 6 strategies on rank are coloured in green. Strategies with negative values are coloured in pink.

4.1.1 Impact of using best 6 flock rebuilding strategies – Cumulative cash flow

Cumulative net discounted cashflow (with residual) is graphed for a self-replacing dual purpose flock (Figure 4) and for a Maternal flock (Figure 5).

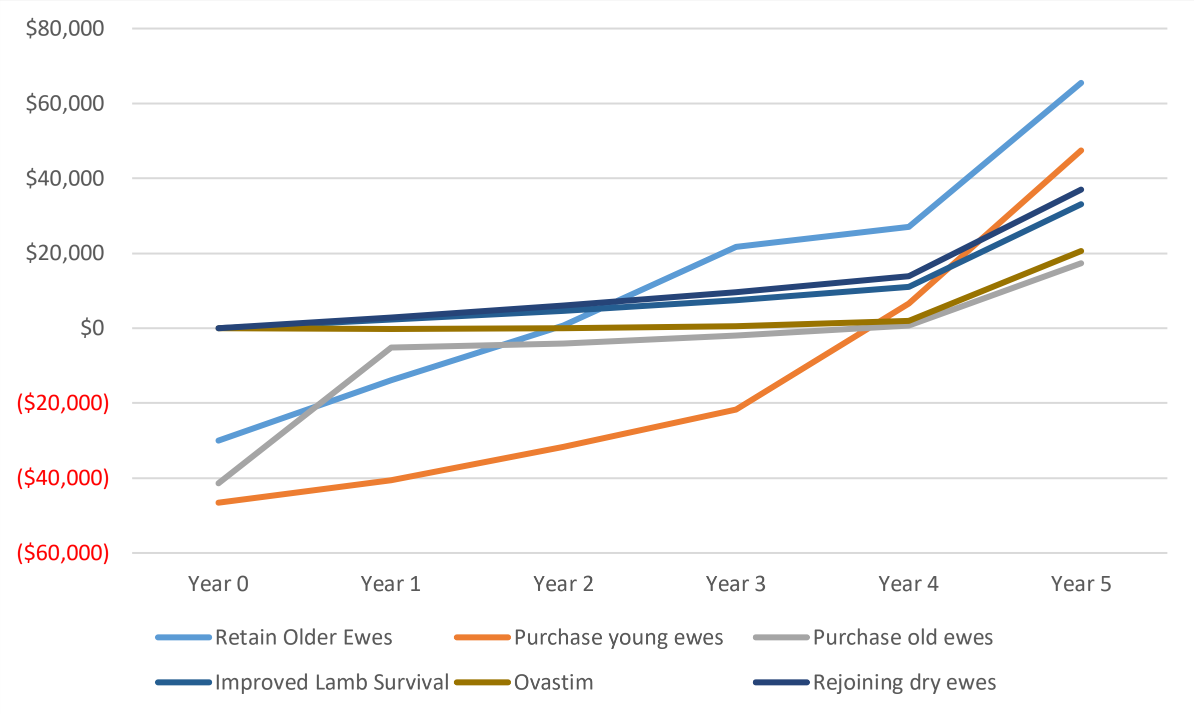

Figure 4. Cumulative net discounted cashflow (with residual) over 5 years from use of the top 6 flock rebuilding strategies for a self-replacing dual purpose Merino flock

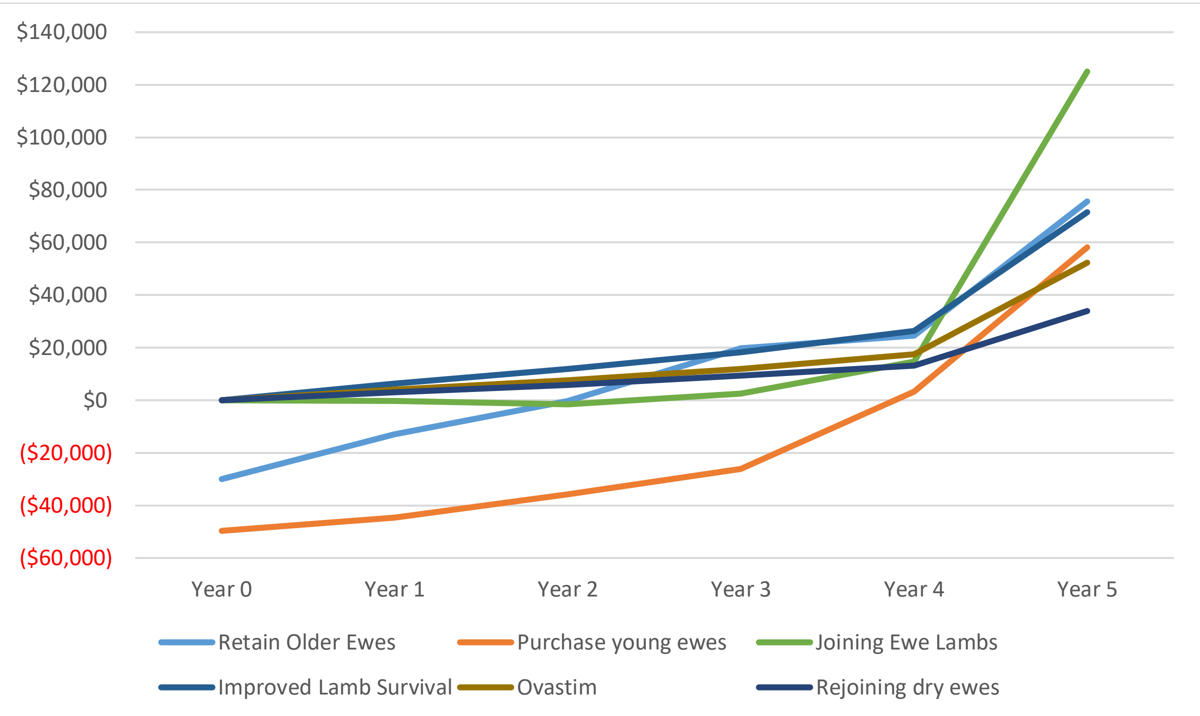

Figure 5. Cumulative net discounted cashflow (with residual) over 5 years from use of the top 6 flock rebuilding strategies for a self-replacing Maternal flock

As expected, strategies of buying additional ewes take longer to return to a positive cash flow than other methods, however all top 6 strategies are in positive (cumulated) cash flow after 4 years, for both flock types.

4.1.2 Impact of using best 6 flock rebuilding strategies – Number of additional Dry Sheep Equivalents (DSE) generated

The number of additional DSE generated over 5 years from the use of the top 6 flock rebuilding strategies are illustrated below for a self-replacing dual purpose Merino flock (Figure 6) and a Maternal flock (Figure 7).

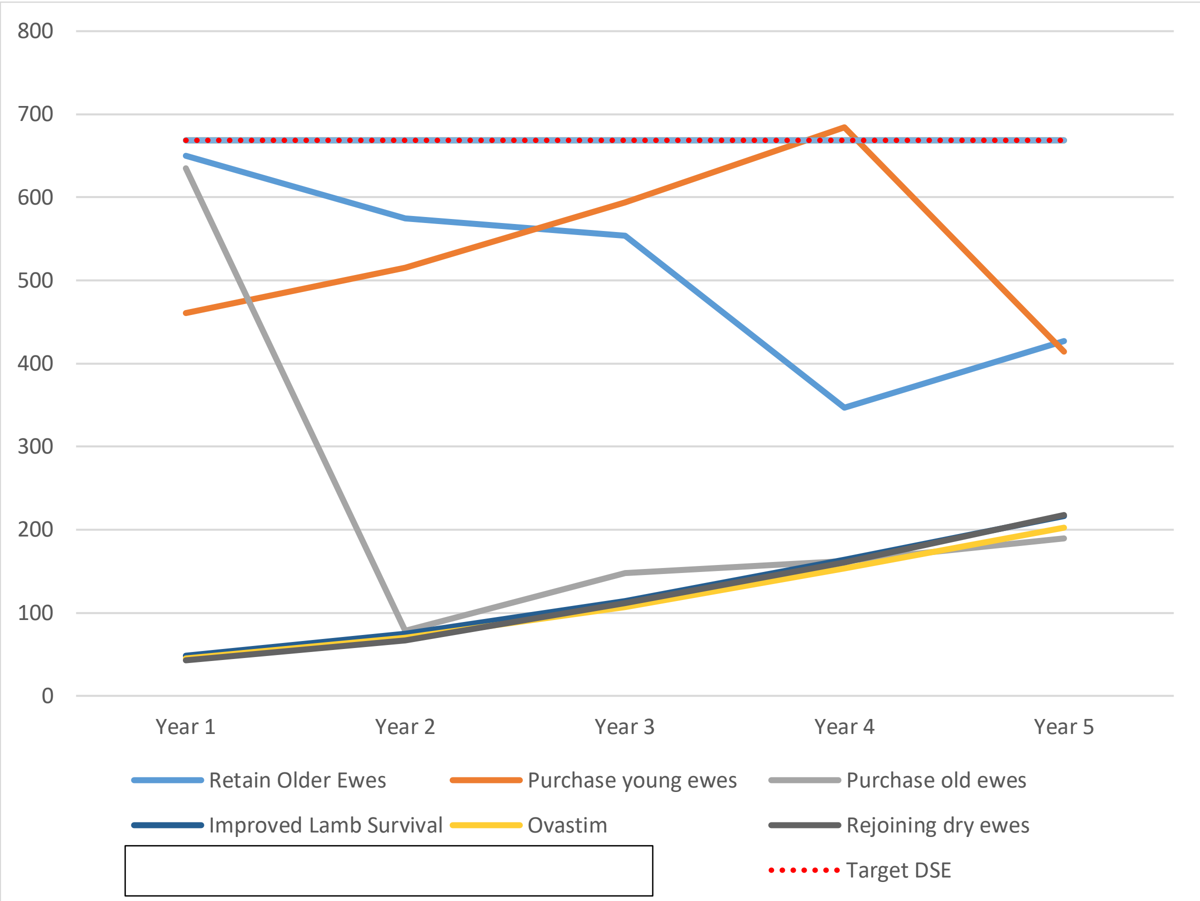

Figure 6. The number of additional dry sheep equivalents (DSE) generated over 5 years from use of the top 6 flock rebuilding strategies for a self-replacing dual purpose Merino flock. The target DSE is the number required to completely restock the property, assumed to be 25% understocked before flock rebuilding strategies are applied.

For a self-replacing dual purpose Merino flock, implementing the strategies of retaining and purchasing older ewes (Strategies 1 and 4) and purchasing hogget ewes (Strategy 3) have a more immediate effect on increasing the dry sheep equivalents (DSE) being carried than implementing the remaining 3 strategies shown. This is a result of more grown sheep (either retained or purchased ewes) being on the property immediately following the strategy being implemented. The effect of strategies to generate more progeny (improving twin lamb survival and vaccinating ewes with Ovastim) take longer to increase DSE, given the time taken from implementation to allow for mating, pregnancy, lactation and weaning before the progeny start contributing to the DSE counts. For a self-replacing Maternal flock, the situation with increasing DSEs is similar, with retention of older ewes and purchasing of ewe hoggets resulting in a more rapid increase, with joining ewe lambs quickly building DSEs, so that by Year 4, the DSEs are approaching the property target. Indeed, some reduction in stock numbers would need to be implemented by Year 5 to keep within the DSE target.

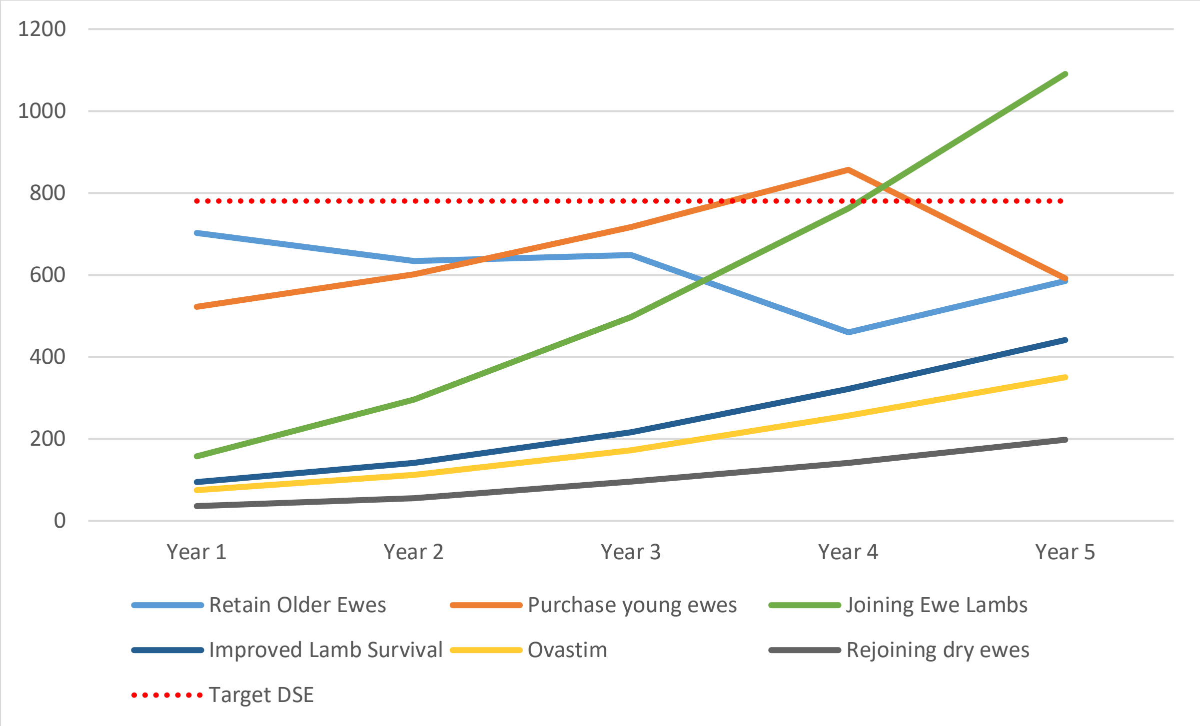

Figure 7. The number of additional dry sheep equivalents (DSE) generated over 5 years from use of the top 6 flock rebuilding strategies for a self-replacing Maternal flock. The target DSE is the number required to completely restock the property, assumed to be 25% understocked before flock rebuilding strategies are applied.

4.2 Sensitivity of flock building strategies

4.2.1 Variation in Supplementary Feed Costs

The sensitivity of flock rebuilding strategies to variation in supplementary feed costs (23% lower and 23% higher than the assumed standard price of $260/tonne) in terms of NPV/DSE values are listed in Table 4 for a self-replacing dual purpose Merino flock and in Table 5 for a self-replacing Maternal flock.

For a self-replacing dual purpose Merino flock, varying supplementary feed costs by 23% had little effect on the NPV/DSE value or rank (based on NPV/DSE value) of the top 6 of 16 flock rebuilding strategies (1. Retain older ewes, 3. Buy ewe hoggets, 4. Buy aged ewes, 5c. Ovastim injection, 6. Increase survival of twin lambs and 8. Re-join dry ewes), except as follows.

Strategy 4. Buy aged ewes (5.5 year old), while increasing in profitability as a strategy with lower supplementary feed costs, moved down in rank from 6th to 7th, being replaced as one of the top 6 strategies by Strategy 7. join ewe lambs, but this was a relatively inconsequential change. Strategy 5a. Feeding energy pre-joining to ewes became profitable at lower supplementary feed costs, but became more unprofitable when supplementary feed costs increased by 23%. Other than that, the ranking and NPV/DSE values of other flock rebuilding strategies not in the top 6 changed little.

Table 4. The effect of a 23% change (lower and higher than the standard supplementary feed costs of $260/tonne) on Net Present Values/dry sheep equivalent values ($) and rank for flock rebuilding strategies (self-replacing dual purpose Merino flock).

Flock Rebuild Strategy	Self-replacing dual purpose Merino flock		
	Low Feed Cost ($200/tonne)	Standard Feed Cost ($260/tonne)	High Feed Cost ($320/tonne)
1. Retain older ewes	**$159**	**$153***	**$147**
2. Retain more young ewes	$21	$18	$15
3. Buy ewe hoggets	**$121**	**$115**	**$108**
4. Buy aged ewes	$98	**$92**	**$85**
5. Increasing fertility & fecundity			
5a. Feeding energy pre-joining	$28	**-$8****	**-$44**
5b. Flushing with lupins	$53	$22	**-$9**
5c. Ovastim injection	**$110**	**$102**	**$94**
6. Increase survival of twin lambs	**$162**	**$153**	**$144**
7. Join ewe lambs	**$103**	$78	$52
8. Re-join dry ewes	**$173**	**$170**	**$167**
9. Increase Merino x Merino matings	$27	$24	$21
10. Accel. Lambing – Type 1	$31	$1	$13
11. Accel. Lambing – Type 2	$35	$7	$16
12. Sexed semen use	**-$332**	**-$335**	**-$338**

*Top 6 strategies are emboldened and coloured in blue font, unless NPV/DSE is negative
**Strategies with negative values are coloured in red font and emboldened

Table 5. The effect of a 23% change (lower and higher than the standard supplementary feed costs of $260/tonne) on Net Present Values/dry sheep equivalent values ($) and rank for flock rebuilding strategies (self-replacing Maternal flock).

Flock Rebuild Strategy	Self-replacing Maternal flock		
	Low Feed Cost ($200/tonne)	Standard Feed Cost ($260/tonne)	High Feed Cost ($320/tonne)
1. Retain older ewes	**$134**	**$129***	**$124**
2. Retain more young ewes	$18	$16	$13
3. Buy ewe hoggets	$104	$98	**$93**
4. Buy aged ewes	$87	$82	$77
5. Increasing fertility & fecundity			
5a. Feeding energy pre-joining	$96	$71	$47
5b. Flushing with lupins	**$120**	**$99**	$79
5c. Ovastim injection	**$155**	**$149**	**$143**
6. Increase survival of twin lambs	**$171**	**$162**	**$153**
7. Join ewe lambs	**$134**	**$115**	**$95**
8. Re-join dry ewes	**$174**	**$171**	**$169**
9. Increase Merino x Merino matings	N/A	N/A	N/A
10. Accel. Lambing – Type 1	**-$27****	**-$36**	**-$45**
11. Accel. Lambing – Type 2	**-$16**	**-$25**	**-$35**
12. Sexed semen use	**-$250**	**-$253**	**-$256**

*Top 6 strategies are emboldened and coloured in blue font, unless NPV/DSE is negative
**Strategies with negative values are coloured in red font and emboldened

For a self-replacing Maternal flock, the top 6 flock rebuilding strategies remained the same under a low compared to a standard supplementary feeding cost assumption. These were:

1. Retain older ewes, 5b. Flushing with lupins, 5c. Ovastim injection, 7. Join ewe lambs and 8. Re-join dry ewes. Under a high feeding cost assumption, Strategy 3. Buy ewe hoggets, became one of the

top 6 strategies, replacing Strategy 5b. Flushing with lupins; other than that, the ranking of the top 6 strategies did not change with differing supplementary feed cost assumptions. The absolute NPV/DSE values are little changed either. Strategy 5a. feeding energy supplement to ewes pre-joining becomes more attractive with lower supplementary feeding costs and less so with a higher cost, but maintains profitability. There are no other changes in NPV/DSE of consequence for the flock rebuilding strategies to note as a result of lower or higher supplementary feeding costs.

4.2.2 Variation in Stock Prices (includes sale, inventory, purchase and ram values)

The sensitivity of flock rebuilding strategies to variation in stock prices (20% lower of 20% higher than the assumed standard prices) in terms of NPV/DSE values are listed in Tables 6 and 7 for a self-replacing dual purpose Merino flock and a self-replacing Maternal flock, respectively.

Table 6. The effect of a 20% change (lower and higher than the standard stock prices) on Net Present Values/dry sheep equivalent values ($) and rank for flock rebuilding strategies (self-replacing dual purpose Merino flock).

Flock Rebuild Strategy	**Self-replacing dual purpose Merino flock**		
	20% Lower Stock Prices	**Standard Stock Prices**	**20% Higher Stock Prices**
1. Retain older ewes	**$112**	**$153***	**$194**
2. Retain more young ewes	$9	$18	$27
3. Buy ewe hoggets	**$81**	**$115**	**$148**
4. Buy aged ewes	**$62**	**$92**	**$121**
5. Increasing fertility & fecundity			
5a. feeding energy pre-joining	**-$26**	**-$8****	$40
5b. flushing with lupins	**-$26**	$22	$70
5c. Ovastim injection	**$54**	**$102**	**$150**
6. Increase survival of twin lambs	**$105**	**$153**	**$201**
7. Join ewe lambs	$34	$78	$121
8. Re-join dry ewes	**$127**	**$170**	**$213**
9. Increase Merino x Merino matings	$13	$24	$35
10. Accel. Lambing – Type 1	**-$6**	$1	$50
11. Accel. Lambing – Type 2	**-$4**	$7	$56
12. Sexed semen use	**-$329**	**-$335**	**-$342**

*Top 6 strategies are emboldened and coloured in blue font, unless NPV/DSE is negative
**Strategies with negative values are coloured in red font

For self-replacing dual purpose Merinos, varying stock prices by 20% had little effect on the rank (based on NPV/DSE value) of flock rebuilding strategies, with the top 6 of 16 strategies remaining unchanged (as previously listed above when discussing the effect of varying supplementary feeding costs). However, with 20% lower stock prices, while all still profitable, the NPV/DSE values for the top 6 six flock rebuilding strategies were typically reduced by 25% to 33%, the most affected strategy being Ovastim vaccination (with a decline of 47% in NPV/DSE). Conversely, a 20% increase in stock prices increased the profitability of most flock rebuilding strategies considered, with the NPV/DSE values for the top 6 strategies typically increasing by 25% to 32%.

With 20% higher stock prices (compared to the prices assumed in the standard model), some flock rebuilding strategies previously lowly ranked, become more profitable. In particular, Strategy 7. Join ewe lambs, become more worthwhile (increasing to rank 7th out of 16, similar to Strategy 4. Buy aged ewes), with accelerated lambing systems and feeding energy supplements pre-joining to improve ewe condition score also assessed as having NPV/DSE values of $40 or better. Also, Strategy 5b. Flushing with lupins became more profitable under a high stock price scenario. However, with the exception of Strategy 7. Join ewe lambs, these strategies become unprofitable if there were to be a 20% decrease in stock prices from their currently assumed values and are therefore assessed as being more unreliable economically to use that the top 6 ranked strategies, as well as generally being less profitable, regardless of reigning stock prices.

Under all stock price assumptions, Strategy 12. Sexed-semen use, to generate a higher proportion of female progeny, was a distinctly unprofitable flock rebuilding strategy.

For a self-replacing Maternal flock, again the top 6 flock rebuilding strategies remained the top 6 (as previously listed above when discussing the effect of varying supplementary feeding costs), each with the same rank. At 20% lower stock prices, the top 6 strategies all remained profitable, but decreased in NPV/DSE by 29 to 47% compared to the assumed standard prices. However, some lower-ranked flock rebuilding strategies, either became unprofitable (Strategy 2 - Retain more young ewes) or became more marginal in profitability (Strategy 4 - Buying aged ewes and Strategy 5a. Feeding energy supplements pre-joining). At 20% higher stock prices, all bar 3 flock rebuilding strategies (Accelerated lambing systems, Strategies 10 and 11 and Strategy 12 – Use of sexed semen) became profitable. At 20% higher stock prices, the top 6 strategies increased in NPV/DSE by 30 to 47% compared to the assumed standard prices.

Table 7. The effect of a 20% change (lower and higher than the standard stock prices) on Net Present Values/dry sheep equivalent values ($) and rank for flock rebuilding strategies (self-replacing Maternal flock)

Flock Rebuild Strategy	**Self-replacing Maternal flock**		
	20% Lower Stock Prices	**Standard Stock Prices**	**20% Higher Stock Prices**
1. Retain older ewes	**$78**	**$129***	**$180**
2. Retain more young ewes	**-$2**	$16	$33
3. Buy ewe hoggets	**$52**	$98	**$144**
4. Buy aged ewes	$39	$82	$125
5. Increasing fertility & fecundity			
5a. feeding energy pre-joining	$14	$71	$129
5b. flushing with lupins	$42	**$99**	**$157**
5c. Ovastim injection	**$92**	**$149**	**$207**
6. Increase survival of twin lambs	**$105**	**$162**	**$219**
7. Join ewe lambs	**$62**	**$115**	**$167**
8. Re-join dry ewes	**$121**	**$171**	**$222**
9. Increase Merino x Merino matings	N/A	N/A	N/A
10. Accel. Lambing – Type 1	**-$58**	**-$36**	**-$14**
11. Accel. Lambing – Type 2	**-$51**	**-$25**	$0
12. Sexed semen use	**-$257**	**-$253**	**-$248**

*Top 6 strategies are emboldened and coloured in blue font, unless NPV/DSE is negative
**Strategies with negative values are coloured in red font

4.2.3 Variation in Flock Structure

The effect of using an older flock structure (ewes given 6 annual mating opportunities and culled at 7.5 years of age compared to culling at 5.5 years of age, with only 4 annual mating opportunities given) on the NPV/DSE of flock rebuilding strategies and their rank, is documented in Table 8 for a self-replacing dual purpose Merino flock. Note that a 10% lower lamb marking% for adult ewes is assumed in the older flock structure (and 5% lower for maiden ewes).

Note that reproductive performance under an older flock structure is assumed to be 10% lower for adult ewes. This assumption was made from observations that older flock structures are often associated with lower reproductive performance and a need to carry more ewe age groups to generate sufficient flock replacements after allowing for some culling of ewe lambs and hoggets.

Table 8. The effect of using an older ewe flock structure (6 age groups vs 4) on Net Present Values/dry sheep equivalent values ($) and rank for flock rebuilding strategies

Flock Rebuild Strategy	**Flock Structure - self-replacing dual purpose Merino flock**	
	Standard: 4 ewe age groups *100% lamb marking% for adult ewes* *90% for hogget ewes*	**Older: 6 ewe age groups** *90% lamb marking% for adult ewes* *85% for hogget ewes*
1. Retain older ewes	**$153***	**$157**
2. Retain more young ewes	$18	**-$4**
3. Buy ewe hoggets	**$115**	**$59**
4. Buy aged ewes	**$92**	**$217**
5. Increasing fertility & fecundity		
5a. feeding energy pre-joining	**-$8****	**-$17**
5b. flushing with lupins	$22	$16
5c. Ovastim injection	**$102**	**$103**
6. Increase survival of twin lambs	**$153**	**$122**
7. Join ewe lambs	$78	$37
8. Re-join dry ewes	**$170**	**$175**
9. Increase Merino x Merino matings	$24	$10
10. Accel. Lambing – Type 1	$1	**-$1**
11. Accel. Lambing – Type 2	$7	**$5**
12. Sexed semen use	**-$335**	**-$432**

*Top 6 strategies are emboldened and coloured in blue font, unless NPV/DSE is negative
**Strategies with negative values are coloured in red font and emboldened

The top 6 flock rebuilding strategies remained the top 6 under an older flock structure. However, the biggest effect of assuming an older age structure is that Strategy 4. Buy old ewes (5.5 year-old ewes), becomes the most profitable, with Strategy 3. Buy ewe hoggets, becomes relatively less profitable. This is not totally surprising, as ewes purchased at 5.5 years of age can still be bred for 2 years before being culled under an older age structure, whereas they can only be bred for 1 year under the standard flock structure. Other changes in profitability and ranking of flock rebuilding strategies from changing to an older flock structure are relatively minor. Strategies 2 (retaining more young ewes), 10 and 11 (accelerated lambing systems) become unprofitable and joining ewe lambs, whilst still profitable, becomes less so.

4.3 Flock rebuilding options in the rangelands zone

Flock rebuilding options in the rangelands zone are more limited for a number of practical reasons. In particular, the infrequent mustering of flocks to only the key events of shearing and lamb marking (and possibly pregnancy scanning) severely limits the opportunities for more intense management.

For these reasons, flock rebuilding options qualifying as both profitable and practical in the rangelands zone are:
Strategy 1. Retain older ewes for both self-replacing Merino and Cleanskin flock types (provided ewes are sound and have a high probability of surviving).
Strategy 3. Buy in hogget ewes for a self-replacing Merino flock type, when feed availability is strong.
Strategy 8. Re-join dry ewes for both self-replacing Merino and Cleanskin flock types. However, this strategy may be more practical in a rangelands zone for self-replacing Merinos if re-mating is delayed until the next annual mating time, so that lambing is not spread out over 2 times of the year. This is not so critical for Cleanskin flock types.

4.4 Intangible barriers to flock rebuilding

In relation to this section, the project contract states '*identify and report intangible barriers to flock rebuilding including*

a. Struggling with making timely decisions
b. Acting too promptly when signs of dry seasons appear
c. Lacking a positive outlook despite positive external conditions
d. Concerns about biosecurity when buying ewes
e. Lacking confidence to deal with challenges to cash flow
f. Need for example business case for bank manager'

The following other intangible barriers can also be added:

g. Concerns about the lack of ability to reliably assess genetic merit when buying ewes.
h. Perception of additional stress from managing more mobs and, or, bigger mobs.
i. Some producers may not see the need to increase flock size, as they are making good returns because of current high sheep meat prices.
j. Some producers may also perceive that increasing flock sizes (their own and those of other producers) may flood the meat and wool markets, driving down prices.

Whilst all these barriers are likely to limit the implementation of flock rebuilding by some sheep producers, the importance of a number of these intangible barriers is likely to vary according to the actual flock rebuilding strategy. To consider the relative importance of these intangible barriers, a hierarchy of the order in which flock rebuilding strategies should be considered for implementation is described. This hierarchy commences with the simplest and easiest to implement strategies and progresses to other categories of strategies that need increasingly more inputs of management planning, monitoring, resources and skills to achieve a successful outcome.

The broad categories of strategies (and individual strategies within each category) are listed below.

i. Utilise more home-bred ewes or purchase more *(simplest and easiest to implement)*

- Retain older ewes (Strategy 1)
- Retain more younger ewes (Strategy 2)
- Purchase young (Strategy 3) or old ewes (Strategy 4)

ii. Improve fertility and lamb survival *(reduce reproductive wastage – good profitability, but requires more managerial input e.g. utilising scanning results)*

- Re-join dry ewes (Strategy 8)
- Improve twin-lamb survival (Strategy 6)

iii. Increase reproductive potential (*boost ovulation rate & frequency of joining, join ewe lambs – need to successfully address improving twin lamb survival before considering these*):

- Energy supplements to increase CS pre-joining (Strategy 5a)
- Flushing with lupins (Strategy 5b)
- Ovastim (Strategy 5c)
- Accelerated lambing systems (Strategies 10 and 11)
- Join ewe lambs (Strategy 7)

Intangible barriers have been discussed in Table 9 below in the context of this hierarchy of flock rebuilding strategies:

Table 9. Comments on intangible barriers for the differing categories of flock rebuilding strategies

Category of flock Rebuilding	Comment on intangible barriers
i. Utilise more home-bred ewes or purchase more	Retaining older ewes (Strategy 1) avoids the biosecurity risks of purchasing stock and only lowers cash flow temporarily. This can be reduced by retaining a smaller proportion of older ewes each year, but repeating the strategy over 2-3 years. If purchasing ewes (Strategies 2 and 3), the biosecurity risks can be reduced (but not eliminated) by buying from a known source and strictly adhering to a biosecurity plan. Cash flow is negative for first 2-3 years with buying young ewes, but the strategy is profitable and leads to rapid flock rebuilding.
ii. Improve fertility and lamb survival	Re-joining ewes scanned as dry (Strategy 11) and improving twin lamb survival (Strategy 6) are low risk, profitable and do not negatively impact cash flow. They will have a positive effect from extra progeny sold, plus extra replacements for flock rebuilding. However, sheep producers need to pregnancy scan. Re-joining dry ewes is the simplest to implement, but will require additional management input because of an additional lambing time.
iii. Increase reproductive potential	Generally, these strategies are more marginally profitable, need more managerial input and skill to ensure good lamb and ewe survival rates and, if joined, good ewe lamb performance. Only consider these strategies if achieving lamb survival rates of 90% for singles and 70-75% for twins. That is, ensure that the recommendations for ewe condition score (CS) at joining, nutrition during joining and late pregnancy, CS pre lambing, and lamb survival are being met first.

4.5 Pros and cons of individual flock rebuild strategies

General. As outlined in the Methodology Section (3.1.1), the project team used a range of metrics to assess the economics of the flock rebuilding options investigated (NPV per DSE, NPV or NPV per hectare, Internal Rate of Return and Benefit to Cost ratio).

The chosen method presented in the results section, NPV per DSE (or BCR, when an NPV could not be calculated), in the main has adequately represented the relative profitability of each of the flock rebuilding strategies investigated, with some exceptions presented (Table 10) and discussed below.

Table 10. A descriptive comparison of economic measures of profitability of a sub-set of the flock rebuilding strategies investigated. NPV is the Net Present Value ($), DSE is dry sheep equivalents and BCR is the Benefit to Cost Ratio.

Flock Rebuilding Strategy	NPV	NPV/DSE or BCR	DSE
Strategies 2 and 4. Buy hogget and older ewes, respectively	High	Moderate	High
Strategy 8. Rejoin dry ewes	Moderate	High	Low
Strategy 9. Increase Merino x Merino matings	Low	Low	Low
Strategies 10 and 11. Accelerated lambing, Type 1 and 2, respectively	High	Low or zero	Very High

For Strategy 8. Rejoin dry ewes, the combination of a moderate NPV and a low DSE resulted in a high NPV per DSE value, which can be somewhat misleading. This is discussed further in the specific section on the pros and cons of Strategy 8.

For Strategies 10 and 11. Accelerated lambing systems, it is assumed that, as soon as these strategies are implemented, there will be a large and immediate increase in the number of dry sheep equivalents on the modelled property, beyond the target DSE capacity, even before any more progeny have been bred. These very high DSE numbers, when applied to calculate the NPV per DSE value, assuming the NPV is positive, create a low value close to zero and may underestimate the actual profitability of these options. There is no easy way to fix these shortcomings, other than to examine and interpret a range of the economic metrics calculated, or use a different methodology entirely (not contemplated).

For the rest of flock rebuilding options examined, such as those listed in Table 10 (Strategies 2, 4 and 9), the measures of NPV, NPV and DSE provide a consistent ranking.

Strategy 1 - Retaining older ewes. How old can ewes be retained for? There are documented declines in productivity, with fleece weights in Merinos tending to decline from ~2 years of age (Brown *et al.* 1966, Mullaney and Brown 1969, Cloete *et al.* 2003 and Safari *et al.* 2007). Fibre diameter increases with age (Brown *et al.* 1966, Mullaney and Brown 1969, Langlands *et al.* 1984, Cloete *et al.* 2003 and Safari *et al.* 2007). In contrast, reproductive performance tends to increase with age and peaked at 6 years of age on the central west plains of NSW in the study of Richards, Sladek and Lee (2018), although the authors noted that 'better genetics or environments show a minimal loss in productivity from increased age of animals, but ewes with poorer genetics, or those in harsher environments need to be more closely monitored. Therefore, the environment and ewe genotype should influence the choice of age structure'.

If a flock is already old, there will not be much scope for retaining older age groups. However, there is probably an underlying issue with lower reproductive rates driving the need to keep more ewe age groups in a stable flock situation (i.e. not attempting to build up ewe numbers, just maintain them) and attention to fixing that issue first seems logical before adopting other flock rebuilding strategies.

Strategy 3 – Purchasing older ewes. In modelling this strategy, it is assumed that 5.5 year-old ewes are purchased and kept for 1 year of breeding before being culled. If this strategy is repeated for more than one year, or if the purchased ewes are still in good condition and are mated and kept for a second year of breeding, more rapid flock rebuilding will ensue compared with only retaining these purchased ewes for one year.

Strategies 5a to 5c - Increasing fertility and fecundity strategies. The project team and the producer reference group had concerns that use of these strategies can lead to higher rates of lamb mortality, as it is well known that mortality is higher with increasing fecundity (litter size) (Hinch and Brien, 2014). If not addressed, limited additional lambs marked and weaned will be obtained. With those concerns in mind, there is a need to improve ewe nutrition during pregnancy, to meet recommended condition score targets for lambing BEFORE contemplating increasing fecundity.

The project team also had concerns about the variability of response, particularly for:

- Strategy 5b - flushing with lupins. Croker *et al.* (1985) documented a very large range of on-farm responses in lamb marking% (-14% to +21%) from lupin feeding pre-joining/into the start of joining. In the more recent trial work reported by Gaunt *et al.* (2017), a significant increase in conception rates (foetuses scanned/ewes joined) compared to unsupplemented ewes on dry pasture was only obtained on 5 of the 8 properties that included lupin grain supplementation (ranging from 3 to 21 extra foetuses per 100 ewes joined).
- Strategy 5c - Use of Ovastim vaccination. Anecdotally, the project team and the producer reference group have heard widely different accounts of how successful or otherwise use of Ovastim vaccination has been. It is difficult to reconcile these accounts, other than raise them and emphasise the importance of ewes meeting nutritional guidelines for condition score, particularly by lambing time, according to the litter size they carry.

***Strategy 6 - Improving lamb survival*.** This strategy is targeted at increasing the survival of twin-born lambs (from 60% to 67%). It has not assumed any improvement in single-born lambs. However, there was an increase of 6% in survival with a full condition score increase in ewe condition scoring at lambing in the study of Behrendt *et al.* (2011), so a 0.5 condition score improvement should be associated with a 3% increase in the survival of single-born Merino lambs, hence the assumptions in the modelling err on the conservative side.

This strategy requires that a sheep producer has pregnancy scanning data for foetal numbers to be able to identify which ewes are bearing twins (or multiples) and that they have the ability to accurately assess ewe condition score. However, as only 31% of Australian sheep producers currently scan for foetal numbers (Howard and Beattie, 2018), less than 1 in 3 producers will meet the requirement for data on litter size of individual ewes.

Strategy 7 - Joining ewe lambs. The project team had concerns on the variability of results. The latest literature recommends that ewe lambs are gaining live weight (at least 100 g/day) throughout joining at the very least and is considered more important than the absolute mating weight itself (Thompson *et al.* 2019, 2021). This implies that considerable managerial input is required in providing adequate feed rations and monitoring ewe lambs to obtain a successful result. However, sheep producers who are able to achieve good performance from the mating of ewe lambs are in a good position to help rapidly rebuild their flock. The strategy has high profitability for a self-replacing Maternal flock situation, but is also profitable for a self-replacing dual purpose Merino flock, where lower reproductive performance has been assumed.

Strategy 8 - Re-joining dry ewes (recorded as 'once-dry'). Although this invariably is one of the most profitable strategies (on a dry sheep equivalent basis), the effect of this strategy on increasing stock numbers is very modest, as shown in Figures 6 and 7. After 5 years of implementation, only 200 of the extra 750 DSEs required to meet the DSE target for the modelled property have been achieved using this strategy.

Further, our assumptions are based on research findings from re-joining at the following annual joining time (Hatcher *et al.* 2018 and K. Atkins, personal communication) , not re-joining more or less immediately following a pregnancy scanning, within the same breeding season. So, there is some uncertainty around our assumptions of re-breeding rates. To re-join these ewes within the same breeding season, it is highly desirable that ewes are pregnancy-scanned, with re-mating occurring immediately afterwards. Indeed, some sheep producers pre-empt scanning results, by re-joining the entire flock at least 2-3 weeks after the completion of the first joining, similar to use of a back-up natural mating following an AI mating program.

Re-joining dry ewes in the same breeding season will involve a second lambing period (for a relatively small mob) on the property, which will be later than the chosen lambing date preferred by the sheep producer for the main flock. From a practical perspective, the sheep producer will need to decide whether the extra management and logistics involved is worth the effort, given the modest increase in stock numbers.

It is important to emphasize that this option is based on re-joining ewes recorded as dry only once. Ewes recorded as twice-dry, either at scanning time or at lambing time (including those that actually lamb, but fail to rear) need to be culled from the flock, as they will subsequently wean only half as many lambs as the flock average (Hatcher *et al.* 2018).

Finally, there is currently some conjecture about the typical proportion of ewes that are scanned 'dry'. Large-scale on-farm studies, such as that reported by Kleemann and Walker (2005), indicated that slightly less than 10% of mature Merino ewes were scanned as dry. However, a current investigation of scanning data from over 5 million ewes, collected over 11 to 13 years suggests that the proportion of ewes scanned as 'dry' exceeds 20% (S. deGraaf, personal communication). If this is confirmed by further analysis, the strategy of re-joining once-dry ewes (as assessed at pregnancy scanning) may, depending on flock type, end up being a more important strategy to reduce reproductive wastage than first thought.

Strategies 10 and 11 - Accelerated lambing systems. With little published data to refer to, conservative assumptions have been used for the feeding of ewes and lambs, especially for those lambs born out of season. Per ewe, an extra $33.95 is assumed in feeding costs (which is an extra 97 kg @ 35 cents/kg), plus an extra husbandry/labour cost of $20. However, even if the amount of extra feed and husbandry required has been grossly overestimated, a dramatic reduction of these costs (assume 17.5% of extra feed required is supplement, rather than 35% and extra husbandry/labour cost is $10/ewe, not $20/ewe), the flock rebuilding strategy of accelerated lambing – type 2, as used at Turretfield Research Centre from 2008 to 2011, whilst becoming more profitable, is still only ranked 9th out of 16 strategies (based on NPV per DSE), compared with 12th out of 16 for a self-replacing dual purpose Merino flock.

5. Conclusion

The project has provided a strong platform for assessing the merits of a range of flock rebuilding strategies across the main flock types and geographical zones in Australia where sheep are run.

The project team assessed a total of 14 individual flock rebuilding strategies, which can be categorised into 3 broad groups, which are:

i. Utilise more home-bred ewes or purchase more ewes
ii. Improve fertility and lamb survival
iii. Increase reproductive potential

In a broad sense, flock rebuilding strategies assessed as being profitable to highly profitable and that could also help rebuild flock numbers quickly mainly belonged to category i. *Utilise more home-bred ewes or purchase more ewes*. Category ii. *Improve fertility and lamb survival* strategies, although profitable as flock rebuilding strategies, do not have the same immediate capacity to rapidly rebuild flock numbers as category i. strategies.

The simplicity and ease of implementation of category i. flock rebuilding strategies is one of the main reasons why they are already well adopted in the Australian sheep industry. This is especially the case with the strategy of retaining more older ewes, which is the predominant method being adopted by sheep producers to rebuild their flocks, according to the latest MLA & AWI wool and sheepmeat survey results for June 2021 (as noted in the introduction).

Despite the current high stock prices, purchasing in young ewes in particular (and to a lesser extent, older ewes, typically cast-for-age at 5-6 years of age) is a profitable strategy to rapidly rebuild stock numbers. Sheep producers with self-replacing flocks that do not regularly purchase in replacements (apart from rams) may be understandably concerned about the biosecurity risk, the cash flow implications and the uncertainty of the genetic merit of purchased ewes sourced from outside their own flocks. These concerns need careful consideration and weighing against other flock rebuilding options, which is one of the ways the outputs of this project can be of assistance.

Some of the flock building strategies that fall into Category iii. *Increase reproductive potential*, can be profitable. However, the project team and the producer reference group believe strongly that before these strategies are considered, especially those that increase litter size, the fundamental recommendations around ewe condition score at joining, nutrition during joining and late pregnancy, ewe condition score pre- lambing, and lamb survival (singles at 90% and twins at 70-75%) need to be met first.

5.1 Key findings

The top 6 flock rebuilding strategies for profitability, as ranked on Net Present Value/Dry Sheep Equivalents ($), or by Benefit/Cost ratio, regardless of flock type, invariably included (with exceptions noted):

- Strategy 8 – re-join once-dry ewes (in the same breeding season) scanned once as dry, noting that the predicted impact on increasing stock numbers is only modest
- Strategy 1 – retain more older ewes
- Strategy 3 – purchase young (hogget ewes)

- Strategy 4 – purchase older ewes (mostly 5-6 year olds) – in Merino and Merino cross flock types, not in Maternal flocks or Cleanskin flock types
- Strategy 5c – Use of Ovastim vaccination to increase fecundity
- Strategy 6 – Increase survival of twins by improving ewe condition score by 0.5 pre-lambing
- Strategy 7 – Joining ewe lambs – in Maternal and Clean Skin flock types, not Merinos

When also assessed for their ability to rapidly rebuild flock numbers, the qualifying strategies were restricted to:

- Strategy 1 – retain more older ewes
- Strategy 3 – purchase young (hogget ewes)
- Strategy 4 – purchase older ewes (mostly 5-6 year olds) – in Merino and Merino cross flock types, not in Maternal flocks or Cleanskin flock types
- Strategy 7 – Joining ewe lambs – in Maternal and Clean Skin flock types, not Merinos

These top 6 flock rebuilding strategies were not very sensitive to variations in supplementary feeding costs, changes in stock prices, nor different flock age structures. However, there are some exceptions to these general findings:

- At 23% lower supplementary feed costs, the profitability of joining ewe lambs moved up in ranking, to be in the top 6 for a self-replacing dual purpose Merino flock type
- With an older age structure in a self-replacing dual purpose Merino flock type, where ewes are retained to 7.5 years of age rather than 5.5 years of age, purchasing 5.5 year old ewes becomes the most profitable flock rebuilding strategy

Strategy 5a – feeding of energy supplements pre-joining to improve ewe condition score by 0.5 to increase reproductive potential was unprofitable in a self-replacing dual purpose Merino flock, but was profitable in a self-replacing Maternal flock and in a Cleanskin flock in the agricultural zone. However, when the cost of supplementary feeding was 23% lower than the assumed standard values, the strategy also became profitable for a self-replacing dual purpose Merino flock.

Strategy 5b – flushing with lupins around joining time, assumed to last for 14 days, was profitable in most flock types and regions, except the rangelands, and for dual purpose Merinos, the strategy became unprofitable with 23% higher supplementary feeding costs and 20% lower stock prices. Caution should however be applied to this finding, given the highly variable responses documented in Western Australian farm trials (Croker *et al.* 1985) and more recently in on-farm trials in the south-east of Australia (Gaunt *et al.* 2017).

Strategy 9. Increasing Merino x Merino matings. This strategy, although not among the top 6, is modestly profitable in dual purpose Merinos (and not sensitive to higher or lower supplementary feed costs or stock prices, or a change of flock structure from 4 to 6 breeding age groups) and where the flock is wool focussed. Under the assumptions made in this study, the strategy is slightly unprofitable for Merinos in a rangeland environment.

Finally, Strategy 12 – use of sexed semen to breed mostly female offspring were assessed as a very unprofitable method of flock rebuilding across all flock types and this result was not sensitive to variations in feed costs, stock prices or flock structure.

5.2 Benefits to industry

Recommendations as a result of the findings of this project are as follows:

a. Flock rebuilding strategies involved retention of older ewes and purchasing in additional ewes are, in general, more profitable and allow more rapid rebuilding than any other methods investigated. These are the primary methods of flock rebuilding to promote to the red meat industry.
b. Joining of ewe lambs, although requiring more managerial input, monitoring and skill level to implement than retaining older ewes and purchasing additional ewes, has the capacity to have good profitability and rapidly rebuild flock numbers. In particular, further development and refinement of guidelines for the management of ewe lambs to facilitate good levels of mating and lambing performance, is highly recommended, noting that some sheep producers are already obtaining consistently good results.
c. The re-joining of once dry ewes within the same breeding season (assessed as dry at pregnancy scanning), is a profitable flocking rebuilding method across all flock types assessed, with little exception. However, its contribution to the rate of flock rebuilding is very modest and implementation involves running an extra mob or mobs that lamb later than the main flock. The direct research data underpinning this recommendation is limited to results from annual mating scenarios. Claims made recently in the mass media state that once-dry ewes should not be given a second chance (the project team strongly disagrees). More relevant data than that obtained from once-yearly breeding is needed to refute these claims.

6. Future research and recommendations

In general, the project team, in consultation with the producer reference group and access to published and unpublished data were able to make defendable assumptions on performance of sheep for the purposes of the project. However, there were some aspects of performance, particularly the reproductive performance of sheep across a range of regions and different flock types that are not well documented and, in a few cases, assumptions could only be made based on best guesses. High amongst these uncertainties is the level of twin lamb survival being achieved on Australian farms, but also the level of fertility (in the narrow sense of the proportion of ewes that are pregnant), with some recent, but as yet unpublished data from 11-13 years of commercial pregnancy scanning data suggesting that fertility levels in Australian sheep may be considerably lower than assumed from earlier studies. These are high priority issues that need addressing at an industry-wide level, particularly by the Sheep Reproduction Strategic Partnership program.

R&D

- Up-to-date benchmarks of reproductive performance are needed across the key sheep regions, for the key breed/genotypes. This includes measurements of fertility, fecundity, and lamb survival rates by litter size
- Reproductive performance data from experimental flocks where once-dry ewes (assessed at scanning) are re-joined within the same breeding season and compared with the performance of ewes that were pregnant at first scan
- Detailed guidelines on optimal nutrition for non-Merino and Merino cross enterprises need to be made available. This is not only important for generally enhancing reproductive performance, but is vital for sheep producers contemplating the use of flock rebuilding strategies that increase ovulation rates and litter size, that run the risk of failure due to low levels of lamb survival in twins and multiple lambs born to ewes with non-optimised nutrition.

- The producer reference group recommended that the impact of using multiple flock rebuilding strategies should also be assessed. Although the project team agreed, it was considered beyond the immediate scope of the existing project.

Practical application of the project's insights

- The original aim of the project was focussed on flock rebuilding following a period of lower flock numbers arising from drought and a range of other factors. However, it has become apparent during the course of the project that flock rebuilding strategies are readily applicable as general flock expansion strategies, for example to stock newly acquired properties that have either been purchased or leased.
- Although a spreadsheet model could be made available from the project and adapted for more general use by consultants and producers, the project team questions whether such a tool would receive sufficient use to justify the additional investment required to make it fit for purpose.

Development and adoption activities which would ensure the red meat industry achieves full value from the project's findings

- The project team believes the principal means of extending the findings of the project are through use of targeted factsheets, but also podcasts, presentations to groups and integration of the findings into existing MLA and AWI courses

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8. Appendix

8.1 Assumptions in modelling of flock rebuilding strategies (self-replacing dual purpose Merino and Maternal flocks)

Assumption for modelling a self-replacing dual purpose Merino flock

Common assumptions to all rebuild pathways

	Sale/inventory value	Mortality rate	Cull rate if retained for another year
8-year-old	$ 100	9.0%	15.0%
7-year-old	$ 125	8.0%	13.0%
6-year-old	$ 150	6.0%	10.0%
5-year-old	$ 175	4.0%	6.0%
4-year-old	$ 200	3.5%	4.0%
3-year-old	$ 250	3.0%	3.0%
2-year-old	$ 275	2.5%	2.0%
Ewe hogget	$ 250	2.0%	9.0%
Ewe lamb	$ 165	2.0%	40.0%

	Lamb survival from scanning to weaning
Single bearing ewes	90%
Multiple bearing ewes	60%

Breeding flock productivity	Annual fleece value	Lambing %	Wether lamb sale value	Percentage of ewes scanned dry
Mature breeding ewes	$ 50.00	100%	$ 125.00	6%
Maiden ewes	$ 50.00	90%	$ 125.00	10%

Supplementary feed cost per tonne as fed	$ 260.00
Pasture cost per tonne as fed	$ 50.00
Ewe cull age	5.5
Average breeding ewe weight	65
Breeding ewe DSE rating (including raising a lamb)	2.5
Total annual feed cost per breeding ewe	$ 55.00
Ram cost per ewe joined	$ 6.35
Discount rate applied to future cashflows	3.5%

Retain older ewes

- Ewes retained for one extra year
- 200 retained in year 1
- 150 retained in year 2
- 100 retained in year 3
- None retained in year 4 and 5

Buy ewe hoggets

- Age at purchase – 1.5-year-old
- 150 head purchased at $300/head
- 15% reduction (from the average in the main flock) in lambing percentage in the first year as they adjust to the property
- Purchased as dry ewes

Buy aged ewes

- Age at purchase – 5.5-year-old
- Culled after 1 year
- 200 head purchased at $200/head
- 10% reduction (from the average in the main flock) in lambing percentage in the first year as they adjust to the property
- Purchased as dry ewes

More Merino x Merino joinings

- 200 ewes joined to a Merino instead of a terminal sire in years 1 and 2 and none after that
- 7% reduction in lambing percentage in Merino x Merino lambings when compared to crossbred lambings
- $35 decrease in progeny sale value

Retain additional young ewes

- 5% reduction in lifetime performance of ewes applied to account for the fact that they would normally be culls

	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**
Current ewe hogget cull rate	9%	9%	9%	9%	9%
New ewe hogget cull rate	8%	9%	9%	9%	9%
Current ewe lamb cull rate	40%	40%	40%	40%	40%
New ewe lamb cull rate	35%	35%	35%	40%	40%

Joining ewe lambs

	Lambing %	Lamb sale value	Additional husbandry costs	Additional feed costs
Ewe lambs	50%	$ 100.00	$ 10.00	$ 40.00

Increasing twin lamb survival

Cost of scanning per ewe inc. travel	$ 1.00
Total cost of feed to gain 0.5 condition scores	$ 4.55
Previous twin lamb survival	60%
New twin lamb survival	67%

Flushing with lupins

Number of days on lupins	14
Lupins fed grams/head/day	500
Total amount fed per ewe (kg)	7.0
Cost of lupins $/t	$ 450
Feed out costs $/t	$ 100
Total cost as fed $/t	$ 550
Cost of lupins per ewe	$ 3.85
Feed costs for each additional twin bearing ewe to account for increased demand in late pregnancy and lactation	$ 6.25
Uplift in scanning percentage	10%

Feeding energy pre-joining

Feed cost per ewe	$ 4.55
Feed costs for each additional twin bearing ewe to account for increased demand in late pregnancy and lactation	$ 6.25
Uplift in scanning percentage	10%

Ovastim injection

Ovastim injection cost per ewe	$4.00
Feed costs for each additional twin bearing ewe to account for increased demand in late pregnancy and lactation	$6.25
Uplift in scanning percentage	20%

Re-join dry ewes

	Reduction in lambing percentage in comparison to the main flock	Reduction in lamb sale value in comparison to the main flock. To account for the lighter turn off weight with a later lambing
Mature breeding ewes	-15%	-$ 25
Maiden ewes	-15%	-$ 25

Accel. Lambing – Type 1

Additional DSE rating per breeding ewe	0.6
Proportion of extra feed demand fed by supplementary feed	30%
Total annual cost of feed per ewe	$ 30.66
Extra husbandry/labour cost/ewe	$ 15.00
Total extra costs per ewe	$ 45.66
Reduction in ewe lamb sale/inventory value to account for lighter turn off	-$ 30
Reduction in wether lamb sale value to account for lighter turn off	-$ 25
Annualised lambing percentage – Breeding ewes	143%
Annualised lambing percentage – Maiden ewes	128%

Accel. Lambing – Type 2 (Turretfield)

Additional DSE rating per breeding ewe	0.6
Proportion of extra feed demand fed by supplementary feed	35%
Total annual cost of feed per ewe	$ 33.95
Extra husbandry/labour cost/ewe	$ 20.00
Total extra costs per ewe	$ 53.95
Reduction in ewe lamb sale/inventory value to account for lighter turn off	-$ 30
Reduction in wether lamb sale value to account for lighter turn off	-$ 25
Annualised lambing percentage – Breeding ewes	150%
Annualised lambing percentage – Maiden ewes	135%

Use of sexed semen

- 200 ewes artificially inseminated in year 1, 2 and 3 and none in years 4 and 5

Cost of semen per dose	$ 30
Cost of artificial insemination per ewe	$ 40
Cost of sexing semen	$ 30
Total semen/AI costs per ewe	$ 100
Conception rate to AI	60%
Conception rate to back up rams	30%
Percentage of ewes scanned dry	10%
Lambing percentage (inc. AI and back up conceptions)	100%
Percentage of AI sired lambs born as ewes	70%

Assumptions for modelling the self-replacing maternal flock

Common assumptions to all rebuild pathways

	Sale/inventory value	Mortality rate	Cull rate if retained for another year
8-year-old	$ 100	9.0%	15.0%
7-year-old	$ 125	8.0%	13.0%
6-year-old	$ 150	6.0%	10.0%
5-year-old	$ 175	4.0%	6.0%
4-year-old	$ 200	3.5%	4.0%
3-year-old	$ 250	3.0%	3.0%
2-year-old	$ 275	2.5%	2.0%
Ewe hogget	$ 250	2.0%	9.0%
Ewe lamb	$ 165	2.0%	45.0%

	Lamb survival from scanning to weaning
Single bearing ewes	90%
Multiple bearing ewes	70%

Breeding flock productivity	Annual fleece value	Lambing %	Wether lamb sale value	Percentage of ewes scanned dry
Mature breeding ewes	$ 10.00	135%	$ 160.00	3%
Maiden ewes	$ 10.00	120%	$ 160.00	8%

Supplementary feed cost per tonne as fed	$ 260.00
Pasture cost per tonne as fed	$ 50.00
Ewe cull age	5.5
Average breeding ewe weight	70
Breeding ewe DSE rating (including raising a lamb)	2.5
Total annual feed cost per breeding ewe	$ 55.00
Ram cost per ewe joined	$ 7.35
Discount rate applied to future cashflows	3.5%

Retain older ewes

- Ewes retained for one extra year
- 200 retained in year 1
- 150 retained in year 2
- 100 retained in year 3
- None retained in year 4 and 5

Buy ewe hoggets

- Age at purchase – 1.5-year-old
- 160 head purchased at $300/head
- 15% reduction (from the average in the main flock) in lambing percentage in the first year as they adjust to the property
- Purchased as dry ewes

Buy aged ewes

- Age at purchase – 5.5-year-old
- Culled after 1 year
- 200 head purchased at $200/head
- 10% reduction (from the average in the main flock) in lambing percentage in the first year as they adjust to the property
- Purchased as dry ewes

Retain additional young ewes

- 5% reduction in lifetime performance of ewes applied to account for the fact that they would normally be culls

	Year 1	Year 2	Year 3	Year 4	Year 5
Current ewe hogget cull rate	9%	9%	9%	9%	9%
New ewe hogget cull rate	8%	9%	9%	9%	9%
Current ewe lamb cull rate	45%	45%	45%	45%	45%
New ewe lamb cull rate	40%	40%	40%	45%	45%

Joining ewe lambs

	Lambing %	Lamb sale value	Additional husbandry costs	Additional feed costs
Ewe lambs	70%	$ 130.00	$ 10.00	$ 40.00

Increasing twin lamb survival

Cost of scanning per ewe inc. travel	$ 1.00
Total cost of feed to gain 0.5 condition scores	$ 4.90
Previous twin lamb survival	70%
New twin lamb survival	77%

Flushing with lupins

Number of days on lupins	14
Lupins fed grams/head/day	500
Total amount fed per ewe (kg)	7.0
Cost of lupins $/t	$ 450
Feed out costs $/t	$ 100
Total cost as fed $/t	$ 550
Cost of lupins per ewe	$ 3.85
Feed costs for each additional twin bearing ewe to account for increased demand in late pregnancy and lactation	$ 6.25
Uplift in scanning percentage	10%

Feeding energy pre-joining

Feed cost per ewe	$ 4.90
Feed costs for each additional twin bearing ewe to account for increased demand in late pregnancy and lactation	$ 6.25
Uplift in scanning percentage	10%

Ovastim injection

Ovastim injection cost per ewe	$4.00
Feed costs for each additional twin bearing ewe to account for increased demand in late pregnancy and lactation	$6.25
Uplift in scanning percentage	20%

Re-join dry ewes

	Reduction in lambing percentage in comparison to the main flock	Reduction in lamb sale value in comparison to the main flock. To account for the lighter turn off weight with a later lambing
Mature breeding ewes	-15%	-$ 30
Maiden ewes	-15%	-$ 30

Accel. Lambing – Type 1

Additional DSE rating per breeding ewe	0.6
Proportion of extra feed demand fed by supplementary feed	30%
Total annual cost of feed per ewe	$ 30.66
Extra husbandry/labour cost/ewe	$ 15.00
Total extra costs per ewe	$ 45.66
Reduction in ewe lamb sale/inventory value to account for lighter turn off	-$ 30
Reduction in wether lamb sale value to account for lighter turn off	-$ 30
Annualised lambing percentage – Breeding ewes	173%
Annualised lambing percentage – Maiden ewes	158%

Accel. Lambing – Type 2 (Turretfield)

Additional DSE rating per breeding ewe	0.6
Proportion of extra feed demand fed by supplementary feed	35%
Total annual cost of feed per ewe	$ 33.95
Extra husbandry/labour cost/ewe	$ 20.00
Total extra costs per ewe	$ 53.95
Reduction in ewe lamb sale/inventory value to account for lighter turn off	-$ 30
Reduction in wether lamb sale value to account for lighter turn off	-$ 30
Annualised lambing percentage – Breeding ewes	180%
Annualised lambing percentage – Maiden ewes	165%

Use of sexed semen

- 200 ewes artificially inseminated in year 1, 2 and 3 and none in years 4 and 5

Cost of semen per dose	$ 30
Cost of artificial insemination per ewe	$ 40
Cost of sexing semen	$ 30
Total semen/AI costs per ewe	$ 100
Conception rate to AI	60%
Conception rate to back up rams	30%
Percentage of ewes scanned dry	10%
Lambing percentage (inc. AI and back up conceptions)	135%
Percentage of AI sired lambs born as ewes	70%