Rangelands of central-western Queensland

Building resilient and diverse livestock production systems

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Note: the herd and flock models and analyses have been compiled in a modified version of the Breedcow and Dynama suite of programs. Please contact the authors if you would like a copy of any of the files.

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Summary

This report details the economic analysis of alternative livestock enterprises applicable to building resilience and profit in the rangelands of central-western Queensland. Accompanying reports in this series present strategies and results for other regions across Queensland's grazing lands. It is intended that these analyses will support the implementation of resilient grazing, livestock management, and business practices necessary to manage seasonal variability. The property-level, regionally-specific livestock and business models that we have developed can be used by consultants, advisors and producers to assess both strategic and tactical management decisions for specific properties.

We applied scenario analysis to allow assessment of alternative livestock enterprises for profitability and resilience. In doing this, we developed regionally representative models of the following enterprises: (1) self-replacing beef cattle herd, (2) steer finishing, (3) a self-replacing Merino wool flock, (3) Merino wether sheep, (4) meat sheep, and (5) rangeland meat goats. Firstly, biological and economic values derived from available data and producer experience were applied within the herd or flock budgeting models to identify the relative profitability of beef cattle, wool sheep, meat sheep, and meat goat enterprises in steady-state analyses. Secondly, partial discounted cash flow budgets were then applied to consider the value of integrating or fully adopting several of the alternative enterprises from a starting base of either a self-replacing (1) beef cattle herd or (2) wool sheep flock. The economic and financial effect of implementing each strategy was assessed by comparison to the base enterprise for the representative property. An investment period of 30-years was applied to consider the change in profit and risk generated by alternative management strategies. Changes in herd or flock structure, labour, capital and the implementation phase were included in the investment analysis.

It is important to note that the prices and costs applied in this analysis are heavily impacted by (1) current and past market circumstances and (2) the assumptions made about starting resources and property infrastructure. Taking the results of the analysis to represent the future prospects of any particular property or the potential enterprise mix for any property is not encouraged. Each individual property in the region will have an available set of resources and management skills which may have more influence on determining the final enterprise choice than (1) the cost of converting from one enterprise mix to another, or (2) the price and cost expectations for the alternative enterprises. Managers and others should use the framework applied in this analysis to develop their own investment strategies and mix of enterprises relevant to their own circumstances, expectations and available resources.

This report focusses on strategies to improve resilience and profit. Other reports in this series consider manager decisions made in response to, and recovery from, drought (Bowen and Chudleigh 2018b, Bowen *et al.* 2019a,b). We have not repeated this exercise here but instead refer readers to the previous reports which are available from the project internet page: https://futurebeef.com.au/projects/improving-profitability-and-resilience-of-beef-and-sheep-businesses-in-queensland-preparing-for-responding-to-and-recovering-from-drought/.   Additionally, spreadsheet tools that can be used to assess drought response and recovery options, and recorded presentations giving detailed explanation of how to use them, are provided on the project internet page.

Representative (base) property

A hypothetical (base) property was established to be representative of the central-western rangelands near Longreach. The base property was 16,200 ha of primarily native pastures growing on a range of land types common to the region. For most of the examples developed for the analysis, the simplifying assumption was initially made that an effective exclusion fence and ongoing wild dog control was already in place and that the property would be capable of running either beef cattle, wool sheep, meat sheep, or meat goats with minimal further expenditure. The land types and condition of the base property was based upon that developed for a previous analysis for the Central West Mitchell Grasslands region that focussed on assessing grazing management strategies (Bowen *et al.* 2019b). The land condition of the base property was set to be in B condition (ca. 70% of the pasture biomass as perennial grasses). An initial long-term stocking target of ca.1,071 adult equivalents (AE), or 9,000 dry sheep equivalents (DSE), was informed by experienced local livestock producers.

The profitability and resilience of alternative enterprises – steady-state analysis

The major challenges facing livestock producers in the central-western rangelands of Queensland are associated with the large inter-annual and decadal rainfall variability, and resulting major temporal variability in pasture production and enterprise profitability. To remain economically viable, and to build resilience to droughts, floods and market shocks, livestock producers need to increase profit and equity. To make timely and optimal management decisions producers need to assess the impact of alternative strategies on profitability, risk, and the period of time before benefits can be expected. The broad understanding gained from the property-level, steady-state analyses was that the expected profitability of the discrete livestock enterprise types could be quite different at the same standard of management. (Table 1). Meat sheep and rangeland meat goat enterprises produced the greatest rate of return on total capital (3.85 and 3.74%, respectively) followed by self-replacing wool sheep (3.26%). Steer finishing, or a self-replacing beef herd, produced intermediate returns (2.76 and 2.41%, respectively) while wether wool production enterprises produced the lowest returns (1.34 and 0.58% for 8 months or 12 months shearing intervals, respectively). An important assumption for the sheep and goat enterprise analyses was that wild dogs had minimal impact on the sheep or goat production system, i.e., that the property was already protected from wild dogs with suitable fencing. It was also assumed for the goat enterprise that internal fencing was already at a suitable standard to allow effective control of goats under rangeland conditions. The impact on investment returns, when changing from one enterprise to another, are considered in the next section.

Table 1 – Underlying assumptions and modelled property-level returns expressed as the operating profit, rate of return on total capital, and the gross margin per dry sheep equivalent (DSE) after interest, for alternative enterprises on a representative property in the rangelands of central-western Queensland

Calculation of property-level returns	**Enterprise scenario**						
	Beef cattle		**Merino wool sheep**			**Meat sheep (p. 77)**	**Rangeland meat goats (p. 85)**
	Self-replacing herd (p. 38)	**Steer finishing (p. 51)**	**Self-replacing flock (p. 54)**	**Wethers (8-month shearing) (p. 68)**	**Wethers (12-month shearing) (p. 68)**		
Assumed meat price ($/kg cwt)	$5.15	$5.28	$5.98	$3.80	$3.80	$6.46	$6.00
Assumed wool price ($/kg greasy)	-	-	$8.00	$7.94	$7.94	-	-
Net livestock sales	$373,431	$635,977	$347,340	$206,831	$206,831	$552,471	$480,741
Net wool sales	-	-	$294,892	$445,698	$356,558	-	-
Husbandry costs	$12,615	$1,645	$174,678	$115,459	$89,040	$9,535	$6,651
Net bull, steer, ram or buck replacement	$10,000	$251,807	$26,000	$265,098	$265,098	$58,000	$4,000
Gross margin (before interest)	*$350,816*	*$382,525*	*$441,554*	*$271,972*	*$209,251*	*$484,937*	*$470,090*
Gross margin/DSE after interest	*$33.92*	*$37.92*	*$43.97*	*$26.65*	*$19.68*	*$49.28*	*$48.80*
Fixed costs and labour	$87,500	$87,500	$97,500	$92,500	$87,500	$97,500	$102,500
Plant replacement allowance	$21,950	$21,950	$21,950	$21,950	$21,950	$21,950	$21,950
Allowance for operator's labour and management	$60,000	$60,000	$80,000	$65,000	$60,000	$80,000	$70,000
Operating profit	*$181,366*	*$213,075*	*$242,104*	*$92,522*	*$39,801*	*$285,487*	*$275,640*
Rate of return on total capital	*2.41%*	*2.76%*	*3.26%*	*1.34%*	*0.58%*	*3.85%*	*3.74%*

cwt, carcass weight; DSE, dry sheep equivalent.

Table 2 shows the sensitivity of five of the seven enterprises, when run as a sole enterprise on the constructed property, to a change in key parameters underpinning the models. Each parameter was varied by an amount relevant to the expected medium-term variability of each parameter. Operating profit for all enterprises, other than Merino wethers, was most sensitive to the meat price. For example, for the self-replacing beef enterprise, a 1% change in meat price had up to four times the impact on profit of any other factor. For the rangeland meat goat enterprise, a 1% change in the price of goat meat had five- or six-times greater effect on the level of farm operating profit than any of the other main parameters.

Table 2 - Expected impact on average operating profit of changing model parameter values for each alternative enterprise

Parameter	Percentage change relative to base				
	Self-replacing beef herd	**Self-replacing wool flock**	**Wethers (8 months shearing)**	**Meat sheep**	**Rangeland meat goats**
Wool price minus 20%	-	-25%	-98%	-	-
Wool price plus 20%		25%	98%		
Wool cut minus 20%	-	-24%	-96%	-	-
Wool cut plus 20%		24%	96%		
Meat price minus 20%	-43%	-31%	-48%	-41%	-36%
Meat price plus 20%	43%	31%	48%	41%	36%
Fixed costs minus 20%	10%	8%	18%	7%	7%
Fixed costs plus 20%	-10%	-8%	-18%	-7%	-7%
Treatment costs minus 20%	1%	14%	25%	1%	0%
Treatment costs plus 20%	-1%	-14%	-25%	-1%	0%
Mortality rate minus 50%	8%	7%	15%	2%	6%
Mortality rate plus 50%	-8%	-8%	-16%	-2%	-6%
Growth rate minus 5%	-1%	-3%[A]	12%[A]	-6%	0%
Growth rate plus 5%	1%	1%[A]	-12%[A]	-2%	4%
Weaning rate minus 5%	-2%	-5%	-	-4%	-6%
Weaning rate plus 5%	2%	3%	-	6%	5%

[A]No change in wool cut per head.

Conversely, the relative unimportance, of changes in the weaning rate and the growth rate of livestock on operating profit, suggests that implementing high-cost strategies to improve the expected level of these parameters may not be worthwhile. It appears better to focus on low-cost strategies that maintain these two factors, and mortality rates, at their expected levels. It should be noted that the percentage changes to operating profit indicated in Table 2 are ‘costless’. If an investment of either time or capital to change their expected level is required, this would reduce the impact of the level of response, depending upon the investment strategy chosen. The negative outcome shown for a positive change in the expected growth rate of lambs is due to rounding of flock numbers as they are transferred from Breedewe (meat sheep version) to the dynamic flock model. The increased growth rate of lambs would be expected to produce a similar result to that of the beef enterprise due to the changed DSE weighting of growing sheep reducing the overall flock numbers and maintaining about the same level of operating profit. The effect of changing the growth rate of meat goats was impacted by the rounding of numbers and the large number of animals in the models. A small error in the DSE weighting per growing goat would have a large impact on final numbers in the model. Given the lack of data to support DSE rating changes in growing goats in the rangelands, the results for the change in growth rate require better data to verify accuracy.

The sensitivity analyses identified a key attribute of a resilient livestock enterprise in the rangelands of Queensland. That is, where the operating profit generated by alternative livestock enterprises is similar, incorporating the capacity of a self-replacing wool sheep flock, to moderate the expected variation in returns due to fluctuations in meat price, could be important. The trend relationship in meat prices for sheep, beef and goat meat, shown by the individual analyses of price over time, suggests that a falling or rising trend in meat prices will be reflected across all meat-based production systems in the rangelands. Therefore, having a component of the overall operating profit derived from wool sales may offset the variation in expected operating profit compared to where all income from the business was derived from meat sales. The self-replacing wool flock can also have the proportion of dry sheep and lambing ewes in the flock adjusted relatively quickly when faced with seasonal and inter-annual climate variability, if pregnancy testing and a flock segregation system is in place. If the property was run solely as a self-replacing Merino wool sheep enterprise, a similar change in the expected level of price received for wool or sheep meat, or the expected amount of wool cut, had a similar impact on the expected operating profit of the property (Table 2). The implication is that a 20% increase in sheep meat price could offset a 20% decrease in wool price. Our assumption that a change in the growth rate would not affect the wool cut is probably unrealistic. Even so, it appears likely that changing the growth rate of sheep in this flock will have either a slightly negative, or negligible, impact on the average level of operating profit.

Because the Merino wether enterprise is largely a trading enterprise, a change in the expected level of the price of sheep meat is much less important to the profitability of the wether enterprise than a change in the price received for wool or the amount of wool cut per head. Running lighter wethers that cut the same amount of wool per head as 5% heavier wethers, leads to slightly more wethers run on the property in the model and improves profitability. Whether this would occur in reality, and whether it would be measurable, are unknown, but the results indicate that small changes to the growth rate of wethers are relatively unimportant to the financial and economic performance of this enterprise.

The effect on profit and resilience of moving to alternative enterprises

Beef production has become the predominant land use in the rangelands of central-western Queensland following long-term structural change in the economic circumstances of the sheep industry. To facilitate a change to an alternative sheep or goat enterprise, or to diversify their current enterprise mix, properties currently focussed on beef would need to invest capital and learn new skills. A number of change scenarios have been modelled for variations of the starting point of the constructed property (Table 3). However, each property considering change faces different circumstances. Therefore, we emphasise that the results of this discrete analysis do not indicate whether change is warranted for any particular property. Furthermore, the results shown in Table 3 may only indicate the value of change for (1) properties that have similar characteristics to the constructed property and (2) face similar future prices, costs and outputs.

Table 3 – Value of implementing alternative strategies to improve profitability and resilience of a representative property in the rangelands of central-western Queensland

The analysis was conducted for a 30-year investment period

Enterprise change scenario	Annualised NPV[A]	Peak deficit (with interest)[B]	Years to peak deficit	Payback period (years)[C]	IRR (%)[D]
Convert from self-replacing beef herd to self-replacing Merino wool sheep flock with investment in exclusion fencing (p. 96)	-$20,256	-$1,637,496	20	n/c	2.99
Convert from self-replacing beef herd to rangeland meat goats with investment in exclusion fencing (p. 99)	$45,686	-$681,884	3	12	12.83
Convert from 100% self-replacing wool sheep to 50% wool sheep and 50% rangeland meat goats with investment in goat infrastructure (p. 101)	-$6,469	-$419,531	20	n/c	1.82

n/c, not calculable.

[A]**Annualised (or amortised) NPV** (net present value) is the sum of the discounted values of the future income and costs associated with a farm project or plan amortised to represent the average annual value of the NPV. A positive annualised NPV at the required discount rate means that the project has earned more than the 5% rate of return used as the discount rate. In this case it is calculated as the difference between the base property and the same property after the management strategy is implemented. **The annualised NPV provides an indication of the potential average annual change in profit over 30 years, resulting from the management strategy.**

[B]**Peak deficit is the maximum difference in cumulative net cash flow between the implemented strategy and the base scenario over the 30-year period of the analysis.** It is compounded at the discount rate and is a measure of riskiness.

[C]**Payback period is the number of years it takes for the cumulative net cash flow to become positive.** The cumulative net cash flow is compounded at the discount rate and, other things being equal, the shorter the payback period, the more appealing the investment. n/c indicates that a value was not able to be calculated, i.e., the investment did not pay back in the 30 years of the analysis.

[D]**IRR (internal rate of return) is the rate of return on the additional capital invested**. It is the discount rate at which the present value of income from the project equals the present value of total expenditure (capital and annual costs) on the project, i.e., the break-even discount rate. It is a discounted measure of project worth.

Where the constructed property was (1) operated as a beef property, (2) had some existing infrastructure to manage sheep or goats, but (3) required the construction of an exclusion fence to operate a sheep or goat enterprise, the relative profitability of the property could be improved over the long term with an investment in an exclusion fence and a switch to a meat goat enterprise. The significant constraint on this investment was the level of additional debt required to make the change and the number of years before the property would be back to the same financial position that it would have maintained without the investment. These aspects make the investment in an exclusion fence quite risky for the constructed property where it is operated solely as a beef production enterprise.

The better performance of the investment in the exclusion fence and conversion to a rangeland meat goat enterprise (compared to wool sheep) is heavily dependent upon the assumptions that the capital adjustment to move from beef to goats will be lower than a move from beef to wool sheep and that the relative and absolute price of goat meat will be maintained over the longer term. In this analysis the greater capital adjustments required to convert to sheep (cf. goats) was largely due to the higher value of sheep and additional equipment required to shear the sheep.

The relatively poor investment performance of the conversion from a self-replacing wool sheep flock, to a mixture of meat goats and wool sheep, is mainly due to the small difference between the expected returns of the two enterprises. The opportunity cost of the extra capital invested in goat infrastructure is greater than the extra return generated by the combined enterprises. However, this component of the analysis did not account for any potential synergies arising from running goats and sheep on the one property when it comes to either grazing land management or drought management.

Conclusions

The rangelands of central-western Queensland experience high levels of climate variability and have a history of suffering extended and extensive droughts. Our analysis identified that, at the predicted prices and costs for each livestock enterprise, the self-replacing Merino wool sheep flock was likely to be one of the more profitable and resilient enterprise alternatives. However, key to this result was the assumption that sufficient infrastructure, including an exclusion fence, was already in place to achieve the predicted levels of flock performance. Variation of the key assumptions in the sensitivity analysis revealed that a significant and sustained improvement in the relative beef price would be required before an existing wool sheep producer with a self-replacing flock would be better off changing to beef production. The sensitivity analysis also indicated that an integrated enterprise, that included a significant component of income derived from a self-replacing wool flock enterprise, was likely to be more resilient in terms of maintaining an average level of profit in the face of the expected fluctuations in meat price and wool price. Where full investment in an exclusion fence around the majority of the property was required to facilitate a shift from beef to some form of sheep or goat production, the investment was likely to increase the riskiness of the overall enterprise and thus would be unlikely to be undertaken by many existing beef producers in the region. This was the case even when the long-term profitability and resilience of the property could be substantially improved, e.g., by a change to rangeland meat goats. The lack of reliable data for rangeland meat goat production in this region limits the confidence in conclusions about the role of rangeland goats, long-term. However, maintenance of the demand for goat meat, together with increased knowledge of effective goat management strategies, could see rangeland goats play a very important role in maintaining profitable and resilient production systems in the future. The steady-state analysis indicated that the profitability of the meat sheep enterprise was the greatest of all livestock alternatives for this region. However, as for rangeland meat goats, the lack of published data for production of meat sheep breeds in the central-western rangelands region indicates that caution is required in the extrapolation of these results.

The herd and flock modelling approach applied in this study allowed the integration of alternative livestock enterprises within the one investment model and enabled a whole-of-business analysis of the effect of change on productivity and profitability at the property level. The property-level, regionally specific herd and business models developed in this project are available to be used by consultants, advisors and producers to assess both strategic and tactical decisions for their own businesses.

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1 General introduction

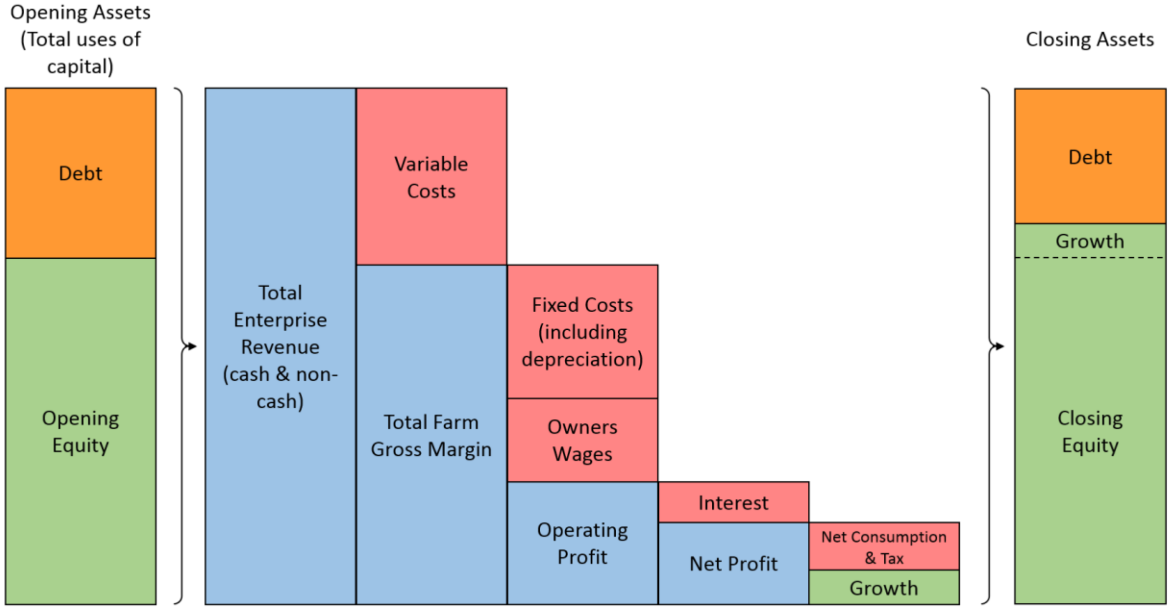
More than 80% of Queensland's total area of 173 million ha is used for grazing livestock on lands extending from humid tropical areas to arid western rangelands (QLUMP 2017). Most extensive grazing enterprises occur on native pastures with introduced (sown) pastures constituting less than 10% of the total grazing area and occurring on the more fertile land types (McIvor 2005; QLUMP 2017). Grazing industries, and particularly beef cattle, make an important contribution to the Queensland economy. In 2018-19 the beef cattle industry accounted for 45% ($5.8 billion) of the total gross value of Queensland agricultural production. In the same period, sheep meat accounted for 0.1% ($19 million) and wool accounted for 0.8% ($108 million), (ABS 2020b).

Queensland's variable rainfall, especially long periods of drought, is one of the biggest challenges for grazing land managers. As well as the potential for causing degradation of the grazing resource, drought has a severe impact on business viability, is a regular occurrence, and provides the context for many of the production and investment decisions made by managers of grazing enterprises. Climate change is expected to result in increased severity and impact of droughts in Queensland, in addition to an overall decrease in annual precipitation (2-3% lower by 2050) and warmer temperatures (1.4-1.9^{0}C greater by 2050), (Queensland Government 2018). The Queensland beef and sheep industries are also challenged by variable commodity prices and by pressures on long-term financial performance and viability due to an ongoing disconnect between asset values and returns, high debt levels and a declining trend in terms of trade (ABARES 2019).

To remain in production, and to build resilience, beef and sheep properties need to be profitable and to build equity (Figure 1). Building resilience usually means investments have to be made and alternative management strategies considered well before encountering extended dry spells or drought. To make profitable management decisions, graziers need to be able to appropriately assess the impact of different strategies on profitability, the associated risks, and the period of time before benefits can be expected. The effects of such alternative management strategies are best assessed using property-level, regionally relevant models that determine whole-of-property productivity and profitability (Malcolm 2000, Malcolm *et al.* 2005).

Decision making during drought often has a more tactical, short term focus but also relies upon applying a framework to assess the relative value of the alternatives over both the short and medium term. Recovery from drought is also a challenging period when decision making should include both the strategic response – returning to the most profitable herd structure, and the tactical response – how to survive while the production system is being rebuilt. Simple spreadsheets applying a farm management economics framework can be used to quickly gather relevant information and highlight possible outcomes of decision making during and after drought. These tools can complement traditional decision-making processes.

Figure 1 – The link between profit and growth in equity



Although regularly achieving a profit is a key ingredient of a drought resilient livestock production system, profit does not necessarily drive the goals of the vast majority of livestock producers (McCartney 2017; Paxton 2019). The factors that motivate them are much more complex and diverse. However, to be a livestock producer in northern Australia you need to be efficient, i.e., you need to regularly produce a profit. Therefore, profit is necessarily the focus of this report.

This report was produced as part of the project titled, *'Delivering integrated production and economic knowledge and skills to improve drought management outcomes for grazing enterprises'*. The objective of this project was to improve the knowledge and skills of advisors and graziers in assessing the economic implications of management decisions which can be applied to (1) prepare for, (2) respond to, or (3) recover from drought. We have applied scenario analysis to examine a range of management strategies and technologies that may contribute to building both more profitable and more drought resilient grazing properties for a number of disparate regions across Queensland. In doing this we have developed property-level, regionally specific herd, flock and business models. These incorporate spreadsheets and a decision support framework that can be used by consultants and advisors to assist producers to assess both strategic and tactical scenarios. This report details the economic analysis of various livestock production systems applicable to the rangelands of central-western Queensland.

1.1 The rangelands of central-western Queensland

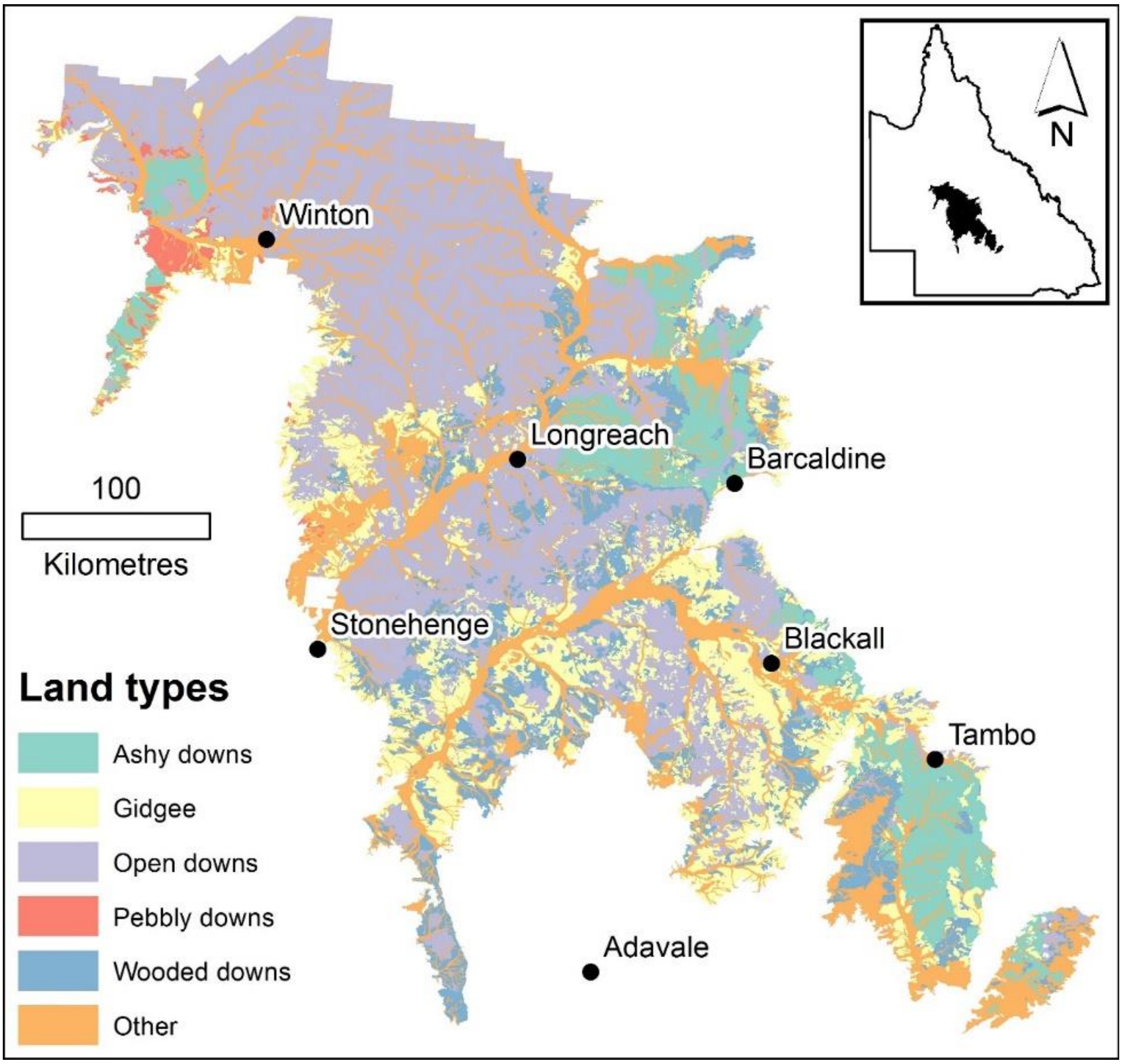
1.1.1 The land resource

For the purposes of this report, we have defined the rangelands of central-western Queensland as encompassing ca. 10 million ha of grazing land (DNRM 2010; DNRM 2017) which is used for extensive livestock production. The same region was identified as the 'Central West Mitchell Grasslands' in an accompanying report (Bowen *et al.* 2019b). The region (Figure 2) is part of the larger Mitchel Grass Downs bioregion (hereafter, Mitchell grasslands) which extends across central Queensland and into the Northern Territory with a total area of ca. 45 million ha (Orr and Phelps

2013). The Mitchell grasslands consist of largely treeless, undulating clay-soil downs. Other land types comprise ca. 30% of the Mitchell grasslands bioregion (Bray *et al.* 2014) and include timbered gidgee, boree and mulga woodlands, flooded country, and spinifex sand plains. The dominant vegetation type in the bioregion is perennial native Mitchell grasses (*Astrebla* spp.). Mitchell grasses are characterised by their resilience under heavy grazing and variable rainfall and their ability to recover well in good rainfall years due their deep root system and tough tussock crowns (Partridge 1996; Orr and Phelps 2013). A range of other perennial and annual native grasses and forbs are found in the bioregion, including the introduced perennial grass, buffel (*Cenchrus ciliaris*).

Figure 2 – Map of the rangelands of central-western Queensland showing the distribution of major land types on land used for grazing

Land used for purposes other than grazing is marked white. The region includes the Mitchell Grasslands bioregion sub-IBRAs MGD07 and MGD08 but with the northern boundary set as the ABS Outback South statistical division boundary. Note that Wooded downs land type includes Boree wooded downs on this map



1.1.2 Rainfall and drought

The rangelands of central-western Queensland are characterised by a semi-arid to arid environment with long dry seasons, extreme temperatures, high evaporation rates, and high rainfall variability. The amount and distribution of rainfall are primary determinants of pasture growth and quality with the expected pasture-growing season and highest quality of forage typically lasting for 8-10 weeks during summer (Bray *et al.* 2014). Examples of seasonal distribution of rainfall are shown for six locations across the region (BOM 2019; Table 4). Annual rainfall in the region ranges from 485 mm at Tambo to 313 mm at Jundah. The variability of annual rainfall in the region ranges from 'high' in the west to 'moderate to high' in the east (scale low to extreme) based on an index of variability determined by percentile analysis (BOM 2018; Figure 3).

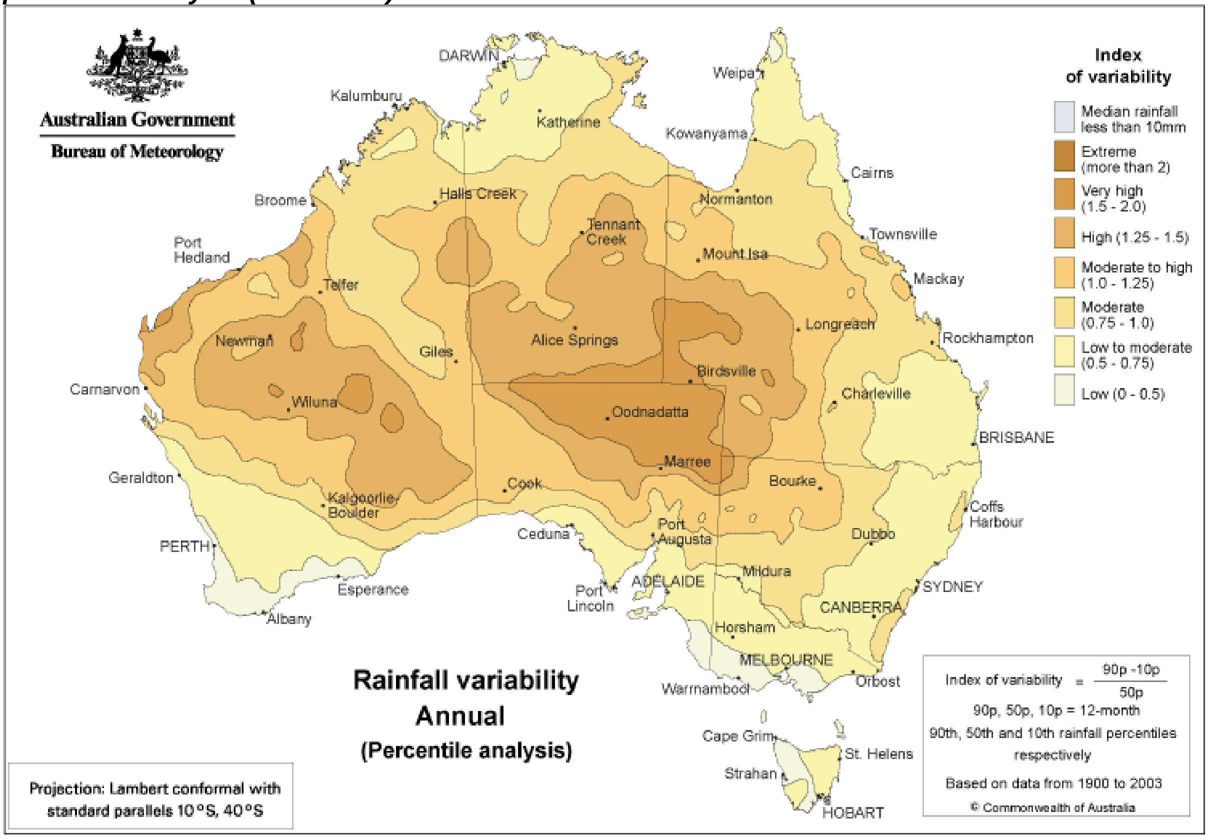
Table 4 - Median seasonal distribution of rainfall (mm) at six locations across the rangelands of central-western Queensland for the 30-year 'climate normal' period 1961-1990 (BOM 2019)[A]

Town	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Winton[B]	48.5	54.5	31.5	7.7	6.5	0.2	0.0	0.0	0.0	5.6	9.0	46.0	363.2
Longreach	40.3	35.3	52.8	11.1	12.7	3.8	5.7	3.5	0.9	8.4	14.4	40.0	436.7
Barcaldine	66.1	55.7	40.4	28.0	13.8	7.2	9.6	6.1	3.0	20.8	26.7	49.8	424.8
Blackall	53.9	46.4	39.9	24.5	22.8	8.3	7.4	8.5	8.1	21.9	26.4	54.0	477.6
Jundah	29.5	35.4	32.5	10.1	6.6	3.2	7.5	4.0	2.5	8.3	6.6	20.7	313.1
Tambo	51.8	58.5	47.7	20.5	20.9	9.6	9.0	15.9	7.4	23.5	33.9	47.2	485.2

[A]Statistics calculated over standard periods of 30 years are called 'climate normals' and are used as reference values for comparative purposes. A 30-year period is considered long enough to include the majority of typical year-to-year variation in the climate but not so long that it is significantly influenced by longer-term climate changes. In Australia, the current reference climate normal is generated over the 30-year period 1 January 1961 to 31 December 1990 (BOM 2019).

[B]Data for closest weather station at Bladensburg 13.8 km from Winton.

Figure 3 – Map of the annual rainfall variability across Australia determined using the percentile analysis (BOM 2018)



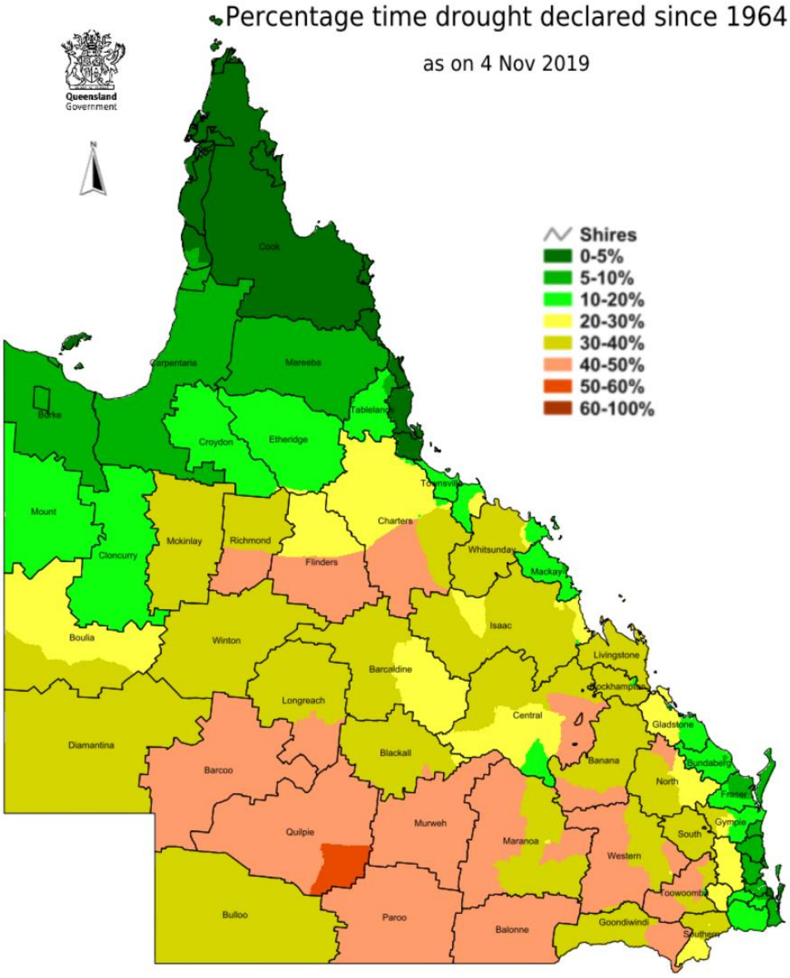
Queensland's variable climate, especially long periods of drought, is one of the biggest challenges for managers of grazing enterprises. Drought regularly has a severe impact on profitability and provides the context for many production and investment decisions made by managers of grazing properties. While there is no universal definition of drought, one that is common in agriculture is the 'drought percentile method' (BOM 2019). For instance, rainfall for the previous 12-month period is expressed as a percentile, which is a measure of where the rainfall received fits into the long-term distribution. A rainfall value <10% is considered 'drought' (Commonwealth of Australia 2019). This means that a 12-month rainfall total in the bottom 10% of all historical values indicates a 'drought'. An example of historical drought data obtained from the Australian CliMate website using this definition is presented for Longreach (Table 5). Using this definition, there have been 38 droughts at Longreach since 1900, the longest lasting 23 months. Figure 4 shows the percentage of time, over the period 1964-2019, that Queensland shires have been drought declared (The State of Queensland 2019). The northern and southern sections of the Longreach shire have been drought declared 30-40% and 40-50% of the time, respectively.

Table 5 - Historical droughts (1900–2019) at Longreach ranked by depth and duration and with subsequent recovery rainfall[A]

Rank	Drought period	Drought length (months)	Drought depth (percentile)	Subsequent recovery rainfall (mm)
1	Feb 2014 - Dec 2015	23	1.7	323
2	May 1902 - Feb 1903	10	0	125
3	Feb 1915 - Dec 1915	11	0	175
4	May 1969 - Nov 1969	7	0.9	34
5	Mar 1926 - Aug 1926	6	1.7	51
6	Dec 1934 - Sep 1935	10	0.9	180
7	Nov 1982 - Apr 1983	6	0	139
8	Oct 2002 - Jan 2003	4	0	27
9	Feb 1988 - Jul 1988	6	1.7	153
10	Dec 1900 - Mar 1901	4	0	96
11	Sep 1927 - Nov 1927	3	1.7	21
12	Feb 1920 - Apr 1920	3	0.9	123
13	Oct 1905 - Jan 1906	4	1.7	125
14	Jul 1985 - Sep 1985	3	4.3	37
15	Aug 1967 - Nov 1967	4	5.1	28
16	Feb 1945 - May 1945	4	5.1	47
17	Jan 1947	1	0.8	34
18	May 1933 - Jun 1933	2	5.1	31
19	May 1993 - Jul 1993	3	5.1	49
20	Dec 2017 - Jan 2018	2	4.2	23
21	Sep 2017 - Oct 2017	2	6	19
22	Feb 1923 - Mar 1923	2	5.1	43
23	Jan 1967	1	5.1	5
24	May 1978 - Jun 1978	2	6.8	22
25	Jul 1970 - Aug 1970	2	7.7	0
26	Aug 1946 - Oct 1946	3	7.7	3
27	Dec 1965	1	5.9	56
28	Jan 1952	1	5.9	0
29	Mar 1952 - Apr 1952	2	6.8	32
30	Jan 1944	1	6.8	23
31	Jun 1952 - Aug 1952	3	8.5	13
32	Apr 1992	1	7.7	0
33	Oct 2018 - Nov 2018	2	8.5	23
34	Nov 1948	1	8.5	17
35	Sep 1993	1	8.5	14
36	Apr 1930	1	8.5	0
37	Dec 1952	1	9.3	8
38	Feb 1939	1	9.4	25

[A] Drought defined using the 'drought percentile method' and using a 1-year residence period so that rainfall for the previous 12-month period was expressed as a percentile. Rainfall values <10% are considered as 'drought'. (Commonwealth of Australia 2019).

Figure 4 - Map showing the percentage of time Queensland shires have been drought declared over the period 1964-2019 (The State of Queensland 2019)



1.1.3 Livestock production systems in the rangelands of central-western Queensland

Extensive grazing, primarily on native pastures, is the principal land use in the rangelands of central-western Queensland. The region falls within the Desert Channels Natural Resource Management (NRM) region for statistical reporting which is 44,150,071 ha and supports 639 meat cattle businesses and 238 sheep businesses (ABS 2020a). The Desert Channels NRM region has a total meat cattle herd size of ca. 1,306,644, representing 6% of Australia's and 12% of Queensland's meat cattle numbers and producing $672,581,010 or 5% of Australia's and 12% of Queensland's gross value of cattle in 2018-19 (ABS 2020a,b). The sheep flock in the region totals 912,925, representing 1.4% of Australia's and 43% of Queensland's total sheep flock (ABS 2020a). The gross value of sheep meat and wool production in the Desert Channels NRM region is $7,726,118 and $46,836,714, respectively (ABS 2020b). No statistics are currently available for rangeland meat goat production in NRM regions of Queensland. Total goat slaughter figures for Queensland in 2019 were 377,634 head, with the majority coming from harvesting of semi-wild rangeland goats in western Queensland and New South Wales (MLA 2020a).

Historically, Merino sheep production was dominant in the rangelands of central-western Queensland with cattle numbers increasing during the 1990s so that by 2010 very few wool sheep remained north of Longreach (Bray *et al.* 2014). Long-term structural change in the economic circumstances of the sheep industry, and associated increases in wild dog numbers, have contributed to the decline in sheep production in the region. With the increase in sheep meat and wool prices in recent years there has been some return to sheep production in the area, including the farming of meat sheep breeds (Pepper *et al*. 2002; Alemseged and Hacker 2014).

Additionally, diversification into rangeland goat production has occurred since the 1990s. The Australian rangeland goat is a composite breed comprised of dairy, fibre and meat goat breeds. The rangeland goat has evolved over the past 200 years from animals that escaped domestication and formed small herds in more arid areas in Australia, largely in western New South Wales and south western Queensland (MLA 2006; Hacker and Alemseged 2014). As the value of the goat meat industry in Australia has increased over recent decades, so has the interest in managed production systems, rather than harvesting wild populations (Hacker and Alemseged 2014; Robertson *et al*. 2020). In the Queensland rangelands, various levels of management intensity are currently applied following containment of goats with suitable fencing. This may include (1) mating rangeland does with selected or introduced bucks including rangeland, Boer or Kalahari Red breeds, (2) control of mating period, (3) weaning and (4) supplementation.

Although the relative profitability of wool and meat sheep, and rangeland goats, has improved in recent years, the requirement for substantial infrastructure redevelopment, particularly wild dog exclusion fences, to support small ruminant production has limited the extent of conversion, and cattle remain the dominant livestock in the region (ABS 2020a).

In previous decades, the Mitchell grasslands bioregion has been documented as being in better land condition than many other bioregions in Australia's grazing lands due to the resilient nature of the Mitchell grass pastures (Pressland 1984; Commonwealth of Australia 2008). Further, areas of poor land condition were historically due to invasion by woody weeds (primarily in the north of the region), increasing white speargrass (*Aristida leptopoda*; in the south-west) and feathertop (*Aristida latifolia*; in the central west). However, more recent reports suggest the application of higher stocking rates and pasture utilisation rates in the Mitchell grasslands bioregion than used traditionally (Commonwealth of Australia 2008; Bray *et al.* 2014). This has been highlighted as posing a potential risk to land condition over time. It has been suggested that this trend towards increased pasture utilisation is linked to (1) financial pressures of graziers, as well as (2) increased total grazing pressure from macropods and feral animals such as goats, and (3) increasing density and area of native and weedy woody vegetation that decreases pasture growth (Johnston *et al.* 1990; Commonwealth of Australia 2008; Bray *et al.* 2014).

1.1.4 Estimating grazing pressure equivalence for cattle, sheep and goats in the Australian rangelands

As the profit generated by a grazing business is very sensitive to pasture utilisation rate and therefore stocking rate (e.g., Bowen and Chudleigh 2018a) it is critically important to maintain an equivalent or appropriate level of grazing pressure across scenarios that are being compared within the one economic analysis. Not doing so, will strongly bias the scenario or strategy assigned the inappropriate level of grazing pressure. Maintaining equivalent grazing pressure across different species (e.g., cattle, sheep and goats) and classes of livestock requires conversion to a standard animal unit to describe and quantify the grazing pressure applied to the feed base by foraging ruminants. In Australia, the most commonly applied standard animal units are adult equivalent (AE) and dry sheep equivalent (DSE) ratings. However, there are many different definitions of AE and DSE in use and a wide variation in the literature in the relationship between the two (McLennan *et al.* 2020). Additionally, there is a paucity of information to indicate the appropriate ratings for the Australian rangeland goat, including incorporating consideration of the high reproductive rate of the species (e.g., Hacker and Alemseged 2014). In this section, we have briefly summarised the available literature to provide background and justification for the definitions and approach that we have adopted in our analysis to estimate grazing pressure equivalence between species.

In the Breedcow and Dynama herd-budgeting software (BCD; Holmes *et al.* 2017), which was applied to conduct economic scenario analyses in this project, an AE was taken as a non-pregnant, non-lactating beast of average weight 455 kg (1,000 lbs) carried for 12 months (i.e., a linear AE, not adjusted for metabolic weight). This simplified approach to assigning stocking rates and maintaining constant grazing pressure, between alternative scenarios and classes of cattle, has proven robust over many years in conducting scenario analysis for a single species. However, to determine grazing pressure equivalence of cattle, sheep and goats grazing in the Australian rangelands, a more rigorous approach was required. Therefore, we adopted the recommendations of McLennan *et al.* (2020) in their recent review of animal unit equivalence. These authors defined the AE or DSE rank assigned to a grazing animal as the ratio of its metabolisable energy (ME) requirements for a particular level of production to that of a 'standard animal' (cattle (AE) or sheep (DSE)). In doing this, ME requirements are determined using the Australian feeding standards for ruminants (NRDR 2007). While this approach was used in our analysis to determine grazing pressure equivalence (via assigning AE or DSE rank to animal species and the classes within), it was not used in the subsequent herd and flock modelling economic modelling in BCD. However, to test the effect of applying the 'ME requirement' AE cf. the linear AE, in the subsequent herd and economic modelling, the equations of McLennan *et al.* (2020) were incorporated into a modified version of BCD and used to test the ranking of economic outcomes from this approach, with the traditional linear AE approach. As the ranking of outcomes was the same with both approaches (unpublished data) the application of the simplified, linear AE approach in the economic scenario analyses was justified in this study.

In our analysis we have not attempted to account for livestock 'substitution ratios' between cattle, sheep and goats which relate to differences in diet selection and digestion between species (Scarnecchia 1990). As reviewed by Pahl (2019a), relative energy requirements of herbivores grazing Australian rangelands may not be equivalent to relative dry matter intakes due to the differences in the structure of digestive tracts, and selective foraging capabilities resulting in differences in diet quality. Furthermore, there are differences between livestock species in the preferential selection of the forage component/s of the feed-base and foraging areas (Hacker and Alemseged 2014; Pahl 2019b). Pahl (2019b) concluded that equivalency in what and where different herbivore species eat is not quantifiable but appears to be high overall, particularly for perennial grass which is the dominant forage for all species in the rangelands. Selection of proportionally more browse in the diet of goats, in particular, relative to the other species (Hacker and Alemseged 2014; Pahl 2019b), could be assumed to result in less grazing pressure on the perennial grass pasture and therefore enable relatively more AE or DSE units of goats to be grazed in an area without causing pasture condition to decline. However, diet selection differences between livestock species will vary in magnitude according to many factors including (1) the proportion, palatability, stage of maturity or 'greenness' of grass, forbs and browse in a particular grazing area, and (2) the breed, size and stage of maturity of the animals. In this analysis, in the absence of better information to quantify the diet selected by different livestock species under practical grazing situations, we have assumed grazing pressure equivalency of cattle, sheep and goat animal units, based on energy requirements.

1.1.4.1 Cattle

In estimating grazing pressure equivalence of livestock species, we have adopted the recommendations of McLennan *et al.* (2020) that an AE be defined as the ME requirement of a standard bovine animal. The definition of the standard bovine animal was that described by McLean and Blakely (2014) where 1 AE was defined as a 450 kg, 2.25 year-old *Bos taurus* steer with zero weight change and walking 7 km/day on level ground. The ME requirements of the standard bovine AE was calculated as 64 MJ/day using the NRDR (2007) equations with modifications for cattle consuming subtropical forage diets and assuming a standard diet of 55% dry matter digestibility (DMD; equivalent to diet energy density of 7.75 MJ/kg DM), (McLennan *et al.* 2020). The modifications to NRDR (2007) equations were made to address previously identified issues of over-estimation of ME requirements for cattle consuming tropical forages in northern Australia (McLennan and Poppi 2005; Dove *et al.* 2010; McLennan 2013; Bowen *et al.* 2015) However, the ME requirement calculated using NRDR (2007) without modification was 73 MJ/day for a standard diet of 55% DMD. This latter value was adopted when relating AE to DSE, and hence cattle to sheep and goats, as the modifications to the NRDR (2007) equations for tropical diets have not been tested for small ruminants.

1.1.4.2 Sheep

To facilitate estimation of grazing pressure equivalence of livestock species, we have adopted the recommendations of McLennan *et al.* (2020) that the definition of a standard ovine animal, representing 1 DSE is a 45 kg Merino wether with zero weight change, walking 7 km/day on level ground and with no wool growth above that included in maintenance. The ME requirements of the standard ovine DSE was calculated as 8.7 MJ/day for a standard diet of 55% DMD and using NRDR (2007) equations without modification.

Based on the definitions above, the ratio of DSE : AE, using NRDR (2007) unmodified equations, is 8.4 : 1 (73/8.7 MJ/day). This ratio was used to express the numbers of cattle or sheep in modelled scenarios in DSE units.

1.1.4.3 Goats

Unfortunately, McLennan *et al.* (2020) did not make recommendations on the standard caprine animal unit. However, we have applied the same ME requirements approach used for cattle and sheep. We have assumed equivalence between sheep and goats in DSE rating so that 1 DSE is a 45 kg wether goat with zero weight change, walking 7 km/day on level ground and with no fibre growth above that included in maintenance. Therefore, the same ratio of DSE : AE, using NRDR (2007) unmodified equations, of 8.4 : 1 (73/8.7 MJ/day) was used to express the numbers of goats in modelled scenarios in DSE units to achieve uniform grazing pressure across species.

The assumption of equivalence between sheep and goats is generally supported by the recommendations of NRDR (2007), McGregor (2005) and Norton (2020). Consistent with McGregor (2005), Norton (2020) recommended that the generally accepted value for basal energy requirement of goats, with minimal activity, of ca. 400 kJ ME/kg $W^{0.75}$.day be adopted until further information is available. As ME requirements should account for the ‘normal’ activity of a grazing ruminant (NRDR 2007), addition of an activity rating to this basal energy requirement is necessary for application to a grazing rangeland goat. Application of an activity rating of 7 km/day, consistent with McLennan *et al.* (2020) recommendations for cattle and sheep, increases the daily ME requirement by ca. 25% for a 45 kg wether goat, which is within the 30% maximum allowance for activity increment recommended for goats in the Australian rangelands by Norton (2020). Norton (2020) suggested that the practice of adding an arbitrary 'activity' factor to the basal energy requirements of maintenance of Australian rangeland goats often inflates estimates of energy requirements by up to 50% and that a more reliable and realistic guide to grazing pressure requirements is required to avoid over-stating the grazing pressure applied. The application of the NRDR (2007) formulae for predicting ME requirements, including an activity level of 7 km/day, as applied by McLennan *et al.* (2020) is a more quantitative approach and was adopted in our analysis.

1.1.4.4 Weighting for female breeding stock that produce a calf, lamb or kid

In the BCD herd-budgeting software, that was applied to conduct economic analyses in this project, an additional allowance of 0.35 AE was made for each breeder (cow) that rears a calf. This rating is placed on the calves themselves, effectively from conception to age 5 months, while their mothers were rated entirely on weight. In the development of the BCD software, this rating was derived with input from S. McLennan (pers. comm.) with use of an earlier version of QuikIntake spreadsheet based on equations in the ruminant feeding standards at that time (SCA 1990), (McLennan and Poppi 2005). We tested the robustness of the 0.35 AE allowance using the revised equations of McLennan *et al.* (2020) and the associated, most recent version of QuikIntake (Version 6) and concluded that this weighting was still appropriate for use in the BCD software for cattle.

The weighting applied to a cow that produces a weaner in the BCD software was converted to DSE by multiplying 0.35 AE by 8.4 (i.e., 2.94 DSE) as recommended by McLennan *et al.* (2020). The same weighting (0.35) was applied to the DSE rating for a ewe in a self-replacing wool flock in this analysis as it was assumed the flock would achieve approximately the same level of weaning rate from ewes mated as the beef herd in the same environment. Meat sheep flocks and meat goat herds that achieved weaning rates greater than 100% had their weighting increased proportionally to the expected increase in lambing or kidding rate above 100%. For, example, the DSE weighting for a doe weaning 1.5 kids (on average) was 0.525 (0.35 x 1.5). This estimate was based on 150% weaning rate of kids and needs to be adjusted proportionally in the model for a higher or lower kidding percentage.

1.1.5 Climate variability and stocking rate

In an earlier analysis conducted as part of this project (Bowen *et al.* 2019b; Bowen *et al.* 2021) we applied farm management economics, in a bio-economic modelling framework, to assess the effects of alternative grazing management strategies on the profitability and sustainability of a beef enterprise in the rangelands of central-western Queensland (named as Central West Mitchell Grasslands region in that analysis). Underpinning this work was the determination of safe stocking rates and long-term safe carrying capacities for this region, and its representative land types. Historical climate data was used to provide a representative example of the climate variability experienced in this region, and the resulting effect on pasture production and carrying capacity. The same representative property and land types, as that modelled in the bio-economic analysis, was used in the current study.

In the bio-economic modelling analysis, four grazing management strategies were simulated over a 36-year period (1982-2017) in the GRASP pasture growth model (McKeon *et al.* 2000; Rickert *et al.* 2000) using historic climate records for Longreach. Simulated annual stocking rates and steer liveweight gain predictions from GRASP were integrated with published functions for mortality and conception rates in beef breeding cattle in northern Australia (Mayer *et al.* 2012), and then used to develop dynamic BCD cattle herd models and discounted cash-flow budgets over the last 30 years of the period (1988-2017; Holmes *et al.* (2017), following a 6-year model-equilibration period. The key finding from this work was that, in a highly variable and unpredictable climate, managing stocking rates with a moderate degree of flexibility in response to pasture availability (drought responsive management) was the most profitable approach and also maintained pasture condition. However, it was essential to economic viability that the property was restocked with purchased stock, as soon as possible, in line with pasture availability, once good seasonal conditions returned.

The average (410 mm), median (426 mm) and the year-to-year variability (CV 41%) in annual rainfall, for the representative property near Longreach over the 36-year GRASP pasture simulation period (1982-2017) were similar to the standard 30-year climate normal period (1961-1990; 424 mm, 437 mm, CV 36%), (Figure 5 and Table 4). The annual rainfall over the 36 years ranged from 141 mm in 1983 (Year 2) to 777 mm in 1990 (Year 9).

Figure 5 – Annual rainfall for a representative property near Longreach over the 36-year period 1982-2017 (Bowen et al. 2019b)

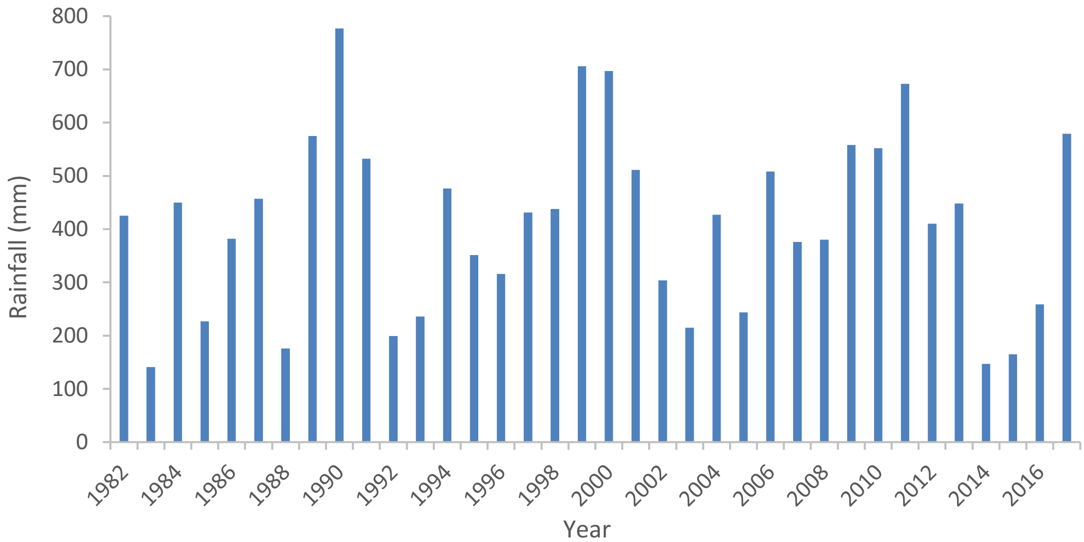
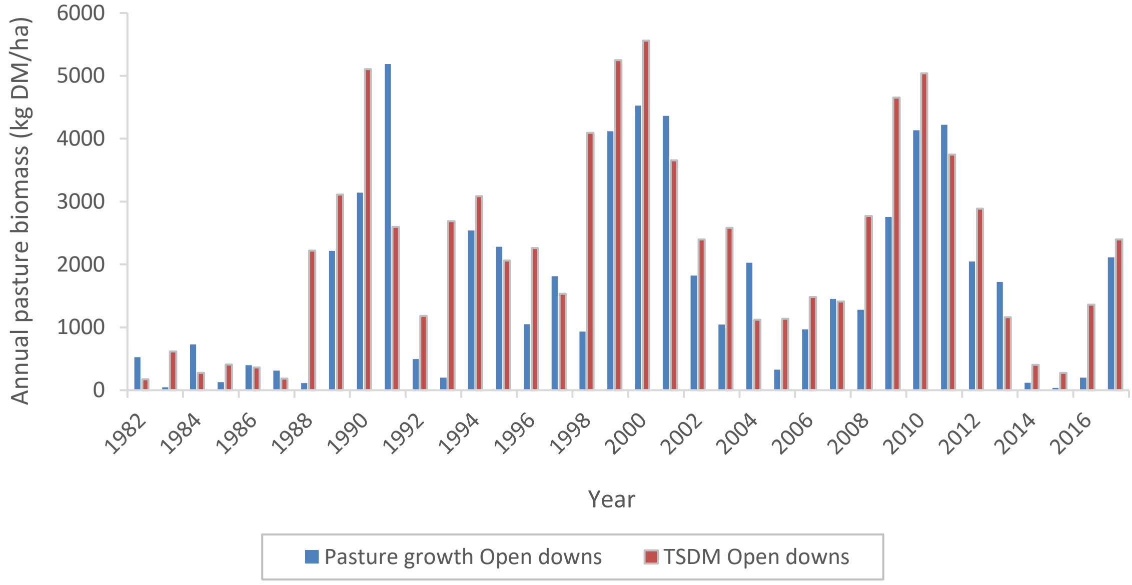


Figure 6 indicates the 12-month total pasture growth per ha (dry matter (DM) basis) and total standing dry matter (TSDM) on 1 May, estimated by GRASP for the years 1982 to 2017 for the open downs land type in B land condition near Longreach under the drought responsive grazing management strategy. The annual pasture growth predictions ranged from 34 to 5,189 kg DM/ha while TSDM at 1 May ranged from 174 to 5,559 kg DM/ha over the same period.

Figure 6 - GRASP estimate of 12-month total pasture growth per hectare (kg DM/ha) and total standing dry matter (TSDM; kg DM/ha) on 1 May for the open downs land type near Longreach over the 36-year period 1982-2017 under the drought responsive grazing management strategy (Bowen et al. 2019b)



For this region, the target 'safe' utilisation rates (%) of annual pasture biomass growth (kg DM/ha) and total standing dry matter (TSDM; kg DM/ha) at 1 May, respectively, were considered to be 22% and 30% for open downs, 20% and 25% for wooded downs, 30% and 35% for soft gidgee cleared, 18% and 20% for soft gidgee wooded, 22% and 30% for boree wooded downs, and 18% and 20% for open alluvial plains. The drought responsive grazing management strategy, the most economically attractive scenario that also maintained pasture condition over the modelled period, attempted to mimic a drought responsive manager who made annual changes in cattle numbers to match forage TSDM available on the 1 May using safe utilisation rates but with the following limitations:

a) annual changes in cattle numbers were limited to 30% increases and 60% decreases, and

b) over the 36 years, changes in animal numbers were limited to a 100% increase and a 75% decrease from the initial stocking rate.

The proportion used as the lower limit for stock numbers in this scenario, rather than fully destocking, was based on an AgForce producer survey indicating that the majority of properties retained 25% of their pre-drought stock numbers (AgForce 2015). The intention of the drought responsive grazing management scenario was to reflect what many producers and pasture scientists believe is the optimal way to manage grazing pressure in a highly variable climate.

Figure 7 shows the total DSE calculated by GRASP to run on the constructed, representative property for each year of the drought responsive grazing management strategy. The low numbers for DSE in the 1980s is a response to low pasture production. Table 6 indicates the average, median, minimum and maximum number of DSE applied in the drought responsive scenario.

Figure 7 - Annual property dry sheep equivalents (DSE) predicted by GRASP for the drought responsive strategy over 36 years (1982-2017), (adapted from Bowen et al. (2019b))

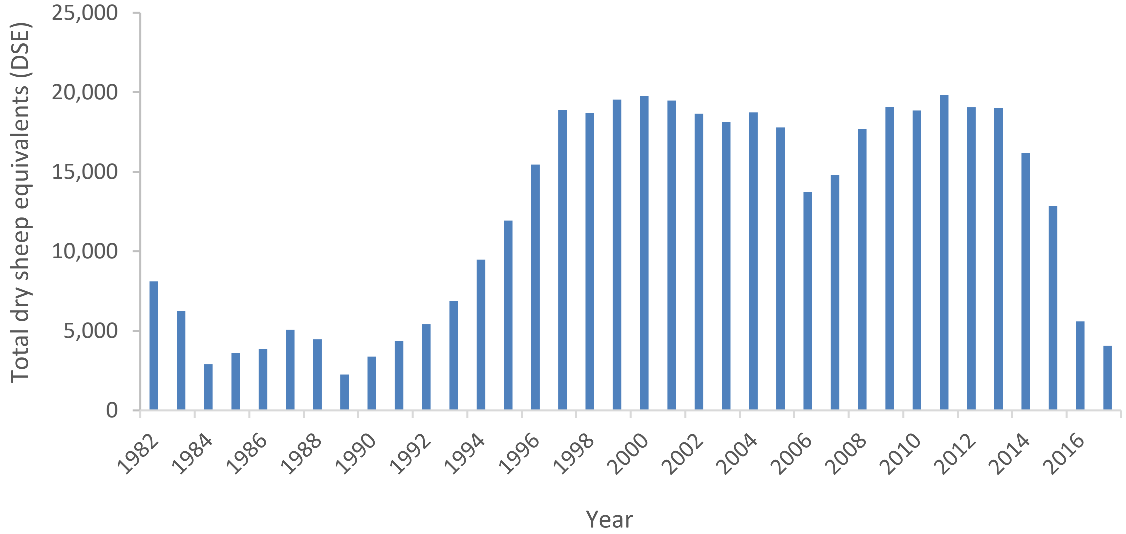


Table 6 - Annual statistics for GRASP-predicted dry sheep equivalent (DSE) ratings for the drought responsive strategy over 36 years (1982-2017) for the constructed property (adapted from Bowen et al. (2019b))

Parameter	**Average**	**Median**	**Minimum**	**Maximum**
Annual DSE rating	12,329	14,280	2,253	19,814

The GRASP modelling indicated that the drought responsive manager achieved an average of about 12,000 DSE on the property over the modelled period. Local sheep and beef producers also provided estimates of the variability of stocking rates for the example property defined in Bowen *et al.* (2019b) and which was also adopted in this report (Section 2.3). Their expected value for stocking rate was derived from estimates of probability of occurrence of discrete stocking rates (Table 7). The expected value for the stocking rate of the constructed, example property, based on the estimates of local sheep and beef producers, was 8,900 DSE and included 1 year when the property was completely destocked.

Table 7 – Local producer expectations of appropriate stocking rate (dry sheep equivalents; DSE) for the same constructed property identified in Bowen et al. (2019b)

Probability of occurrence (Years in 10; P)	**Expected DSE on the property (x)**	**Value (Px)**
1	0	0
2	7,000	14,000
6	10,000	60,000
1	15,000	15,000
10	*8,900*	*89,000*

There is considerable divergence between the average carrying capacity of the property estimated by the GRASP modelling for a 'drought responsive manager' and that estimated by the local livestock producers. The experience gained by the locals during the recent extended droughts, where many had to destock their properties, is possibly a better guide to the expected stocking rate applicable to a steady-state herd or flock modelling exercise. The current mathematical programming within the GRASP model only allowed for annual changes to livestock numbers on 1 May, based on the safe pasture utilisation rates. In addition, the modelled decision rules limited the changes in cattle numbers to 30% increases and 60% decreases at each change. This resulted in overgrazing in the simulated paddocks in a number of years in the months leading up to the change in numbers. It is acknowledged that the modelling approach of only altering livestock numbers once per year, and within limits, does not reflect the experience of the reference group of graziers. As these limitations were considered likely to have had major effects on the outcomes of the GRASP and BCD modelling in the previous study (Bowen *et al.* 2019; Bowen *et al.* 2021) the producer expectations in terms of appropriate long-term, average stocking rate were adopted in this current report and analyses. An expected stocking rate of 9,000 DSE, or 1,071 AE (DSE : AE of 8.4 : 1), was applied throughout the current analyses to represent the variability of the local climate (on average) and include some of the impacts on farm profit generated by climate variability that cannot be easily included in a steady-state modelling exercise.

2 General methods – approach to economic evaluation

2.1 Summary of approach

The economic performance of alternative livestock enterprises was assessed for a representative extensive grazing property in the rangelands of central-western Queensland using scenario analysis. The levels of production associated with this representative property, and the production responses to alternative management strategies, were determined with reference to interrogation of existing data sets and published literature where available, and the expert opinion of experienced local producers and Department of Agriculture and Fisheries, Queensland (DAF) staff. Model development has involved an iterative process of obtaining feedback and then applying adjustments to ensure that the models have been adequately structured and calibrated for the representative property and for each scenario.

The approach was implemented according to the following steps:

1. A hypothetical, representative property was constructed for the rangelands of central-western Queensland near Longreach. An initial stocking target of ca. 1,071 AE or 9,000 DSE was determined after comparison of outputs for the GRASP pasture-growth model and the expected value for stocking rate predicted by experienced local livestock producers, as described in section 1.1.5.
2. A base management strategy was initially modelled for a beef herd using recent values for prices, rates of growth, mortality and conception using the BCD suite of programs (Breedcowplus, Version 6.02; Holmes *et al.* 2017).
3. The property was also modelled in a steady-state analysis for a variety of sheep or meat goat enterprises using a modified version of the BCD suite of programs, for sheep: Breedewe and BreedMeatSheep or for meat goats: Breeddoe.
4. The modelled, steady-state, analysis of cattle, sheep and meat goat production systems for the base property then provided a reference point for comparison of the expected value of integrating or fully adopting several of the alternative enterprises from a starting base of either a 1) beef cattle or (2) self-replacing wool sheep enterprise.

The analysis applied an expected values approach that relied on estimating the expected, long-term average level of production and performance of each enterprise type. This approach was considered equally as capable of predicting the relative differences between the alternative enterprises as the stochastic and dynamic modelling approach, which is more complex to apply and communicate. The approach applied here allowed a focus on 1) the key parameters that underscore the difference between the enterprises and 2) identifying the enterprises most capable of building resilience over time.

The standard methods of farm management economics (Makeham and Malcolm 1993, Malcolm *et al.* 2005) were applied to consider the difference between alternative livestock enterprises for the same property. Key components of this framework were as described below.

- Either a discrete, whole-farm perspective or a marginal, whole-farm perspective was applied where applicable.
- Investments were analysed over their expected life and the same investment period was applied to all comparable, alternative investments.

- The full profit or cash implications of any capital investments were captured.
- Cash (financial feasibility) and profit (economic efficiency) components were clearly distinguished.
- The time value of capital invested was incorporated where appropriate.
- Livestock reconciliation or trading schedules appropriately incorporated livestock trading profits and losses.
- Constant (or real) dollar values were consistently applied and not interchanged with current (nominal) dollar values.
- The relative riskiness of the alternative strategy was identified, where possible. As it is usual for the comparison to be between an investment in a relatively low-input, low-output operation and other more intensive operations, an assessment of the risks can be critical.

Components of the BCD suite of programs were modified to allow the modelling of wool sheep, meat goat and meat sheep enterprises. Initially steady-state flock and herd models based on the Breedcowplus structure were used to identify the herd or flock target and the optimal herd or flock structure. Each variant (Breedcowplus, Breedewe, BreedMeatSheep, or Breeddoe,) is a steady-state herd or flock model that applies a constantly recurring pattern of calving, lambing or kidding losses, respectively, and sales for a stable herd/flock with a pre-determined grazing pressure constraint that effectively sets the property or herd/flock size (total number of DSE or AE).

Steady-state models like Breedcowplus and Breedewe are not suitable for considering scenarios that take time to implement, increase the financial risk of the property, require a change in capital investment or additional labour, or result in an incremental change in herd of flock structure, performance or production. As most change scenarios in the rangelands of central-western Queensland require consideration of such factors over time, it is necessary to undertake the scenario analysis in a dynamic model that can take into account the time to implement change. Models like Dynamaplus that consider herd structures and performance with annual time steps facilitate analysis of any change in the herd costs, incomes, or management strategy over time. Derivative models based on the Dynamaplus structure were developed to allow implementation of wethers for wool and self-replacing sheep flocks (Sheepdyn), meat sheep (MeatSheepDynama), or rangeland goats (RangelandGoatsDyn). A third derivative of Dynamaplus that could model the integration over time of alternative beef, wool sheep, meat sheep and meat goat enterprises as component enterprises of one property was also developed.

In this study, steady-state models were applied to identify a) optimal or current herd or flock structures for the start of each scenario, and b) each annual change in herd or flock structure or performance expected to occur for as long as it took to implement change and reach the expected structure. The incremental steady-state models were transferred into the dynamic models to reflect steps in the change process, thereby accurately modelling the impact of the change over time and allowing targeted herd or flock structures and sales targets to be maintained.

Once the structure for both a) a property enterprise structure that did not change, and b) a property enterprise structure that did change were fully implemented in separate dynamic models, the difference between the two models was identified with the Investan program (also within the BCD suite). To take full account of the economic life and impact of the investments modelled the capability of the dynamic and Investan models were extended to 30 years. In summary, for each alternative management strategy, the regionally relevant herd or flock model was applied to determine and compare the expected and alternative productivity and profitability over a 30-year investment period. Change was implemented by altering the herd or flock performance and inputs of the base scenario to construct the new scenario. The comparison of the two scenarios, one of which reflected the implementation and results of the proposed change from a common starting point, was the focus of the analysis.

Partial discounted cash flow (DCF) techniques were applied using an extended, 30-year version of the Investan program linked to a dynamic investment model to look at the net present value (NPV) and internal rate of return (IRR) associated with any additional capital or resources invested within the property. The DCF analysis was compiled in real (constant value) terms, with all variables expressed in terms of the price level of the current year (2020). It was assumed that the current relationship between costs and prices would be maintained for the period of the analysis. Representative livestock and wool sale prices, calculated from values of the recent past, were taken to represent the constant value of livestock prices.

The whole farm analysis was calculated at the level of operating profit, which, in turn, was calculated as: *operating profit = (total receipts – variable costs = total gross margin) – overheads*. Operating profit was defined as the return to total capital invested after the variable and overhead (fixed) costs involved in earning the revenue were deducted. Operating profit represents the reward to all of the capital managed by the property. The calculation of operating profit included an annual allowance for plant replacement/depreciation and for the labour and management supplied by the owner, even though this is often unpaid or underpaid. Our definition of an operators allowance was that it is the value of the owner's labour and management estimated by reference to what professional farm managers/overseers are paid to manage a similar property. For a true estimate of farm profit, these allowances need to be valued appropriately and included.

Any annual figures usually applied in the calculation of operating profit were modified to calculate the NPV for the property or each alternative management strategy. For example, the depreciation allowance was not part of the calculation of NPV and was replaced by the relevant capital expenditure or salvage value of a piece of plant when it occurred during the investment period. Opening and salvage values for land, plant and livestock were applied at the beginning and end of the DCF analysis to capture the opening and residual value of assets.

The BCD software and herd models, the steady-state sheep and goat models, plus the 30-year version of the models applied in this analysis are available from the authors of this report. A summary of the role of each component of the BCD suite of programs is provided in Appendix 1. Breedcow and Dynama software. Additionally, a more detailed explanation of the methods and terminology used investment analysis is provided in Appendix 2. Discounting and investment analysis.

2.2 Criteria used to compare the strategies

The economic criteria were NPV at the required rate of return (5%; taken as the real opportunity cost of funds to the producer) and IRR. A present value model is a mathematical relationship that depicts the value of discounted future cash flows in the current period. It therefore provides a measure of the net impact of the investment in current value terms and takes into account the timing of benefits and costs over the life of the investment. The NPV is the sum of the discounted values of the future income and costs associated with the change in the herd, flock or pasture management strategy and was calculated as the incremental net returns (operating profit as adjusted) over the life of the investment, expressed in present day terms. In an IRR model, NPV is equal to zero and the discount rate is unknown and must be discovered. IRR was calculated as the discount rate at which the present value of income from a project equals the present value of total expenditure (capital and annual costs) on the project (i.e., the break-even discount rate). An amortised (annualised) NPV was calculated at the discount rate over the investment period to assist in communicating the difference between the representative, base property and the property after the alternative management strategy was implemented. This measure is not the same as the average annual difference in operating profit between the two strategies. The average annual change in operating profit is likely to be greater than the value of the amortised NPV for any given investment as the NPV represents the operating profit discounted back to a present value whereas the average annual change in operating profit is undiscounted. The annualised NPV can be considered as an approximation of potential average annual change in profit over 30 years, resulting from the management strategy.

The financial criteria were peak deficit, the number of years to the peak deficit, and the payback period in years. The representative property started with no debt, but accumulated debt and paid interest as required by the implementation of each strategy. Peak deficit in cash flow was calculated assuming interest was paid on the deficit and compounded in each additional year that the deficit continued into the investment period. The payback period was calculated as the number of years taken for the cumulative net cash flow to become positive. The net cash flow was compounded at the discount rate.

It is important to recognise that while gross margins are a first step in determining the value of an alternative strategy, they do not indicate whether the strategy will be more or less profitable compared to the base operating system or to other alternatives. To make this assessment, it is necessary to conduct a property-level economic analysis that applies a marginal perspective, analyses the investment over its expected life and applies partial discounted net cash flow budgets to define NPV at the required rate of return and the IRR. Such an analysis accounts for changes in unpaid labour, herd structure and capital, and includes the implementation phase. Such an analysis also provides an estimate of the extra return on extra capital invested in developing an existing operation.

2.3 Constructed property

The constructed, representative base property was based upon that developed for a previous analysis for this region that focussed on assessing grazing management strategies (Bowen *et al.* 2019b). The representative property, herd and flock characteristics were informed by recent industry surveys and research relevant to the region (McIvor 2010; Bray *et al.* 2014; McGowan *et al.* 2014). The property closely followed the assumptions described in Scanlan and McIvor (2010) and Scanlan *et al.* (2011) for the rangelands of central-western Queensland, which were derived from regional consultation with livestock producers, researchers and extension officers via workshops and out-of-session reviews.

The hypothetical property was a total area of ca. 16,200 ha of primarily native pastures growing on land types characteristic of the Longreach region. The property was considered to be currently in B land condition on average (scale A-D; Quirk and McIvor 2003; DAF 2011), supporting ca. 1,071 AE or 9,000 DSE, using an AE : DSE conversion of 1 : 8.4 (McLennan *et al.* 2020). This land condition rating was considered as broadly representative of the grazing lands in the target region in 2019-2020 and is supported by survey data of Beutel and Silcock (2008).

Although not necessary for the BCD modelling process, the modelled property was conceptualised as consisting of 10 main paddocks to meet GRASP modelling requirements as part of the previous bio-economic analysis (Bowen *et al.* 2019b; Bowen *et al.* 2021). Each paddock was allocated an area, a main land type, a land condition rating and a carrying capacity (Table 8). Table 8 is indicative only, as a typical property in this region would be unlikely to have just one land type within each paddock.

Table 8 - Paddocks, land types and land condition rating

Paddock	Area (ha)	Main land type	Starting land condition rating	Total AE /paddock	ha/ AE
1	810	Boree wooded downs	B	35.63	22.7
2	810	Open alluvia	B	30.54	26.5
3	2,835	Open downs	B	187.07	15.2
4	2,835	Open downs	B	187.07	15.2
5	2025	Open downs	B	133.62	15.2
6	1,820	Open downs	B	120.09	15.2
7a	1,620	Soft gidgee, cleared of timber[A]	B	149.65	7.6
7b	486	Soft gidgee[B]	B	-	-
8	1,215	Wooded downs	B	80.17	15.2
9	1,215	Wooded downs	B	80.17	15.2
10	1,015	Wooded downs	B	66.98	15.2
Total	*16,200*	-	-	*1,071*	*15.13*

AE, adult equivalent.

[A]Tree basal area (TBA) of 1 m^2/ha, sown to buffel grass.

[B]TBA of 5 m^2/ha, not considered as making a significant contribution to carrying capacity in its present state.

The property was modelled as running either a beef enterprise, a sheep enterprise (wool or meat) or a rangeland meat goat enterprise. A typical property in this region is likely to have sheep and wool production in its history and to have moved towards beef production partly or wholly over recent decades. It appears unlikely that any property within this region is used solely for goat meat production (Hacker and Alemseged 2014), but recent demand for goat products suggests that such a property may exist in the future.

2.3.1 Operating expenses and asset value

Additional information required to complete the analysis included fixed or operating expenses and capital expenditure incurred together with the opening value of the land, plant and improvements. Fixed (or operating) costs are those costs that are not affected by the scale of the activities but must be met in the operation of the property. Table 9 indicates the expected fixed cash costs for the property. Non-cash fixed costs include part or all of the operator’s allowance, which will be identified later.

Table 9 – Annual fixed cash costs for the base property

Item	Cost
Administration	$10,000
Electricity and gas - farm	$5,000
Farm rates	$15,000
Fuel and oil	$10,000
Insurance - farm	$7,500
Motor vehicle expenses	$10,000
Plant repairs	$20,000
Wages[A]	-
Weed control	$5,000
Total	*$82,500*

[A]The amount of wages paid can differ with each livestock enterprise and will be incorporated separately within the relevant sections.

Table 10 shows the plant inventory for the base property. The replacement cost is an estimate of how much it would cost to replace the item if it were to be replaced now. The salvage value is estimated based on the item being valued now but with the item in a condition equivalent to what it will be in when it is replaced. The items were either salvaged or replaced in the DCF analysis at the intervals and capital values indicated in Table 10.

Table 10 - Plant inventory for the base property

Item	Market value	Years to replacement	Replacement cost	Subsequent replacement interval (years)	Salvage value	Replacement allowance
4wd ute	$35,000	4	$50,000	6	$25,000	$4,167
Old ute	$10,000	6	$15,000	10	$5,000	$1,000
Box trailer	$2,500	20	$5,000	20	$0	$250
Tractor with bucket	$45,000	15	$60,000	20	$15,000	$2,250
4wd motor bike	$6,500	7	$12,000	10	$0	$1,200
4wd motor bike	$4,500	3	$12,000	10	$0	$1,200
Buggy	$11,000	5	$20,000	10	$4,000	$1,600
Motor bike	$4,000	5	$7,500	10	$1,000	$650
Motor bike	$3,000	7	$7,000	10	$1,000	$600
Motor bike	$2,000	2	$6,500	10	$1,000	$550
Grain trailer	$5,000	15	$10,000	20	$1,000	$450
Grader	$70,000	25	$90,000	30	$20,000	$2,333
Body truck	$30,000	15	$50,000	20	$10,000	$2,000
Sundry equipment	$20,000	10	$35,000	25	$5,000	$1,200
Workshop, minor plant	$50,000	20	$50,000	20	$0	$2,500
Total	*$298,500*		*$430,000*			*$21,950*

The value of the land and fixed improvements for the example property was set at a current market value of $6,000,000. This resulted in an opening value of the total land, plant and improvements for the property investment of $6,298,500.

The allowance for owner’s labour and management was varied for each livestock enterprise according to an assessment made by our reference group of local producers. The reference allowance was $80,000 per annum for the self-replacing sheep and wool flock and this was varied for each alternative enterprise based on an assessment of the range of skills and effort required to appropriately manage the herd or flock activities to gain the level of output predicted.

3 Profitability of alternative livestock enterprises - steady-state analysis

3.1 Self-replacing beef cattle production activity

3.1.1 Introduction

Beef cattle production has been the dominant livestock enterprise in the central-western rangelands over recent decades producing the largest gross value of all livestock enterprises: $672,581,010 for the Desert Channels NRM region for statistical reporting (44 million ha) in 2018-19 (ABS 2020b). The self-replacing beef herd is the most common beef production system in the region.

3.1.2 Methods

The first activity modelled was a self-replacing breeding and growing activity that relied on the production of weaners by a breeding herd. Weaner steers entered a growing system that varied in size with the period of time steers were retained prior to sale. Heifers were used to maintain the breeding herd or were culled and sold. Breeding cows were culled on reproductive performance and age. Herd bulls were retained in the breeding herd for an average of 5 years. The selected growth path, sale weights, sale ages, costs, prices, reproduction efficiency, and female culling values (all identified below) were optimised to identify the best herd gross margin after interest for the mature cow culling age and the surplus heifers culling age. The optimal age of steer turnoff (sale) was then determined for the herd with the optimal female sale age implemented.

The allowance for operator's labour and management was $60,000/annum which was $20,000 (or 25%) lower than the amount applied to the self-replacing sheep and wool enterprise. An allowance of $5,000/annum was also allocated to contract wages for the property when it was run solely as a self-replacing beef breeding enterprise.

3.1.2.1 Steer and heifer growth assumptions

The pattern of growth over time for steers and heifers underpinned the markets available for both steers and surplus heifers as well as the likely mating age and reproduction performance of the heifers as they enter the breeding herd. Some evidence exists that, where the same nutrition is available, male calves grow about 8% faster than female calves pre-weaning and steers grow about 5% faster than heifers post-weaning (Fordyce *et al.* 1993). To simplify the analyses, all pre-weaning growth rates for female calves were set at 5% lower than male calves, the same as the post-weaning growth rate difference between steers and heifers.

Table 11 indicates the expected post-weaning seasonal performance for steers. Steers were assumed to gain weight at about 0.38 kg/head.day on grass pastures to achieve 139 kg/head.annum post-weaning and heifers to gain ca. 0.36 kg/head.day to achieve 132 kg/head.annum post weaning.

Table 11 – Expected-post weaning steer growth rates for the base scenario

Month	Days	Daily liveweight gain (kg/d)	Total liveweight gain (kg)
Jan	31	0.8	24.8
Feb	28	0.8	22.4
Mar	31	0.7	21.7
Apr	30	0.7	21.0
May	31	0.6	18.6
Jun	30	0.5	15.0
Jul	31	0.2	6.2
Aug	31	0	0.0
Sep	30	0	0.0
Oct	31	0	0.0
Nov	30	0	0.0
Dec	31	0.3	9.3
Average/Annual	*365*	*0.38*	*139.0*

Table 12 shows the expected month-by-month growth pattern for steers and heifers. Expected liveweight at birth, weaning and birthdays are highlighted (yellow, green and orange, respectively). The steer (and heifer) growth model underpinned the herd performance for the modelled base enterprise.

Table 12 - Expected growth of steers and heifers for the base scenario

Age (months)	Month	Steer daily gain (kg/day)	Steer liveweight (kg)	Heifer daily gain (kg/day)	Heifer liveweight (kg)
0	Nov		35		35
1	Dec	0.80	59	0.76	58
2	Jan	0.80	84	0.76	81
3	Feb	0.80	109	0.76	105
4	Mar	0.80	131	0.76	126
5	Apr	0.80	156	0.76	150
6	May	0.80	180	0.76	173
7	Jun	0.5	195	0.48	187
8	Jul	0.2	201	0.19	193
9	Aug	0	201	0.00	193
10	Sep	0	201	0.00	193
11	Oct	0	201	0.00	193
12	Nov	0	201	0.00	193
13	Dec	0.3	210	0.29	202
14	Jan	0.8	235	0.76	225
15	Feb	0.8	260	0.76	249
16	Mar	0.7	280	0.67	267
17	Apr	0.7	301	0.67	288
18	May	0.6	319	0.57	305
19	Jun	0.5	335	0.48	320
20	Jul	0.2	341	0.19	325
21	Aug	0	341	0.00	325
22	Sep	0	341	0.00	325
23	Oct	0	341	0.00	325
24	Nov	0	341	0.00	325
25	Dec	0.3	350	0.29	334
26	Jan	0.8	375	0.76	358
27	Feb	0.8	399	0.76	381
28	Mar	0.7	419	0.67	400
29	Apr	0.7	441	0.67	420
30	May	0.6	459	0.57	437
31	Jun	0.5	474	0.48	452
32	Jul	0.2	480	0.19	458
33	Aug	0	480	0.00	458
34	Sep	0	480	0.00	458
35	Oct	0	480	0.00	458
36	Nov	0	480	0.00	458
37	Dec	0.3	489		
38	Jan	0.8	514		
39	Feb	0.8	539		
40	Mar	0.7	558		
41	Apr	0.7	580		
42	May	0.6	598		
43	Jun	0.5	614		
44	Jul	0.2	620		
45	Aug	0	620		
46	Sep	0	620		
47	Oct	0	620		
48	Nov	0	620		

3.1.2.2 Beef herd DSE assumptions

The DSE ratings were calculated for a period of time, not for a point in time. Except for weaners and sale stock, this was 12 months, e.g., from age 12 months to 24 months. The weaner group was rated for 7 months (age 5 to 12 months) for 'keepers', and less for those sold. This is even though the calves may not be weaned at 5 months old. All sale stock were rated from their nominal birth month to their sale month, e.g., steers sold at age 18 months were rated for 6 months (age 12 to 18 months) in their sale year. Table 13 shows the DSE ratings for all classes of cattle retained in the herd for the entire 12-month period. The AE ratings are also shown, for comparison.

Table 13 – Adult equivalent (AE) and dry sheep equivalent (DSE) ratings for cattle held 12 months[A]

Description at start of rating period	Age at start (months)	Age at end (months)	Cattle carried through whole year				
			Months rated	Lowest or start liveweight (kg)	Highest or end liveweight (kg)	AE/head rating	DSE/head rating
Extra for cows weaning a calf	n/a	n/a	n/a	n/a	n/a	0.35	2.94
Calves 5 months	5	12	7	153	197	0.22	1.88
Heifers 1 year	12	24	12	193	325	0.57	4.78
Heifers 2 years	24	36	12	325	458	0.86	7.23
Cows 3 years+	n/a	n/a	12	500	500	1.10	9.23
Steers 1 year	12	24	12	201	341	0.60	5.00
Steers 2 years	24	36	12	341	480	0.90	7.58
Bullocks 3 years	36	48	12	480	620	1.21	10.15
Bullocks 4 years	48	60	12	620	759	1.52	12.73
Bulls all ages	na	na	12	750	750	1.65	13.85

n/a, not applicable.

[A]In the herd and economic modelling the standard weight of one AE = 455 kg, standard weight of one DSE = 45 kg; (AE : DSE of 1 : 8.4).

As described in section 1.1.4.4, the DSE ratings for breeding stock are based on average weight, plus a loading for breeders that wean a calf. This loading represents the extra nutritional requirement of a cow that rears a calf, relative to a dry cow. The loading for rearing a calf was 0.35 AE. This is equivalent to 2.94 DSE (0.35 x 8.4) and covers the extra load of pregnancy, lactation, and pasture consumed by the weaner itself up to age 5 months, at which point the weaner begins to be rated in its own right. Table 14 shows the AE and DSE ratings for all classes of cattle that may be sold from the herd during a 12-month period.

Table 14 - Adult equivalent (AE) and dry sheep equivalent (DSE) ratings for cattle sold during the year[A]

Description at start of rating period	Sale month	Months rated	Start liveweight (kg)	Paddock liveweight at sale (kg)	AE/head rating	DSE/head rating
Calves 5 months	6	2	153	176	0.06	0.51
Heifers 1 year	2	3	193	320	0.19	2.76
Heifers 2 years	7	8	325	452	0.67	4.18
Cows 3 years+	7	8	500	500	0.70	5.38
Steers 1 year	2	3	201	335	0.20	2.89
Steers 2 years	7	8	341	480	0.70	5.05
Bullocks 3 years	7	8	480	620	0.74	6.77
Bullocks 4 years	7	8	620	737	0.77	6.26
Bulls all ages	7	8	750	750	0.85	8.08

[A]In the herd and economic modelling the standard weight of one AE = 455 kg, standard weight of one DSE = 45 kg; (AE : DSE of 1 : 8.4).

3.1.2.3 Herd husbandry costs and treatments

Table 15 shows the treatments applied to the various classes of cattle held for 12 months in the breeder herd model. Sale stock may or may not have received the treatment depending upon the timing of sale.

Table 15 - Treatments applied and cost per head for the base cattle herd

Treatment	Weaners	Females 1-2 years	Females 2-3 years	Females 3+ years	Bulls
Weaner feed	$10.50	-	-	-	-
NLIS tag	$3.00	-	-	-	-
Dry season supplement[A]	$12.00	$23.00	$23.00	$23.00	$21.00
Vibrio vaccine bulls	-	-	-	-	$10.00
Three-day vaccine bulls	-	-	-	-	$35.00
Pregnancy testing	-	$5.00	$5.00	$5.00	-

[A]This cost was incurred 3 years in 10 by breeding females and by weaner steers and heifers retained for the full year.

3.1.2.4 Other herd performance parameters

Data to describe the reproduction efficiency of the breeder herd was based on the data collected by the CashCow project (McGowan *et al.* 2014). The median reproductive performance values for the CashCow country type termed ‘Northern Downs’ are summarised in Table 16. This data set was seen as being closest to the expected median performance of a beef breeding herd located in the central-western rangelands region near Longreach.

Table 16 - Median reproduction performance for 'Northern Downs' data (McGowan et al. 2014)

Reproduction performance indicator	Heifers	First lactation cows	Second lactation cows	Mature	Aged	Overall
P4M[A]	-	45%	62%	67%	71%	66%
Annual pregnancy[B]	87%	75%	-	82%	83%	80%
Foetal / calf loss	14.9%	4.7%	-	7.20%	9.30%	10.0%
Contributed a weaner[C]	77%	68%	-	71%	70%	72%
Pregnant missing[D]	-	6.7%	-	7.0%	6.50%	6.6%

[A]P4M - Lactating cows that became pregnant within four months of calving.

[B]Percentage of cows in a management group (mob) that became pregnant within a one-year period. For continuously mated herds, this included cows that became pregnant between September 1 of the previous year and August 31 of the current year.

[C]Females were recorded as having successfully weaned a calf if they were diagnosed as being pregnant in the previous year and were recorded as lactating (wet) at an observation after the expected calving date.

[D]pregnant animals that fail to return for routine measures, but not including irregular absentees. It comprises mortalities, animals whose individual identity is lost, and those that permanently relocate either of their own accord or without being recorded by a manager.

Table 17 shows the level of reproductive performance of each class of females required to achieve an expected weaning rate of 71.84% for all cows mated in the Breedcowplus model. The output from the model was similar to the CashCow project's 'contributed a weaner' figure of 72%, and was achieved using similar inputs to the CashCow data for annual pregnancy (conception), calf loss, and 'missing' data. Heifers were first mated at 2 years of age. The expected mortality rates in the base herd were influenced by the CashCow project data for missing pregnant females but were based on the mortality rates estimated by local case study participants.

Table 17 - Calving rate and death rate assumptions for the base cattle herd

Cattle age year start	Weaners	1	2	3	4	5	6	7	8
Cattle age year end	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**
Expected conception (%)	n/a	0	85	70	80	80	80	80	81
Expected calf loss from conception to weaning (%)	n/a	0	14.9	4.7	7.2	7.2	7.2	7.2	9.3
Proportion of empties (PTE) sold (%)	n/a	0	100	100	100	100	100	100	100
Proportion of pregnant females sold (%)	n/a	0	0	0	0	0	0	0	0
Calves weaned/cows retained (%)	n/a	0	85.1	95.3	92.8	92.8	92.8	92.8	90.7
Female death rate (%)	2	2	5	4	4	4	4	4	5
Male death rate (%)	2	2	4	4	4	n/a	n/a	n/a	n/a

n/a, not applicable; PTE, pregnancy tested empty (i.e., not in calf).

Table 18 shows the expected median birth date for calves and the weaning month for the base herd based on a 3-month mating period beginning in the middle of the previous January. Bulls were removed from the breeding herd separately to the one main muster undertaken in May to wean calves and identify cull breeding cows.

Table 18 - Expected mating period for breeders in the base cattle herd

Parameter	Value
Bulls in	18/01/year
Days mated	91
Months mated	2.99
Bulls out	18/04/year
Days gestation	287
First calf	31/10/year
Last calf	30/01/year
Mid-point mating	03/03/year
Mid-point calving	15/12/year
Date when average calf is 6 months old	10/06/year

3.1.2.5 Prices

The hypothetical, constructed property was located near Longreach with a number of selling centres and abattoirs available for sale stock. Slaughter and sale yard values were derived from the MLA 'Queensland over the hooks (OTH)' prices database (MLA monthly market statistics database at http://statistics.mla.com.au/Report/List). The OTH and saleyard indicators are calculated as a weighted average of Queensland processor grids and saleyards. Transport and other selling costs were estimated for either Roma (store cattle, ca. 700 km distance) or Rockhampton (slaughter cattle, ca. 700 km distance).

Prices for sale stock have shown large variability over the last decade with a substantial increase in the prices paid during the last 5 years compared to the average of the previous years. Figure 8 shows the relationship between the prices of medium-sized store steers, cull cows and grass-fed slaughter steers for the decade from January 2010 to December 2019 across Queensland cattle markets.

Figure 8 - Steer and cow prices from January 2010 to December 2019

MLA over the hooks and saleyard cattle price indicators Queensland. Prices converted to $/kg live, GST exclusive

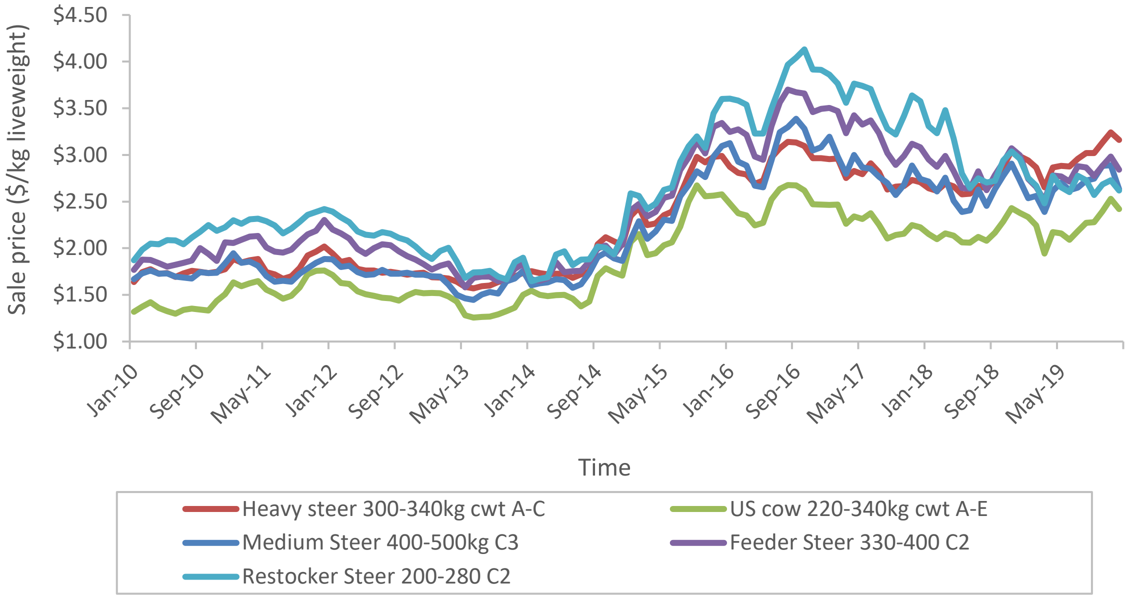


Table 19 shows the relationship between the prices of medium sized store steers, cull cows and grass-fed slaughter steers during a number of periods over the last decade (January 2010 to December 2019) at the Roma store cattle sale.

Table 19 - Steer and cow prices over time from January 2010 to December 2019

Roma store sale combined agents' prices ($/kg liveweight) GST exclusive

Average of last	Class of cattle and liveweight range (kg)											
	Steers					Heifers				Cows		
	<220	221-280	281-350	351-400	401-550	<220	221-280	281-350	351-400	300-400	401-500	>500
10 years	$2.57	$2.55	$2.47	$2.39	$2.34	$2.21	$2.19	$2.12	$2.07	$1.42	$1.65	$1.81
5 years	$3.16	$3.12	$3.03	$2.94	$2.86	$2.67	$2.65	$2.61	$2.56	$1.74	$2.02	$2.21
2 years	$2.76	$2.80	$2.79	$2.77	$2.75	$2.20	$2.29	$2.33	$2.35	$1.53	$1.85	$2.11

Table 20 shows the price margin between light-weight steers and other classes of steers and heifers for different periods over the decade (January 2010 to December 2019) at the Roma store cattle sale.

Table 20 – Price margin to steers 281-350 kg liveweight at the Roma store sale

Time period	Class of cattle and liveweight range (kg)								
	Steers					Heifers			
	<220	221-280	281-350	351-400	401-550	<220	221-280	281-350	351-400
Last 10 years	$0.10	$0.08	$0.00	-$0.08	-$0.13	-$0.25	-$0.28	-$0.35	-$0.39
Last 5 years	$0.13	$0.09	$0.00	-$0.09	-$0.16	-$0.35	-$0.37	-$0.42	-$0.47
Last 2 years	-$0.02	$0.01	$0.00	-$0.01	-$0.04	-$0.59	-$0.50	-$0.45	-$0.43

The analysis of price data allowed the construction of values that can be applied as constant values even though they are based on averages over time. Table 21 shows the price data and selling costs selected for each class in the beef models and applied as constant values.

Table 21 - Prices worksheet showing selling costs, gross and net prices for beef cattle
Data for 1-year old steers highlighted grey

Cattle group	Paddock weight (kg/head)	Weight loss to sale (%)	Sale weight (kg/head)	Price ($/kg)	Margin to 1-year old steers	Commission (% of value)	Other selling costs ($/head)	Freight ($/head)
Weaner heifers	173	5	164	$2.45	-$0.35	4.00	$17.00	$35.00
Heifers 1 year	320	5	304	$2.45	-$0.35	4.00	$17.00	$41.18
Heifers 2 years	452	5	429	$2.60	-$0.20	0.00	$5.00	$53.85
Cows 3 years+	500	5	475	$2.34	-$0.46	0.00	$5.00	$58.83
Weaner steers	180	5	171	$2.80	$0.00	4.00	$17.00	$35.00
Steers 1 year	335	5	318	$2.80	$0.00	4.00	$17.00	$43.75
Steers 2 years	480	5	456	$2.75	-$0.05	4.00	$17.00	$56.00
Steers 3 years	620	5	589	$2.80	$0.00	0.00	$5.00	$70.00
Steers 4 years	737	5	700	$2.70	-$0.10	0.00	$5.00	$93.33
Cull bulls	750	5	700	$2.50	-$0.30	0.00	$5.00	$100.00

An allowance was made for 5% weight loss between the paddock weights and the sale weights. The expected selling costs of each class of stock varied due to whether they were sold in Roma or at Rockhampton ($2.00/km.deck and 700 km to Roma; $2.00/km.deck and 700 km to Rockhampton).

3.1.3 Results and discussion

3.1.3.1 Herd outputs

The optimised female herd structure produced a final cow culling age of 8-9 years with surplus heifers sold between 2-3 years of age. All breeding females were culled on a pregnancy diagnosis or age. Females that were pregnancy-tested in-calf and then failed to produce a weaner were retained in the model. Table 22 shows the final female culling and herd size parameters.

Table 22 – Steady-state herd parameters

Parameter	Value
Weaner heifers to be retained	158
Age at first joining (years)	2
Cow culling age (years)	8
Required herd size (AE)	1,071
Required herd size (DSE)	9,000

AE, adult equivalent; DSE, dry sheep equivalent.

Table 23 indicates the herd gross margin after interest for each steer sale age after the cow culling age was optimised. The highest expected herd gross margin after interest was produced by selling steers between 36 and 48 months of age at an average paddock weight of 620 kg and selling 13% of maiden heifers (that were surplus and culled prior to mating) between 24 to 36 months old. The optimised herd structure was the combined result of (1) the performance of the breeder herd, (2) the price difference between each class of cattle in the model, and (3) the supplement and drought feeding costs associated with the breeder component of the herd.

The optimised herd structure produced expected breeder deaths of 15/annum or 4.32% of female breeding stock maintained for the year. The application of the data for reproduction efficiency and mortality rates produced an expected weaning rate of 71.84% (i.e., weaners from all cows mated). The optimised breeding herd produced about 315 weaners from 439 females mated and sold 283 head/annum. Cull female sales made up 48.4% of total sales. The optimum sale age for steers was identified as slaughter steers to the abattoirs. This is different to current practice for many specialist beef producers in the region who target younger turnoff down to weaner age, and suggests recent droughts have had an impact on herd structures and the need to generate cash flow. The data indicates that, long term, the optimum age of turnoff to maximise drought resilience and management flexibility would be slaughter steers to the abattoirs or feed-on steers.

Table 23 - Steer age of turnoff herd gross margin comparison

The optimum age of steer turnoff was used as a base for comparison with alternatives

Parameter	Age of steer turnoff				
	6 months (Weaners)	**1-2 years**	**2-3 years**	**3-4 years (Bullocks)**	**4-5 years (Bullocks)**
Total adult equivalents (AE)	1,071	1,071	1,071	1,071	1,071
Total cattle carried	1,026	1,139	1,158	1,134	1,111
Weaner heifers retained	241	217	186	158	137
Total breeders mated	672	604	517	439	381
Total breeders mated and kept	532	478	409	347	301
Total calves weaned	483	434	372	315	274
Weaners/total cows mated	71.84%	71.84%	71.84%	71.84%	71.84%
Overall breeder deaths	4.32%	4.32%	4.32%	4.32%	4.32%
Female sales/total sales %	46.39%	46.89%	47.39%	48.41%	49.43%
Total cows and heifers sold	209	188	161	136	118
Maximum cow culling age	8	8	8	8	8
Heifer joining age	2	2	2	2	2
Two-year-old heifer sales %	28.03%	28.03%	28.03%	28.03%	28.03%
Total steers and bullocks sold	241	213	179	145	121
Maximum bullock turnoff age	0	1	2	3	4
Average female price	$1,047.42	$1,047.42	$1,047.42	$1,047.42	$1,047.42
Average steer/bullock price	$407.65	$794.71	$1,130.84	$1,574.20	$1,792.08
Capital value of herd	$852,933	$854,842	$877,265	$915,244	$993,258
Imputed interest on herd value	$42,647	$42,742	$43,863	$45,762	$49,663
Net cattle sales	$317,237	$365,577	$370,368	$371,710	$341,160
Direct costs excluding bulls	$18,445	$17,355	$14,871	$12,612	$10,950
Bull replacement	$12,578	$11,302	$9,685	$8,214	$7,131
Herd gross margin	$286,214	$336,920	$345,812	$350,884	$323,079
Herd gross margin less interest	***$243,567***	***$294,178***	***$301,949***	***$305,122***	***$273,417***
Difference to 3-4-year-old steers	*-$61,554*	*-$10,944*	*-$3,173*	*Base*	*-$31,705*

Table 24 shows the number of females in each age group and the number of calves weaned from each group for a herd structure that turned off bullocks between 3-4 years of age at about 620 kg liveweight in the paddock. Table 25 shows the overall herd structure for turning off bullocks between 3-4 years of age.

Table 24 - Female herd structure for the optimised herd

Cow age start year Cow age end year	1 2	2 3	3 4	4 5	5 6	6 7	7 8	8 9
Cows/heifers available start year	155	151	106	71	55	42	32	25
Sales unmated (% start year cows)	0	13.03	0	0	0	0	0	0
Cows spayed (% of start year)	0	0	0	0	0	0	0	0
Sales after mating (% of number mated)	0	15	30	20	20	20	20	0
Unspayed cows sold	0	34	28	12	10	7	6	22
Cows mated in each age group	0	132	106	71	55	42	32	0
Mated cows retained in each group	0	112	74	57	44	34	26	0
Calves weaned from each group	0	95	71	53	41	31	24	0

Table 25 – Total cattle numbers, adult equivalents (AE), and dry sheep equivalents (DSE)

Age at start of rating period	Number kept whole year	Number Sold	AE/head kept	AE/head sold	Total AEs	Total DSEs
Extra for cows weaning a calf	n/a	n/a	0.35	n/a	110	927
Weaners 5 months	315	0	0.22	0.06	71	594
Heifers 1 year but less than 2	155	0	0.57	0.33	88	739
Heifers 2 years but less than 3	112	39	0.86	0.50	116	974
Cows 3 years plus	235	97	1.10	0.64	321	2692
Steers 1 year but less than 2	155	0	0.60	0.34	155	773
Steers 2 years but less than 3	151	0	0.90	0.60	151	1148
Bullocks 3 years but less than 4	0	145	1.21	0.81	0	984
Bulls all ages	11	2	1.65	0.96	20	165
Total number	*1,134*	*283*	-	-	*1,071*	*8,996*

n/a, not applicable.

The selected sale prices, sale weights, selling costs, treatment costs and bull replacement strategy were applied to produce the summary of the optimised Breedcowplus herd gross margin shown in Table 26.

Table 26 - Herd gross margin for the representative, self-replacing base cattle production enterprise

Parameter	$/herd	$/AE	$/DSE
Net cattle sales	$373,431	$348.68	$41.51
Husbandry costs	$12,615	$11.78	$1.40
Net bull replacement	$10,000	$9.34	$1.11
Gross margin (before interest)	$350,816	$327.56	$39.00
Gross margin less interest on livestock capital	*$305,122*	$284.89	$33.92

AE, adult equivalent; DSE, dry sheep equivalent.

The opening value of the land and fixed improvements for the example breeding property was taken as $6,000,000. The opening value of the total value of land, plant and improvements for the beef enterprise investment was $6,298,500. The opening value of the cattle inventory was $1,263,209.

Table 27 indicates the expected performance parameters for the beef property, calculated as a steady state, in Dynamaplus.

Table 27 - Expected value of annual outcomes for the beef property with a self-replacing breeder herd

Parameter	Value
Dry sheep equivalents (DSE)	9,000
Operating profit	$181,366
Rate of return on total capital	2.41%

3.1.3.2 Sensitivity of operating profit to change in model parameters

Table 28 shows the sensitivity of the predicted operating profit for the beef enterprise to change in key assumptions including (1) the prices paid and received and (2) the level of herd productivity. Each parameter was varied by an amount relevant to the expected medium-term variability of each parameter. The sensitivity analysis is based on a 'costless' change in parameters and therefore should be treated with great caution. There are nearly always additional costs incurred, or saved, that can greatly impact the predicted level of benefit or change in the level of operating profit.

Table 28 - Expected impact on average operating profit of changing model parameter values for the self-replacing beef herd

Parameter	Value	Change to base	% change relative to base
Beef price minus 20%	$102,689	-$78,678	-43%
Beef price plus 20%	$260,044	$78,677	43%
Fixed costs minus 20%	$198,867	$17,500	10%
Fixed costs plus 20%	$163,867	-$17,500	-10%
Treatment costs minus 20%	$183,753	$2,386	1%
Treatment costs plus 20%	$178,981	-$2,386	-1%
Mortality rate minus 50%	$196,276	$14,909	8%
Mortality rate plus 50%	$166,883	-$14,484	-8%
Growth rate minus 5%	$180,027	-$1,340	-1%
Growth rate plus 5%	$183,745	$2,378	1%
Weaning rate minus 5%	$178,025	-$3,342	-2%
Weaning rate plus 5%	$184,600	$3,233	2%

The absolute and relative changes in the level of operating profit identified in the sensitivity analysis for the beef enterprise can be compared to the impact of similar levels of change in key assumptions for the alternative livestock enterprises for the same constructed property. The level of profit generated by the beef enterprise was most sensitive to the beef price received. A 1% change in price had at least four times the impact on profit of any other factor. It should be noted that parameters such as the expected rates of growth, mortality and weaning would require an investment of either time or capital to change their average level and that this investment would reduce the impact of the level of response, depending upon the investment strategy chosen.

3.2 Steer finishing operation

3.2.1 Introduction

A number of properties in the rangelands of central-western Queensland are used predominately for trading cattle or growing steers to a weight and condition suitable for sale. It is difficult to appropriately model the use of the property solely as a trading activity given the range of classes of cattle that could be traded and the variety of periods of time that they could be held. A steer growing or finishing activity, where steers enter the property at a typical weight and are held for a typical period, allows the annual steer growth path to be used to predict weight gains. The relative steer purchase and sale prices can be determined from a price analysis. The previous analysis for the self-replacing breeding herd indicated that slaughter weight bullocks were the most profitable steer sale-age target. The main difference between a breeding and steer finishing activity is that the steer activity purchases all steers as weaners and has no breeders or female cattle on the property and the breeding activity has a breeder herd on the property that produces 1) weaner steers for a steer growing activity, 2) cull heifers, and 3) cull cows. The breeder activity has previously been modelled as the self-replacing beef herd (Section 3.1).

3.2.2 Methods

This section determines the relative profitability, at the farm level, of operating the property to purchase weaners and turn them into finished steers. The beef herd model was restructured to purchase weaner steers at the expected weaner weight of the home-bred steers. They were then held the same amount of time and sold at the same weight and value as identified for the steers sold at the optimum age of turnoff in the base beef breeder herd model (i.e., slaughter steers to the abattoirs).

The purchase price of the weaner steers was based on the value applied in the breeding herd model except in this model the steers were purchased and then transported to a point equivalent to the distance from Cloncurry to Longreach (Table 29). However, it is recognised that steers may be purchased across a number of regions. In this example, the cost to the enterprise was decided by identifying the market value and adding the costs of (1) finding the steers, (2) transport to the property, and (3) settling the cattle on the property.

All other husbandry and selling costs, selling prices and sale weights for steers were maintained at the same average value as the steers produced by the self-replacing beef herd. The losses in purchased steers was doubled in the first 2 years they were retained compared to that experienced by the steers produced by base breeder herd (2% increased to 4%/annum) based on anecdotal evidence.

As for the self-replacing beef cattle herd, the allowance for operator’s labour and management was $60,000/annum which was $20,000 (or 25%) lower than the amount applied to the self-replacing sheep and wool enterprise. The same allowance (as for the self-replacing beef herd) of $5,000/annum was also allocated to contract wages for the property when it was run as a steer finishing operation.

Table 29 – Landed cost of purchased, turnover steers

Purchases are on a liveweight basis

Parameter	Value
Travel costs	$1,000
Number purchased	457
Travel cost/head	$2.19
Transport cost/head	$42.00
Induction cost/head	$5.00
Average purchase liveweight (kg)	180
Buying cost/kg	$0.27
Purchase price/kg at the saleyards	$2.80
Landed purchase cost/kg	$3.06
Cost per head on-farm	*$551.00*

3.2.3 Results and discussion

3.2.3.1 Herd outputs

Removing the breeding herd and replacing them with steers changes the livestock schedule. Table 30 indicates the typical livestock schedule for the steer finishing operation.

Table 30 – Livestock schedule for the steer finishing operation

Description	Opening number	Number purchased	Number sold	Closing number
Weaner steers	-	457	0	439
1 year-old steers	439	0	0	421
2-year-old steers	421	0	0	404
3-year-old steers	404	0	404	0

Table 31 compares the livestock trading schedule for the property operated as a steer finishing operation with the property operated as a breeding and growing operation. Table 32 compares the resulting livestock gross margins for a steer finishing vs. breeding operation.

Table 31 - Livestock trading schedule for (1) steer finishing and (2) breeding enterprises

Parameter	Steer finishing		Breeder herd	
	Number	Value	Number	Value
Opening stock	1,264	$1,460,936	1,414	$1,263,209
Purchases	457	$251,807	2	$10,000
Births	0	$0	315	$0
Transfers in	0	$0	0	$0
Number unaccounted for	0	$0	0	$0
Total	*1,721*	*$1,712,743*	*1,731*	*$1,273,209*
Net sales	404	$635,977	283	$373,431
Deaths	53	$0	67	$0
Rations	0	$0	0	$0
Transfers out	0	$0	0	$0
Closing stock	1,264	1,460,936	2741	$1,263,209
Total	*1,721*	*2,096,913*	*3440*	*$1,636,640*
Trading profit or loss		*$384,170*		*$363,431*

Table 32 - Livestock gross margin for (1) steer finishing and (2) breeding enterprises

Parameter	Steer finishing	Breeder herd
Trading profit or loss	$384,170	$363,431
Agistment	$0	$0
Gross income	$384,170	$363,431
Variable expenses	$1,645	$12,615
Gross margin (before interest)	*$382,525*	*$350,816*

The long-term, breakeven price for purchasing weaner steers (i.e., the maximum average price payable for weaner steers that makes the gross margins for the steer finishing and the breeding enterprises equivalent) is about $3.15/kg at the yards. This is 12% more than the long-term average price applied in calculating the steer purchase price in the steer finishing operation in our analysis. This means that weaner steer purchase prices could increase by up to 12% above their long-term average, with sale prices for steers maintaining the same average price point, before the steer finishing and the breeding enterprises produce about the same herd gross margin.

Table 33 indicates the expected performance parameters for the property run as a steer finishing operation, calculated as a steady state, in Dynamaplus. Other than a slight change in profitability, and a significantly increased exposure to price risk, there are other changes associated with transitioning from a breeding operation to steer turnover. Most importantly, a steer turnover operation, even though it lends itself to more timely destocking during dry periods, requires a greater investment in livestock capital and greater flows of capital as destocking and restocking activities are undertaken. The highly variable annual rainfall and subsequent pasture growth in this region necessitates periodic destocking of properties. Generally, there is a more flexible approach associated with a steer turnover operation enabling managers to sell-down cattle more readily in response to poor seasons. Conversely it is more problematic for those managing a breeding operation with a younger age of steer turnoff to regularly reduce cattle numbers in line with seasonal conditions. Core breeder herds are often carried through dry years increasing mortalities and feeding costs, while sustained overgrazing impacts on resource condition and productivity (McKeon *et al.* 2004). Experienced DAF beef extension officers strongly suggest that the stress and emotional cost of running breeder cattle during dry years must be compared with the peace of mind associated with a steer turnover operation and the agility to make timely sell-down decisions. However, it is impossible to prescribe what a suitable balance might be between a breeding component and a steer trading/turnover component for any individual property as this is principally dependent upon the attitude to risk held by the management team, their goals and skills. The underlying productive capacity of the land resource and the practical management of livestock are secondary considerations in deciding the balance.

Table 33 - Expected value of annual outcomes for the beef property run as a steer finishing operation

Parameter	Value
Dry sheep equivalents (DSE)	9,000
Operating profit	$213,075
Rate of return on total capital	2.76%

3.3 Self-replacing wool production activity

3.3.1 Introduction

Merino sheep production in the central-western rangelands, while once the dominant livestock enterprise, has decreased since the 1990s due to economic factors and the increase in wild dog numbers. The total gross value of sheep meat and wool production in the Desert Channels NRM region for statistical reporting (44 million ha) in 2018-19 was $7,726,118 and $46,836,714, respectively (ABS 2020b). The self-replacing wool production activity is the most common type of sheep production system in the region.

3.3.2 Methods

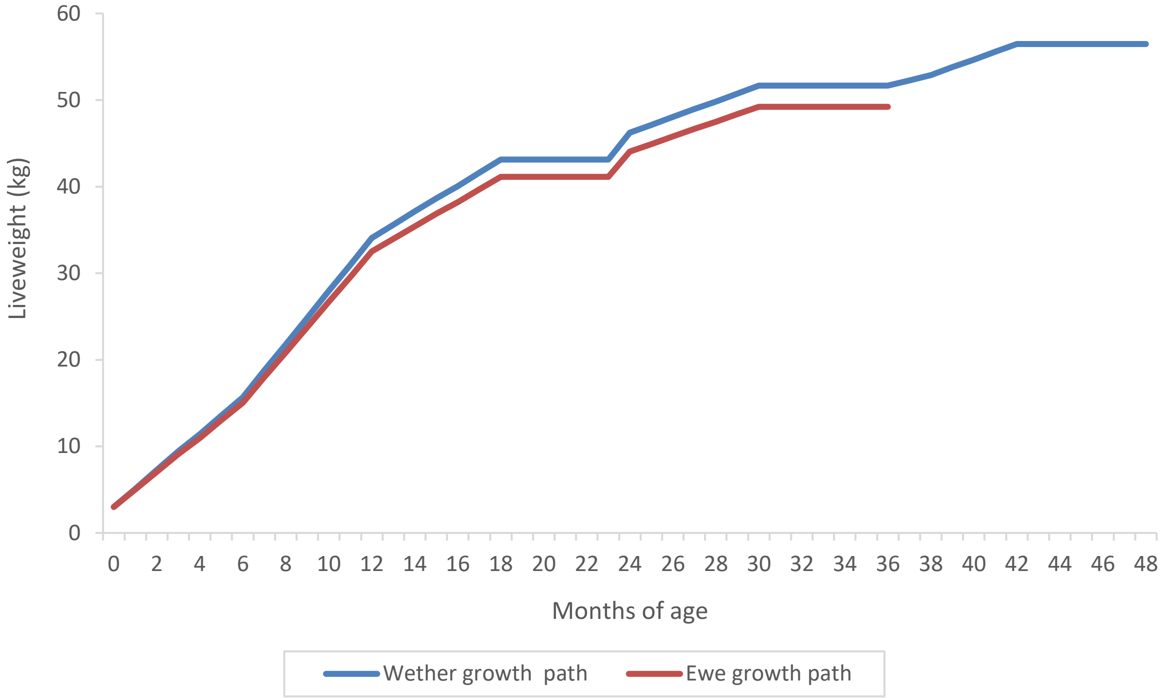
The self-replacing sheep and wool activity relied on the production of weaner sheep by a flock of Merino ewes. Weaner wethers entered a growing system that varied in size with the period of time they were retained prior to sale. Maiden ewes maintained the breeding flock or were culled and sold. Flock ewes were culled on reproductive performance and age. Flock rams were retained in the breeding herd for an average of 4 years.

In the steady-state sheep model, it was assumed that there would be no impact from wild dogs on the level of flock performance. This requires the property to be appropriately fenced or part of an effective cluster, and with ongoing dog control; although it is estimated that at present only 10-15% of the district would be appropriately fenced (extrapolated from RAPAD (2019)). The property employed no permanent labour other than the owner/manager. The allowance for operator's labour and management was $80,000/annum. An allowance of $15,000/annum was allocated to contract wages for the property when it was run solely as a wool sheep enterprise.

3.3.2.1 Wether and young ewe growth assumptions

The pattern of growth over time for wethers and young ewes underpinned the markets available for both wethers and surplus ewes as well as the likely mating age and reproduction performance of the ewes as they entered the breeding flock. Figure 9 indicates the expected post-weaning seasonal performance for wethers and ewes. Growth was expected to plateau after about 18 months of age.

Figure 9 - Wether and ewe growth path



3.3.2.2 Flock DSE assumptions

The DSE rating is calculated for a period of time, not for a point in time. Except for lambs and sale stock, this was 12 months, e.g., from age 12 to 24 months. The lamb weaner group was rated for 7 months (ages 5 to 12 months) for ‘keepers’, and less for those sold. All sale stock were rated from their nominal birth month to their sale month, e.g., wethers sold at age 18 months were rated for 6 months (age 12 to 18 months) in their sale year. Table 34 shows the DSE ratings for all classes of sheep retained in the flock for the entire 12-month period.

Table 34 - Dry sheep equivalent (DSE) ratings for sheep held 12 months[A]

Description at start of rating period	Age at start (months)	Age at end (months)	Sheep carried through whole year			
			Months rated	Lowest or start liveweight (kg)	Highest or end liveweight (kg)	DSE/head rating
Extra for ewes weaning a lamb	n/a	n/a	n/a	n/a	n/a	0.35
Lambs 5 months	5	12	7	13	33	0.30
Ewes 1-2 years	12	24	12	33	44	0.86
Ewes 2-3 years	24	36	12	44	50	1.04
Ewes 3 years+	n/a	n/a	12	50	50	1.11
Wethers 1-2 years	12	24	12	34	46	0.89
Wethers 2-3 years	24	36	12	46	52	1.09
Wethers 3-4 years	36	48	12	52	56	1.20
Wethers 4-5 years	48	60	12	56	61	1.30
Wethers 5-6 years	60	72	12	61	61	1.36
Flock rams all ages	n/a	n/a	12	70	70	1.56

n/a, not applicable.

[A]In the herd and economic modelling the standard weight of one DSE = 45 kg; (AE : DSE of 1 : 8.4).

As described in section 1.1.4.4, the DSE ratings for breeding sheep are based on weight, plus a loading for females that produce a lamb weaner. This loading represents the extra nutritional requirement of a ewe that rears one lamb, relative to a dry ewe. The loading for rearing a lamb in this flock is 0.35 DSE. This covers the extra load of pregnancy, lactation, and pasture consumed by the weaner itself up to age 5 months, at which point the lamb begins to be rated in its own right. Table 35 shows the DSE ratings for all classes of sheep sold from the flock during the 12-month period.

Table 35 - Dry sheep equivalent (DSE) ratings for sheep sold during the year[A]

Description at start of rating period	Sale month	Months rated	Start liveweight (kg)	Paddock liveweight at sale (kg)	DSE/head rating
Lambs 5 months	6	2	13	15	0.05
Ewes 1-2 years	7	8	33	35	0.50
Ewes 2-3 years	7	8	44	45	0.66
Ewes 3 years+	7	8	50	45	0.70
Wethers 1-2 years	7	8	34	43	0.57
Wethers 2-3 years	7	8	46	52	0.73
Wethers 3-4 years	7	8	52	56	0.80
Wethers 4-5 years	7	8	56	61	0.87
Wethers 5-6 years	7	8	61	61	0.90
Flock rams all ages	7	8	70	70	1.04

[A]In the herd and economic modelling the standard weight of one DSE = 45 kg; (AE : DSE of 1 : 8.4).

3.3.2.3 Flock management and husbandry assumptions

Table 36 shows the treatments applied to the various classes of sheep held for 12 months or sold during the year in the flock model.

Table 36 - Treatments applied and cost per head

Treatment	Weaners		Ewes		Wethers		Flock rams	
	Kept	Sold	Kept	Sold	Kept	Sold	Kept	Sold
Shearing	$7.00	$7.00	$7.00	$7.00	$7.00	$7.00	$10.00	$10.00
Crutching	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50
Lamb marking	$2.00	$2.00	-	-	-	-	-	-
Ewe scanning	-	-	$1.50	$1.50	-	-	-	-
Dips, drenches	$2.00	$2.00	$1.50	$1.50	$1.50	$1.50	$1.50	$1.50
Fodder	$4.00	$4.00	$4.80	$4.80	-	-	$5.00	$5.00
Total per head	*$16.50*	*$16.50*	*$16.30*	*$16.30*	*$10.00*	*$10.00*	*$18.00*	*$18.00*

3.3.2.4 Other wool sheep performance parameters

The following are the flock management and husbandry assumptions applied in the analysis:

- Ewes: 50 kg average liveweight, 6 years casting age, 4% mortality increasing to 6% in older age groups, ca. 70% weaning.
- Maiden ewes: 18 months first mating, lamb at 24 months, 5% mortality, ca. 50% weaning rate.
- Rams: run at 2.5%, 10% mortality, $1,000 purchase price of replacements, culls sold for $100.
- Controlled mating was practiced. Wether and ewe weaners were run together but other classes were held in separate groups. The wether flock was not separated on age, but maiden ewes were separated from older ewes.
- Rams entered the ewe flock in early October with an 8-week joining period; ewes were expected to achieve peak conception in November; scanning of ewes for pregnancy testing was practiced.
- Lambing occurred in Autumn (April, with the tail in May). Lamb marking occurred end of May with weaning in June-July.
- Sales in Autumn; crutching early September; shearing early December; mulesing was not conducted.
- Lice control was by back liner treatment applied at shearing time; vaccination with 5-in-1.
- Blowfly control: tactical treatment when necessary.
- Lambing ewes received no supplementation in 3 out of 10 years; dry lick supplements only fed 2 out of 10 years; grain mix or similar fed 5 out of 10 years (barley, cottonseed, faba beans or lupins). Mature ewes received a feeding period of ca. 10 weeks during the dry season (September to November period). Maiden ewes were fed supplements for 15 weeks at 1 kg/head/week. Average feeding cost per ewe (>12 months of age) was $4.80/head.annum.

Table 37 shows the assumed lamb weaning rates, ewe and weather death rates applied in the flock model. The values retained produced a weaning rate of 70%.

Table 37 - Lambing and death rate assumptions

Sheep age year start Sheep age year end	Weaners 1	1 2	2 3	3 4	4 5	5 6	6 7
Expected conception (%)	n/a	50	80	80	80	80	80
Expected lamb loss from conception to weaning (%)	n/a	5	5	5	5	5	5
Proportion of empties (PTE) sold (%)	n/a	50	50	50	50	50	50
Proportion of pregnant females sold (%)	n/a	0	0	0	0	0	0
Lambs weaned/ewes retained (%)	n/a	63.3	84.4	84.4	84.4	84.4	0
Ewe death rate (%)	5	4	4	4	4	4	6
Unmated ewes death rate (%)	5	3	3	3	3	3	5
Wether death rate (%)	4	3.5	3.5	3.5	3.5	n/a	n/a

n/a, not applicable; PTE, pregnancy tested 'empty' (not in lamb).

3.3.2.5 Sheep and wool prices

The hypothetical, constructed property was located near Longreach with no local selling centres or abattoirs available for sale stock. Slaughter and sale values for cull sheep were derived from the MLA New South Wales database for 'Over the hook (OTH)' mutton price indicators (MLA monthly market statistics database at http://statistics.mla.com.au/Report/List). The OTH and saleyard indicators are calculated as a weighted average of New South Wales processor grids. Transport and other selling costs were estimated for Charleville (ca. 600 km distance).

Mutton prices have shown large variability over the last decade with a substantial increase in the prices paid during the last 5 years compared to the average of the previous years. Figure 10 shows the relationship between the prices of light, medium and heavy sheep slaughtered for mutton from January 2010 to December 2019 across New South Wales markets. There has been a significant upward trend in mutton prices over the past decade.

Figure 10 - Mutton prices over time from 2010 to 2020

MLA over the hook mutton price indicators New South Wales. Prices converted to $/kg liveweight at 50% dressing, GST exclusive

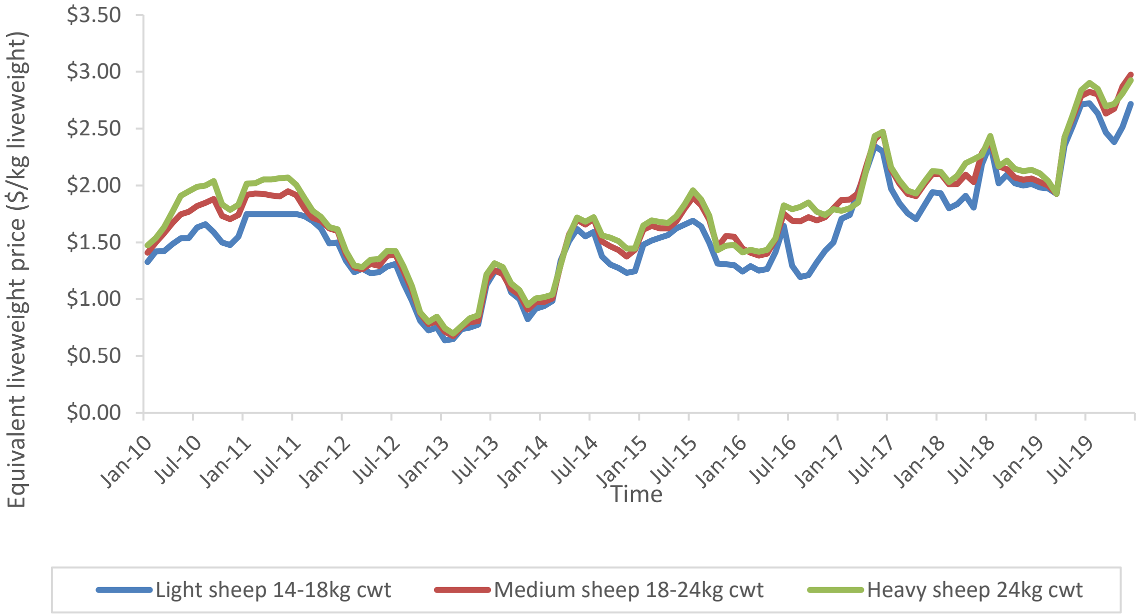


Table 38 shows the mutton prices averaged over a number of periods over the last decade.

Table 38 - Mutton prices over time from 2010 to 2020 ($/kg liveweight)

MLA over the hook mutton price indicators New South Wales. Prices converted to $/kg liveweight at 50% dressing, GST exclusive

Average of last	Light sheep 14-18 kg carcass weight	Medium sheep 18-24 kg carcass weight	Heavy sheep 24 kg carcass weight
10 years	$1.57	$1.70	$1.74
5 years	$1.84	$2.00	$2.03
2 years	$2.20	$2.33	$2.38

Mutton prices underpin sheep sale prices in the rangelands of central-western Queensland but a currently very active market for younger sheep as replacements and breeding stock is influencing local prices with value for young ewes currently well above their value as mutton. Table 39 shows the assumed sheep prices and selling costs applied in the self-replacing wool sheep model.

Table 39 - Sheep prices and selling costs ($/head)

Group Description	Sale weight (kg/head)	Price ($/kg)	Commission (% of value)	Other selling costs ($/head)	Freight ($/head)	Gross price	Net price
Ewe weaners	14	$7.02	4.00%	$0.37	$6.00	$100	$89.63
Ewes 1 yr	33	$4.51	4.00%	$0.37	$6.67	$150	$136.96
Ewes 2 yrs	43	$3.27	4.00%	$0.37	$7.20	$140	$126.83
Ewes 3 yrs	43	$3.04	4.00%	$0.37	$7.20	$130	$117.23
Ewes 4 yrs	43	$2.81	4.00%	$0.37	$7.20	$120	$117.23
Ewes 5 yrs	43	$2.57	4.00%	$0.37	$7.20	$110	$98.03
Ewes 6 yrs	43	$2.57	4.00%	$0.37	$7.20	$110	$98.03
Wether weaners	14	$5.61	4.00%	$0.37	$6.00	$80	$70.43
Wethers 1-2 yrs	41	$2.82	4.00%	$0.37	$7.09	$115	$102.94
Wethers 2-3 yrs	49	$2.23	4.00%	$0.37	$7.26	$110	$97.97
Wethers 3-4 yrs	53	$2.07	4.00%	$0.37	$7.26	$110	$97.97
Wethers 4-5 yrs	58	$1.90	4.00%	$0.37	$7.26	$110	$97.97
Wethers 5-6 yrs	58	$1.90	4.00%	$0.37	$7.26	$110	$97.97
Cull flock rams	67	$1.50	4.00%	$0.37	$7.26	$100	$88.37

yr, year.

Figure 11 indicates the trend in prices for 19 and 20-micron wool from January 2010 to the end of December 2019.

Figure 11 – Clean wool prices over time from 2010 to the end of 2019 (average price (c/kg clean) after sale for 19- and 20-micron wool from selling centres in the eastern states of Australia (source: Australian Wool Innovation)

Table 40 shows the assumed wool cuts, clean wool yield, and clean price for each class of sheep in the self-replacing wool flock. Wool quality was assumed to be 20 microns with the price taken to be about $12.48/kg clean. This is equivalent to a $7.99/kg greasy wool price at an average 64% yield. The average bale weight was taken to be 187 kg.

Table 40 - Wool yield, clean wool price and wool value per head

Group Description	Greasy wool (kg/head)	Yield to sale (%)	Clean weight (kg/head)	Clean price ($/kg)	Commission (%) of value	Gross ($/head)	Selling costs ($/head)	Net wool ($/head)
Ewe weaners	1.75	65%	1.14	$12.80	8.00%	$14.56	$1.16	$13.40
Ewes 1 yr	4	64%	2.56	$12.40	8.00%	$31.74	$2.54	$29.20
Ewes 2 yrs	4.8	64%	3.07	$12.40	8.00%	$38.09	$3.05	$35.05
Ewes 3 yrs	4.8	64%	3.07	$12.40	8.00%	$38.09	$3.05	$35.05
Ewes 4 yrs	4.8	64%	3.07	$12.40	8.00%	$38.09	$3.05	$35.05
Ewes 5 yrs	4.8	64%	3.07	$12.40	8.00%	$38.09	$3.05	$35.05
Ewes 6 yrs	4.4	64%	2.82	$12.40	8.00%	$34.92	$2.79	$32.12
Wether weaners	1.75	65%	1.14	$12.80	8.00%	$14.56	$1.16	$13.40
Wethers 1-2 yrs	4	64%	2.56	$12.40	8.00%	$31.74	$2.54	$29.20
Wethers 2-3 yrs	5.5	64%	3.52	$12.40	8.00%	$43.65	$3.49	$40.16
Wethers 3-4 yrs	6.5	64%	4.16	$12.40	8.00%	$51.58	$4.13	$47.46
Wethers 4-5 yrs	6.5	64%	4.16	$12.40	8.00%	$51.58	$4.13	$47.46
Wethers 5-6 yrs	6.5	64%	4.16	$12.40	8.00%	$51.58	$4.13	$47.46
Cull flock rams	7	64%	4.48	$12.40	8.00%	$55.55	$4.44	$51.11

yr, year.

3.3.3 Results and discussion

3.3.3.1 Flock outputs

Table 41 shows the flock parameters for the self-replacing sheep and wool production system.

Table 41 – Steady-state flock parameters

Parameter	Value
Dry sheep equivalents (DSE)	9,000
Age at first mating (1 or 2 years)	1
Ewe casting age	6
Total ewes joined	5,218
Total lambs weaned	3,521
Lambs weaned/ewes joined (%)	67.48
Ewe weaners retained	1,761
Surplus ewe weaners sold	0
Mature ewes sold	1,494
Total mature ewes shorn	5,956
Total ewe weaners shorn	1,761
Weaner wethers sold	0
Wethers sold	1,690
Total wethers shorn	3,451

Table 42 indicates the flock gross margin after interest for each wether culling age. The highest expected herd gross margin after interest was produced by culling wethers between 1 and 2 years of age. Surplus young ewes were uniformly culled between 1 and 2 years of age with the final cull age for flock ewes culled maintained between 6 and 7 years of age. The key factor underpinning the most profitable flock structure was the price received for young cull ewes. Structuring the flock to produce the optimum number of young cull ewes produced the best result. A change in the demand/price premium for young ewes for restocking would change the optimal flock structure.

Table 42 - Analysis of wether culling age

The optimum age of wether turnoff was used as a base for comparison with alternatives

Parameter	**Cull weaner wethers**	**Cull 1-2-year-old wethers**	**Cull 2-3-year-old wethers**	**Cull 3-4-year-old wethers**	**Cull 4-5-year-old wethers**
Total dry sheep equivalents (DSE)	9,000	9,000	9,000	9,000	9,000
Total sheep carried	7,521	8,114	8,229	8,185	8,064
Weaner ewes retained	2,084	1,761	1,478	1,260	1,091
Total ewes mated	6,177	5,218	4,380	3,735	3,235
Total ewes mated and kept	5,283	4,462	3,745	3,194	2,766
Total lambs weaned	4,168	3,521	2,955	2,520	2,183
Weaners/total ewes mated	67.48%	67.48%	67.48%	67.48%	67.48%
Overall ewe deaths	4.00%	4.00%	4.00%	4.00%	4.00%
Female sales/total sales %	45.91%	46.92%	47.81%	48.70%	49.59%
Total ewes sold	1,769	1,494	1,254	1,069	926
Maximum ewe culling age	6	6	6	6	6
Ewe joining age	1	1	1	1	1
1 year-old ewe sales %	31.70%	31.70%	31.70%	31.70%	31.70%
2 year-old ewe sales %	10.00%	10.00%	10.00%	10.00%	10.00%
Total wethers sold	2084	1690	1369	1127	941
Maximum wether turnoff age	0	1	2	3	4
Average female price	$115.06	$115.06	$115.06	$115.06	$115.06
Average wether price	$70.43	$102.94	$97.97	$97.97	$97.97
Capital value of flock	$928,975	$908,703	$908,770	$889,349	$865,736
Imputed interest on flock value	$46,449	$45,435	$45,439	$44,467	$43,287
Net wool sales	$291,716	$294,871	$301,473	$309,575	$311,947
Net sheep sales	$350,284	$345,875	$278,404	$233,414	$198,788
Direct costs excluding rams	$186,769	$174,667	$160,301	$147,967	$137,645
Flock ram replacement	$29,522	$24,938	$20,932	$17,850	$15,458
Flock gross margin	$425,710	$441,142	$398,645	$377,172	$357,631
Flock gross margin less interest	***$379,261***	***$395,706***	***$353,206***	***$332,705***	***$314,344***
Difference to 1-2-year-old wethers	*-$16,445*	*Base*	*-$42,500*	*-$63,002*	*-$81,362*

Table 43 shows the female flock structure for a wether culling age of 1-2 years. Expected ewe deaths were 178/annum or 4.00% of female breeding stock maintained for the year. The application of the data for reproduction efficiency and mortality rates to the herd model produced an expected weaning rate of 67.48% (i.e., lambs from all ewes mated). The wool sheep flock produced about 3,521 weaners from 5,218 females mated and sold 3,197 head/annum. Cull female sales made up 46.92% of total sales.

Table 43 – Female flock structure for the optimised, self-replacing wool flock

Ewe age start year **Ewe age end year**	**1** **2**	**2** **3**	**3** **4**	**4** **5**	**5** **6**	**6** **7**
Ewes available start year	1,672	1,124	971	839	725	626
Sales unmated (% start year ewes)	6.7	0	0	0	0	0
Ewes surplus pre-mating (% of start year)	0	0	0	0	0	0
Sales after mating (% of number mated)	25	10	10	10	10	0
Unmated ewes sold	502	112	97	84	72	626
Unmated ewes from previous years	0	0	0	0	0	0
Ewes spayed or unmated at start of year	0	0	0	0	0	0
Sales of unmated ewes (% carryover number)	100	100	100	100	100	100
Unmated ewes sold	0	0	0	0	0	0
Ewes mated in each age group	1,560	1,124	971	839	725	0
Mated ewes retained in each group	1,170	1,011	874	755	652	0
Lambs weaned from each group	741	854	738	637	551	0

Table 44 shows the wether flock structure for the optimised, self-replacing sheep and wool flock. The estimated ram requirements are shown in Table 45.

Table 44 - Wether flock structure for the optimised, base flock

Parameter	**Wether age in months**			
	5 to 11	**12 to 23**	**24 to 35**	**36 to 47**
Number available at start year	1,761	1,690	0	0
Number reserved as flock rams	0	0	0	n/a
Optional sales %	0%	0%	0%	0%
Transfers to flock rams	n/a	n/a	0	n/a
Sales at each age	0	1,690	0	0
Average price	n/a	$102.94	*n/a*	*n/a*

n/a, not applicable.

Table 45 - Ram requirements for the optimised, base flock

Parameter	**Value**
Rams/ewes to be used (%)	2.50
Rams required per year	130
% of rams replaced annually (20; $1000/head)	26
Rams sold per year ($50/head)	13
Ram deaths or destruction (10%)	13
Net ram replacement costs/year	$24,938
Net ram cost/lamb weaned	$7.08

The classes of sheep in the optimised flock culling 1-2-year-old ewes are presented in Table 46.

Table 46 - Classes of sheep in the flock

Age at start of rating period	Number kept whole year	Number sold	DSE/head kept	DSE/head sold	Total DSEs
Extra for ewes weaning a lamb.	n/a	n/a	0.35	n/a	1,232
Weaners 5 months	3,521	0	0.30	0.05	1,050
Ewes 1 year but less than 2	1,170	502	0.86	0.50	1,254
Ewes 2 years but less than 3	1,011	112	1.04	0.66	1,130
Ewes 3 years plus	2,281	880	1.11	0.70	3,153
Wethers 1 year but less than 2	0	1,690	0.89	0.57	964
Flock rams all ages	130	10	1.56	1.04	216
Total number	*8,114*	*3,197*	-	-	*9,000*

n/a, not applicable. DSE, dry sheep equivalent.

Wool production and value are shown in Table 47. The total wool bales produced were 218/annum at 187 kg/bale.

Table 47 - Wool production

Group description	Gross wool sales	Wool selling costs	Net wool sales	Greasy wool (kg)
Ewe weaners 5-11 months	$25,633	$2,051	$23,582	3,081
Ewes 1 year	$53,091	$4,247	$48,844	6,690
Ewes 2 years	$42,799	$3,424	$39,375	5,393
Ewes 3 years	$36,978	$2,958	$34,020	4,660
Ewes 4 years	$31,949	$2,556	$29,393	4,026
Ewes 5 years	$27,604	$2,208	$25,396	3,478
Ewes 6 years	$21,862	$1,749	$20,113	2,755
Wether weaners 5-11 months	$25,633	$2,051	$23,582	3,081
Wethers 1-2 years	$53,650	$4,292	$49,358	6,760
Flock rams	$7,247	$580	$6,667	913
Total	*$326,446*	*$26,116*	*$300,330*	*40,837*

Table 48 indicates the average greasy and clean prices expected for the wool clip. The greasy weight average for wool cut was calculated as 3.61 kg/head.

Table 48 - Average greasy and clean wool prices

Parameter	Gross $/kg greasy	Selling costs per kg greasy	Net $/kg greasy	Gross $/kg clean
Wool price	$7.99	$0.64	$7.35	$12.48

Table 49 presents the flock gross margin calculated in Breedewe.

Table 49 - Flock gross margin for the self-replacing sheep and wool flock

Parameter	$/flock	$/sheep	$/DSE
Net wool sales	$294,892	$36.34	$32.77
Net sheep sales	$347,340	$42.81	$38.59
Husbandry costs	$174,678	$21.53	$19.41
Net ram replacement	$26,000	$3.20	$2.89
Gross margin	$441,554	$54.42	$49.06
Gross margin less interest	$395,706	$48.77	$43.97

DSE, dry sheep equivalent.

The opening value of the land and fixed improvements for the example property was taken as $6,000,000. This resulted in an opening value of the total value of land, plant and improvements for the sheep enterprise investment of $6,298,500. The opening value of sheep was $1,174,093.

Table 50 indicates the expected average annual performance parameters for the wool sheep property. The sheep and wool production activity resulted in a rate of return on total capital of about 3.26%. This result was based on the assumption that the property was already protected from wild dogs with appropriate fencing infrastructure. The costs of implementing cluster fencing, or similar, were not included in this analysis. There was also an assumption of sufficient sheep handling infrastructure in existence on the property to efficiently manage the self-replacing sheep and wool enterprise.

Table 50 - Expected value of annual outcomes for the self-replacing sheep and wool flock

Parameter	Value
Dry sheep equivalents (DSE)	9,000
Operating profit	$242,104
Rate of return on total capital	3.26%

3.3.3.2 Sensitivity of operating profit to change in model parameters

A set of key assumptions about the prices paid and received and the level of flock productivity underpin the results of the analysis. Table 51 shows the sensitivity of the level of operating profit predicted for the self-replacing sheep and wool enterprise to relevant levels of change in these assumptions.

Table 51 - Expected impact on average operating profit of changing model parameter values

Parameter	Value	Change to base	% change to base
Self-replacing sheep and wool flock	$242,104	Base	Base
Wool price minus 20%	$182,034	-$60,070	-25%
Wool price plus 20%	$302,175	$60,071	25%
Wool cut minus 20%	$183,126	-$58,978	-24%
Wool cut plus 20%	$301,083	$58,979	24%
Sheep meat price minus 20%	$167,885	-$74,219	-31%
Sheep meat price plus 20%	$316,324	$74,220	31%
Fixed costs minus 20%	$261,604	$19,500	8%
Fixed costs plus 20%	$222,604	-$19,500	-8%
Treatment costs minus 20%	$277,040	$34,936	14%
Treatment costs plus 20%	$207,169	-$34,935	-14%
Mortality rate minus 50%	$259,470	$17,366	7%
Mortality rate plus 50%	$223,589	-$18,515	-8%
Growth rate sheep minus 5%	$235,280	-$6,824	-3%
Growth rate sheep plus 5%	$244,861	$2,757	1%
Lambing rate minus 5%	$229,487	-$12,617	-5%
Lambing rate plus 5%	$248,813	$6,709	3%

The impact of changing the assumed level of a factor underpinning the output of the sheep and wool enterprise was based on no change in the costs required to achieve that level of change and therefore should be treated with great caution. There are nearly always additional costs incurred or saved that can greatly impact the predicted level of benefit or change in the level of operating profit. The absolute and relative changes in the level of operating profit for the self-replacing sheep and wool enterprise can be compared to the impact of similar levels of change in key assumptions for the alternative livestock enterprise for the constructed property.

It is interesting to note that a similar change in the expected level of price received for wool, sheep meat or the expected amount of wool cut has a similar impact on the average operating profit of the property. This suggests a 20% increase in sheep meat price could offset a 20% decrease in wool price. The relative unimportance of changes in the lambing rate and the growth rate of sheep on operating profit suggest that implementing high-cost strategies to improve the expected level of these parameters may not be worthwhile. It appears better to focus on low-cost strategies that maintain these two factors and mortality rates at their current levels. Under our assumptions it appears likely that changing the growth rate of sheep in this flock will have either a negative or negligible impact on the expected level of operating profit. However, our assumption that a change in the growth rate would not affect the wool cut is probably unrealistic.

3.4 Wether production activity

3.4.1 Introduction

Production systems based on grazing purchased Merino wethers for wool production are a relevant enterprise option in the rangelands of central-western Queensland and should be examined in any assessment of alternative enterprises for the representative property.

3.4.2 Methods

In this analysis, two wether production scenarios were examined (1) the wethers were shorn every 8 months (or six times over the 4 years of ownership), or (2) the wethers were shorn every 12 months. Both wether activities relied on the purchase of two-tooth wether sheep that entered a wool production system for a period of four seasons. They were then sold off shears as full mouth sheep. The average liveweight of wethers in the paddock was 53 kg. In the steady-state wether model, it was assumed that there would be no impact from wild dogs on the level of flock performance.

Details for the 8-month shearing scenario are detailed in the following sections. In the 12-month shearing scenario, the wether model for 8-month shearing was adjusted so that wethers were shorn on an annual basis. This involved reducing the annual shearing cost, restoring wool production per wether to that achieved in the self-replacing wool flock and changing the crutching expenses to accommodate the lower frequency of shearing cf. the 8-month scenario. Adjustments were also made to the farm labour required and the allowance for operators labour and management.

The property employed no permanent labour other than the owner/manager. The allowance for operator's labour and management for the wether activity with 8-month shearing interval was reduced by $15,000/annum below that applied in the self-replacing wool flock strategy to $65,000/annum. An allowance of $10,000/annum was allocated to contract wages for the property when it was run solely as a wether enterprise with 8-month shearing frequency. In the 12-month shearing scenario, the allowance for operator's labour and management was $60,000 and the contract wages allocation was $5,000.

3.4.2.1 Flock DSE assumptions

The DSE ratings were calculated for a period of time, not for a point in time. Except for sale wethers, this was 12 months, e.g., from age 12 to 24 months. All sale stock were rated from their nominal birth month to their sale month, e.g., wethers sold at age 18 months were rated for 6 months (age 12 to 18 months) in their sale year. Table 52 shows the DSE ratings for all classes of wethers retained in the flock for the entire twelve-month period.

Table 52 - Dry sheep equivalent (DSE) ratings for wethers held 12 months[A]

Description at start of rating period	Age at start (months)	Age at end (months)	Sheep carried through whole year			
			Months rated	Lowest or start liveweight (kg)	Highest or end liveweight	DSE/head rating
Wethers 1-2 years	12	24	12	34	46	0.89
Wethers 2-3 years	24	36	12	46	52	1.09
Wethers 3-4 years	36	48	12	52	56	1.20
Wethers 4-5 years	48	60	12	56	61	1.30
Wethers 5-6 years	60	72	12	61	61	1.36

[A]In the herd and economic modelling the standard weight of one DSE = 45 kg; (AE : DSE of 1 : 8.4).

Table 53 shows the DSE ratings for all classes of wethers sold from the flock during the 12-month period.

Table 53 - Dry sheep equivalent (DSE) ratings for wethers sold during the year[A]

Description at start of rating period	Sale month	Months rated	Start liveweight (kg)	Paddock liveweight at sale (kg)	DSE/head rating
Wethers 1-2 years	2	3	34	43	0.57
Wethers 2-3 years	7	8	46	52	0.73
Wethers 3-4 years	7	8	52	56	0.80
Wethers 4-5 years	7	8	56	61	0.87
Wethers 5-6 years	7	8	61	61	0.90

[A]In the herd and economic modelling the standard weight of one DSE = 45 kg; (AE : DSE of 1 : 8.4).

3.4.2.2 Flock management and husbandry assumptions

Table 54 shows the treatments applied to the various classes of wethers held for 12 months or sold during the year in the flock model for wethers with 8-month shearing. The shearing costs were increased by 150% to allow for the 8-month shearing interval. Wethers were crutched at half the usual frequency due to the shortened shearing interval.

Table 54 - Treatments applied and cost per head (average cost per annum) for a wether flock with 8-month shearing

Treatment	Husbandry costs ($/wether)	
	Kept	Sold
Shearing	$10.50	$10.50
Crutching	$0.75	$0.75
Dips, drenches	$2.25	-
Fodder	-	-
Total per head	*$13.50*	*$11.25*

3.4.2.3 Other wether flock performance parameters

The expected average annual death rate for wethers was 3.5% across all age groups. The following are the flock management and husbandry assumptions applied in the analysis:

- Sales in autumn, shearing (frequency of either 8 or 12 months),
- Lice control: back liner treatment applied at shearing time.
- Blowfly control: tactical treatment when necessary.

Wool quality was assumed to be 20 microns with the price taken to be $12.40/kg clean. This is equivalent to a $7.94/kg greasy wool price at a 64% yield. The average bale weight was taken to be 187 kg.

3.4.2.4 Sheep and wool prices

The hypothetical, constructed property was located near Longreach with no local selling centres or abattoirs available for sale stock. Slaughter and sale values for cull wethers were derived from the MLA New South Wales database for OTH mutton price indicators (MLA monthly market statistics database at http://statistics.mla.com.au/Report/List). The OTH and saleyard indicators are calculated as a weighted average of New South Wales processor grids. Transport and other selling costs were estimated for Charleville (ca. 600 km distance).

Mutton prices have shown large variability over the last decade with a substantial increase in the prices paid during the last 5 years compared to the average of the previous years. Figure 12 shows the relationship between the prices of light, medium and heavy sheep slaughtered for mutton from January 2010 to December 2019 across New South Wales markets. There has been a significant upward trend in mutton prices experienced over the past decade.

Figure 12 - Mutton prices over time from 2010 to 2020

MLA over the hook mutton price indicators New South Wales. Prices converted to $/kg liveweight at 50% dressing, GST exclusive

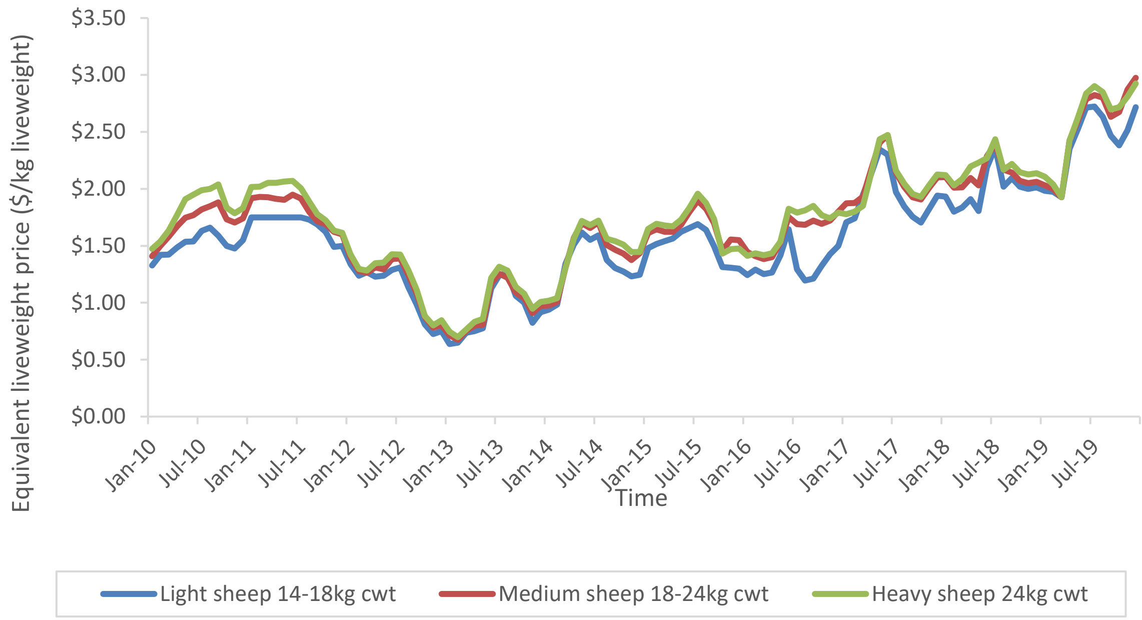


Table 55 shows the mutton prices averaged over the decade, last 5 years and the last 2 years.

Table 55 - Mutton prices over time from 2010 to 2020 ($/kg liveweight)

MLA over the hook mutton price indicators New South Wales. Prices converted to $/kg liveweight at 50% dressing, GST exclusive

Average of last	Light sheep 14-18 kg carcass weight	Medium sheep 18-24 kg carcass weight	Heavy sheep 24 kg carcass weight
10 years	$1.57	$1.70	$1.74
5 years	$1.84	$2.00	$2.03
2 years	$2.20	$2.33	$2.38

Mutton prices underpin sheep sale prices in the rangelands of central-western Queensland but a currently very active market for wethers as replacements is influencing local prices. Table 56 shows the assumed sheep prices and selling costs applied in the wether model.

Table 56 - Wether prices and selling costs ($/head)

Group description	Sale weight (kg/head)	Price ($/kg)	Commission % of value	Other selling costs ($/head)	Freight ($/head)	Gross price	Net price
Wethers 1-2 years	41	$2.82	4%	$0.37	$7.09	$115.20	$103
Wethers 2-3 years	49	$2.23	4%	$0.37	$7.26	$110.16	$98
Wethers 3-4 years	53	$2.07	4%	$0.37	$7.26	$110.12	$98
Wethers 4-5 years	58	$1.90	4%	$0.37	$7.26	$110.11	$98
Wethers 5-6 years	58	$1.90	4%	$0.37	$7.26	$110.11	$98

Table 57 shows the assumed wool cuts, clean wool yield and clean price for each class of wether in the flock with 8-month shearing frequency. The assumption is that shearing the wethers every 8 months will not maintain the same wool yield per cut. Although the wethers will be shorn 6 times over the 4 years they are held, their wool cut increases by 125%, not 150%

Table 57 - Wool yield, clean wool price and wool value per head

Group description	Greasy wool (kg/head)	Yield to sale (%)	Clean weight (Kg/head)	Clean price ($/kg)	Commission (%) of value	Gross ($/head)	Selling costs ($/head)	Net wool ($/head)
Wethers 1-2 years	5.00	64%	3.20	$15.50	8.00%	$49.60	$3.97	$46
Wethers 2-3 years	6.88	64%	4.40	$15.50	8.00%	$68.20	$5.46	$63
Wethers 3-4 years	8.13	64%	5.20	$15.50	8.00%	$80.60	$6.45	$74
Wethers 4-5 years	8.13	64%	5.20	$15.50	8.00%	$80.60	$6.45	$74
Wethers 5-6 years	8.13	64%	5.20	$15.50	8.00%	$80.60	$6.45	$74

3.4.3 Results and discussion

Table 58 indicates the age classes and average numbers within classes for the wether flock run on the constructed property. Replacement wethers were purchased for a landed price of $130/head.

Table 58 - Wether purchases and flock numbers

Description	Opening number	Number purchased	Number sold	Closing number
Wethers 1-2 years	0	2,346	0	2,264
Wethers 2-3 years	2,264	0	0	2,185
Wethers 3-4 years	2,185	0	0	2,109
Wethers 4-5 years	2,109	0	2,109	0
Total Sheep	*6,558*	*2,346*	*2,109*	*6,558*

3.4.3.1 Wether flock with 8-month shearing frequency

Flock outputs

Table 59 shows the parameters for the wether sheep and wool production system with 8-month shearing frequency. Wool production and value are shown in Table 60. The total wool bales produced per annum were 333 at 187 kg/bale.

Table 59 – Steady-state wether flock parameters with 8-month shearing

Parameter	Value
Total dry sheep equivalents (DSE) carried	9,000
Total sales	2,109
Total purchases	2,346
Total new lambs	0
Total deaths	237
Net livestock sales	$206,831
Net livestock purchases	$265,098
Net wool sales	$445,698
Total wethers shorn	8,904

Table 60 – Wool production and value for wethers shorn every 8 months

Shearing occurred six times over 4 years and was converted to an annual fleece weight.

Group description	Kg total	Kg/head shorn (greasy weight)	Net wool sales ($)	$/head shorn
Wethers 1-2 years	11,730	5.00	$118,941	$36.51
Wethers 2- years	15,565	6.88	$157,815	$50.20
Wethers 3-4 years	17,753	8.13	$179,980	$59.32
Wethers 4-5 years	17,136	8.13	$173,693	$59.32
Total	*63,551*	*6.98*	*$454,011*	*$50.99*

The flock gross margin is presented in Table 61.

Table 61 - Flock gross margin for the wether enterprise with 8-month shearing frequency

Parameter	$/flock	$/Sheep	$/DSE[A]
Net wool sales	$445,698	$67.96	$49.51
Net sheep sales	$206,831	$31.54	$22.98
Husbandry costs	$115,459	$17.61	$12.83
Wether purchases	$265,098	$40.42	$29.45
Gross margin (before interest)	$271,972	$41.47	$30.21
Gross margin less interest	*$239,807*	*$36.57*	*$26.64*

DSE, dry sheep equivalent.

[A]In the herd and economic modelling the standard weight of one DSE = 45 kg; (AE : DSE of 1 : 8.4).

The opening value of the land and fixed improvements for the example property was taken as $6,000,000. This resulted in an opening value of the total value of land, plant and improvements for the sheep enterprise investment, $6,298,500. The opening value of wethers was $643,312.

Table 62 indicates the expected average annual performance parameters for the property running a wether flock with 8-month shearing frequency. The wether sheep and wool production activity resulted in a rate of return on total capital of about 1.3%. However, this result was based on the assumption that the property was already protected from wild dogs with appropriate fencing infrastructure. The costs of implementing cluster fencing, or similar, were not included in this analysis. The property also had sufficient sheep handling infrastructure to enable the efficient operation of the wether enterprise.

Table 62 - Expected value of annual outcomes for the wether property with 8-month shearing frequency

Parameter	Value
Dry sheep equivalents	9,000
Operating profit	$92,522
Rate of return on total capital	1.34%

Sensitivity of operating profit to change in model parameters

A set of key assumptions about the prices paid and received and the level of flock productivity underpin the results of the analysis. Table 63 shows the sensitivity of the level of operating profit predicted for the wether wool enterprise to relevant levels of change in these assumptions.

Table 63 - Expected impact on average operating profit of changing model parameter values

Parameter	Value	Change to base	% change relative to base
Wether wool flock, 8-month shearing	$92,522	Base	Base
Wool price minus 20%	$1,720	-$90,802	-98%
Wool price plus 20%	$183,324	$90,802	98%
Wool cut minus 20%	$3,383	-$89,139	-96%
Wool cut plus 20%	$181,662	$89,140	96%
Sheep meat price minus 20%	$47,938	-$44,584	-48%
Sheep meat price plus 20%	$137,107	$44,585	48%
Fixed costs minus 20%	$109,022	$16,500	18%
Fixed costs plus 20%	$76,022	-$16,500	-18%
Treatment costs minus 20%	$115,614	$23,092	25%
Treatment costs plus 20%	$69,431	-$23,091	-25%
Mortality rate minus 50%	$106,726	$14,204	15%
Mortality rate plus 50%	$77,847	-$14,675	-16%
Growth rate sheep minus 5%	$103,501	$10,979	12%
Growth rate sheep plus 5%	$81,657	-$10,865	-12%

The impact of changing the assumed level of a factor underpinning the output of the wether enterprise was based on no change in costs relevant to achieve that level of change and therefore should be treated with great caution. There are nearly always additional costs incurred or saved that can greatly impact the predicted level of benefit or change in the level of operating profit. The absolute and relative changes in the level of operating profit for the wether enterprise can be compared to the impact of similar levels of change in key assumptions for the alternative livestock enterprise for the constructed property.

Because this wether enterprise is largely a trading enterprise, a change in the average level of the price of sheep meat is much less important to the profitability of the wether enterprise than a change in the price received for wool or the amount of wool cut per head. Running lighter wethers that cut the same amount of wool per head as 5% heavier wethers leads to slightly more wethers run on the property in the model and improves profitability. Whether this would occur in reality, and whether it would be measurable, are unknown but the results indicate that small changes to the growth rate of wethers are relatively unimportant to the financial and economic performance of this enterprise.

3.4.3.2 Wether flock with 12-month shearing frequency

The flock gross margin is presented in Table 64 for a wether flock with 12-month, rather than 8-month, shearing frequency.

Table 64 - Flock gross margin for the wether enterprise with 12-month shearing frequency

Parameter	**$/flock**	**$/sheep**	**$/DSE^A**
Net wool sales	$356,558	$54.37	$39.61
Net sheep sales	$206,831	$31.54	$22.98
Husbandry costs	$89,040	$13.58	$9.89
Wether purchases	$265,098	$40.42	$29.45
Gross margin (before interest)	$209,251	$31.91	$23.25
Gross margin less interest	*$177,086*	$27.00	$19.67

DSE, dry sheep equivalent.

[A]In the herd and economic modelling the standard weight of one DSE = 45 kg; (AE : DSE of 1 : 8.4).

Table 65 indicates the expected average annual performance parameters for the property running a wether flock with 12-month shearing frequency. The wether sheep and wool production activity resulted in a rate of return on total capital of about 0.58%, cf. 1.34% for the 8-month shearing frequency scenario. Again, this result was based on the assumption that the property was already protected from wild dogs with appropriate fencing infrastructure. The costs of implementing cluster fencing, or similar, were not included in this analysis. The property also had sufficient sheep handling infrastructure to enable the efficient operation of the wether enterprise

Table 65 - Expected value of annual outcomes for the wether property with annual shearing

Parameter	**Value**
Dry sheep equivalents (DSE)	9,000
Operating profit	$39,801
Rate of return on total capital	0.58%

3.5 Meat sheep production activity

3.5.1 Introduction

Over the past 5 years there has been a significant upward trend in meat prices for all classes of livestock including lamb, mutton, beef and goat meat (MLA 2020b). However, there has been a proportionally greater increase in price for mutton, goat meat and lamb (76%, 62%, and 42%, respectively) cf. steer beef (15% increase). At present less than one third of ewes in Queensland are mated to non-Merino rams, i.e., to meat sheep breeds (ABS 2020a). However, a number of properties in the rangelands of central-western Queensland are used predominately for meat sheep production. Traditional meat sheep breeds used in Queensland include the Suffolk, Border Leicester and Poll Dorset. Several African breeds, including the Dorper, South African Meat Merino (SAMM) and Dohne, and the Australian White composite breed, have also become popular in the semi-arid rangelands in recent decades due to their suitability to particular markets and the adaptation to the environment.

3.5.2 Methods

The herd productivity assumptions for the meat sheep flock in this analysis were not specific to any particular breed but were determined with reference to producers of the Australian White composite breed in the central-western rangelands region. The self-replacing meat sheep activity relied on the production of weaner sheep by a breeding flock. Retained maiden ewes maintained the breeding flock or were culled and sold. Flock ewes were culled on reproductive performance and age. Flock rams were retained in the breeding herd for an average of 4 years. In the steady-state meat sheep model it was assumed that there would be no impact from wild dogs on the level of flock performance. The property employed no permanent labour other than the owner/manager. It was also assumed that there would be no shearing or crutching required. The allowance for operator's labour and management was $80,000/annum. An allowance of $15,000/annum was allocated to contract wages for the property when it was run as a meat sheep enterprise.

3.5.2.1 Wether and young ewe growth assumptions

The pattern of growth over time for lambs and hoggets underpinned the markets available for both as well as the likely mating age and reproduction performance of the ewes as they enter the breeding flock. Table 66 indicates the expected pre- and post-weaning seasonal performance for wethers. They gained weight at ca. 0.11 kg/head.day on grass pastures to achieve 41 kg/head.annum post weaning. All pre-weaning growth rates for female lambs were set at 5% lower than male lambs, the same as the post-weaning growth rate difference between weaner wethers and weaner ewes. All wether lambs were sold at ca. 9 months of age.

Table 66 - Expected post weaning wether lamb growth rates for the base meat sheep scenario

Month	Days	Daily liveweight gain (kg/d)	Total liveweight gain (kg)
Jan	31	0.08	2.5
Feb	28	0.14	3.9
Mar	31	0.2	6.2
Apr	30	0.2	6.0
May	31	0.1	3.1
Jun	30	0.1	3.0
Jul	31	0.1	3.1
Aug	31	0.1	3.1
Sep	30	0.075	2.3
Oct	31	0.085	2.6
Nov	30	0.09	2.7
Dec	31	0.07	2.2
Average/Annual	*365*	*0.11*	*40.66*

3.5.2.2 Flock DSE assumptions

The DSE ratings were calculated for a period of time, not for a point in time. Except for lambs and sale stock, this was 12 months, e.g., from age 12 to 24 months. The lamb weaner group was rated for 7 months (ages 5 to 12 months) for 'keepers', and less for those sold. All sale stock were rated from their nominal birth month to their sale month, e.g., wethers sold at age 18 months were rated for 6 months (age 12 to 18 months) in their sale year. Table 67 shows the DSE ratings for all classes of sheep retained in the flock for the entire 12-month period.

Table 67 - Dry sheep equivalent (DSE) ratings for sheep held 12 months[A]

Description at start of rating period	Age at start (months)	Age at end (months)	Sheep carried through whole year			
			Months rated	Lowest or start liveweight (kg)	Highest or end liveweight	DSE/head rating
Extra for ewes weaning a lamb	n/a	n/a	n/a	n/a	n/a	0.40
Lambs 5 months	5	12	7	34	61	0.62
Ewes 1-2 years	12	24	12	61	63	1.38
Ewes 2-3 years	24	36	12	63	68	1.46
Ewes 3 years+	n/a	n/a	12	68	68	1.51
Flock rams all ages	n/a	n/a	12	85	85	1.89

n/a, not applicable.

[A]In the herd and economic modelling the standard weight of one DSE = 45 kg; (AE : DSE of 1 : 8.4).

As described in section 1.1.4.4 the DSE ratings for breeding sheep are based on weight, plus a loading for females that produce a lamb weaner. This loading represents the extra nutritional requirement of a ewe that rears one lamb, relative to a dry ewe. The loading for rearing a lamb in this flock is 0.35 DSE times the average weaning rate. This covers the extra load of pregnancy, lactation, and pasture consumed by the weaner itself up to age 5 months, at which point the lamb begins to be rated in its own right. Table 68 shows the DSE ratings for all classes of sheep sold from the flock during the 12-month period.

Table 68 - Dry sheep equivalent (DSE) ratings for sheep sold during the year[A]

Description at start of rating period	Sale stock carried past rating boundary				
	Sale month	Months rated	Start liveweight (kg)	Paddock liveweight at sale (kg)	DSE/head rating
Lambs 5 months	9	2	34	54	0.33
Ewes 1-2 years	9	8	61	68	0.24
Ewes 2-3 years	9	8	63	72	0.25
Ewes 3 years+	9	8	68	80	0.27
Flock rams all ages	9	8	85	85	0.31

[A]In the herd and economic modelling the standard weight of one DSE = 45 kg; (AE : DSE of 1 : 8.4).

3.5.2.3 Flock management and husbandry assumptions

Table 69 shows the treatments applied to the various classes of sheep held for 12 months or sold during the year in the flock model.

Table 69 - Treatments applied and cost per head

Treatment	Lambs		Ewes		Wethers		Flock rams	
	Kept	Sold	Kept	Sold	Kept	Sold	Kept	Sold
Lamb marking	$1.00	$1.00	-	-	-	-	-	-
Tags	$0.70	$0.70						
6-in-1 vaccination	$0.50	$0.50						
Total per head	*$2.20*	*$2.20*	*$0*	*$0*	*$0*	*$0*	*$0*	*$0*

3.5.2.4 Other meat sheep performance parameters

The following are the flock management and husbandry assumptions applied in the analysis:

- Ewes: 68 kg average liveweight; 6 years casting age; 2% mortality; 95% conception rate, 50% twinning rate, 113% weaning.
- Maiden ewes: 12 months first mating; no twins; 2% mortality; 72% weaning rate.
- Rams: run at 3%; 2% mortality; $2,000 purchase price of replacements; culls sold for $65 net.
- Controlled mating was practiced; ewe classes were held in separate smaller mating groups, lambing over summer was strictly avoided.

Table 70 shows the assumed lamb weaning rates, ewe and weather death rates applied in the flock model. The values retained produced a weaning rate equivalent of 113.55%.

Table 70 - Lambing and death rate assumptions

Sheep age year start Sheep age year end	Weaners 1	1 2	2 3	3 4	4 5	5 6	6 7
Expected conception (%)	n/a	80	95	95	95	95	95
Expected lamb loss from conception to weaning (%)	n/a	10	10	10	10	10	10
Proportion of empties (PTE) sold (%)	n/a	100	100	100	100	100	100
Proportion of pregnant females sold (%)	n/a	-	-	-	-	-	-
Ewes with twins (%)	n/a	0	50	50	50	50	50
Lambs weaned/ewes retained (%)	n/a	90	135	135	135	135	135
Ewe death rate (%)	2	2	2	2	2	2	2
Wether death rate (%)	2	n/a	n/a	n/a	n/a	n/a	n/a

n/a, not applicable; PTE, pregnancy tested 'empty' (not in lamb).

3.5.2.5 Meat sheep and lamb prices

The hypothetical, constructed property was located near Longreach with no local selling centres or abattoirs available for sale stock. Slaughter and sale values for cull sheep were derived from the MLA New South Wales database for 'Over the hook' mutton price indicators (MLA monthly market statistics database at http://statistics.mla.com.au/Report/List). The OTH and saleyard indicators are calculated as a weighted average of New South Wales processor grids and saleyard prices.

Mutton prices have shown large variability over the last decade with a substantial increase in the prices paid during the last 5 years compared to the average of the previous years. Figure 13 shows the relationship between the prices of light, medium and heavy sheep slaughtered for mutton from

January 2010 to December 2019 across New South Wales markets. There was a significant upward trend in mutton prices experienced over the past decade.

Figure 13 - Mutton prices over time from 2010 to 2020

MLA over the hook mutton price indicators New South Wales. Prices converted to $/kg liveweight at 50% dressing, GST exclusive

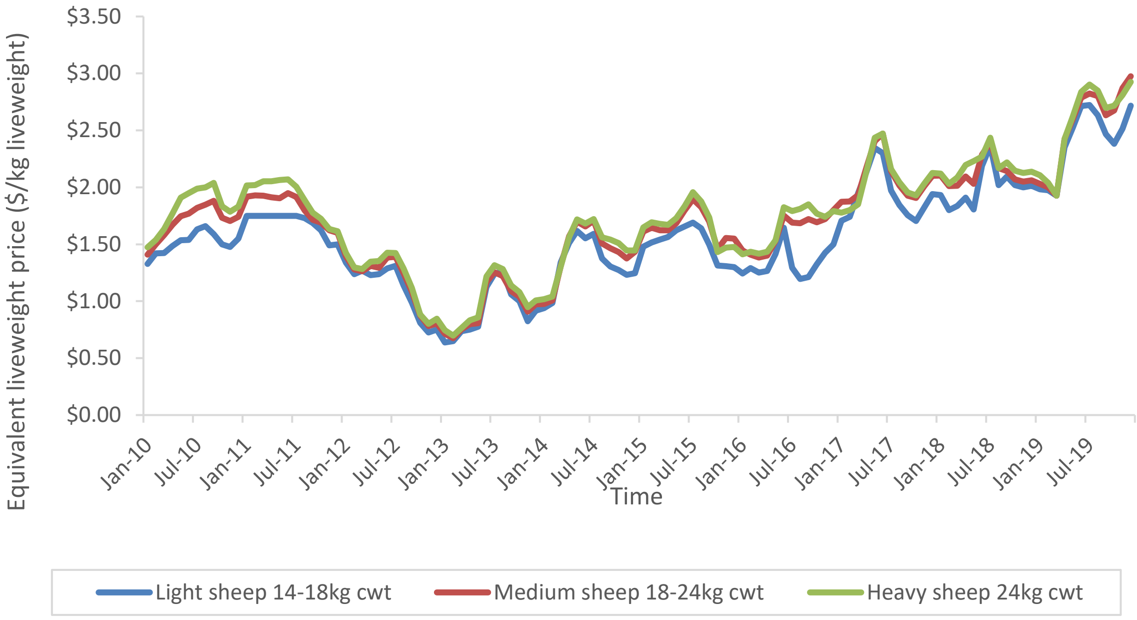


Table 71 shows the mutton prices averaged over the decade, last five years and the last two years.

Table 71 - Mutton prices over time from 2010 to 2020 ($/kg liveweight)

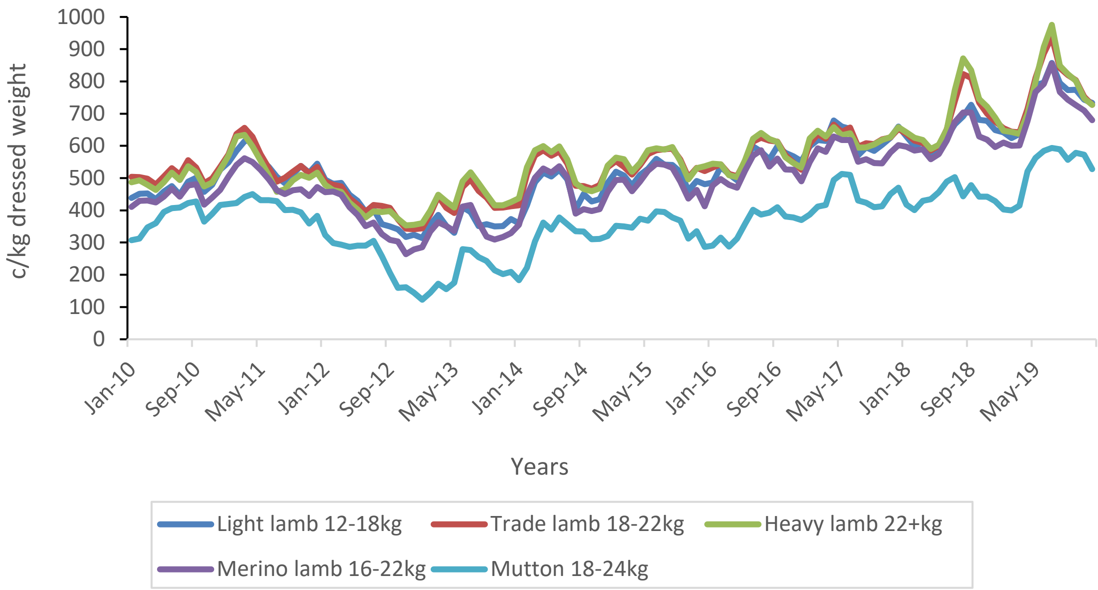
MLA over the hook mutton price indicators New South Wales. Prices converted to $/kg liveweight at 50% dressing, GST exclusive

Average of last	Light sheep 14-18 kg carcass weight	Medium sheep 18-24 kg carcass weight	Heavy sheep 24 kg carcass weight
10 years	$1.57	$1.70	$1.74
5 years	$1.84	$2.00	$2.03
2 years	$2.20	$2.33	$2.38

Lamb prices have also shown large variability over the last decade with a substantial increase in the prices paid during the last 5 years compared to the average of the previous years. Figure 14 shows the relationship between the prices of light, medium, heavy and Merino lambs sold from January 2010 to December 2019 across New South Wales markets. There was a significant upward trend in lamb prices experienced over the past decade.

Figure 14 - Lamb prices over time from 2010 to 2020

MLA saleyard sheep and lamb indicators New South Wales



Mutton and lamb prices underpin sale prices for meat sheep in rangelands of central-western Queensland. Table 72 shows the assumed sheep prices and selling costs applied in the self-replacing meat sheep model. Ewes were sold on farm while lambs and cull rams were transported 1,250 km to slaughter.

Table 72 - Sheep prices and selling costs ($/head)

Group Description	Sale weight (kg/head)	Price ($/kg)	Commission (% of value)	Total selling costs ($/head)	Net price/head
Ewe weaners	49	$3.00	4.00%	$9.93	$138.27
Ewes 1 year	65	$2.50	4.00%	$10.46	$151.04
Ewes 2 years	68	$2.00	4.00%	$9.47	$127.33
Ewes 3 years	76	$1.75	4.00%	$9.32	$123.68
Ewes 4 years	76	$1.75	4.00%	$9.32	$123.68
Ewes 5 years	76	$1.75	4.00%	$9.32	$123.68
Ewes 6 years	76	$1.75	4.00%	$9.32	$123.68
Wether weaners	51	$2.75	4.00%	$18.70	$122.37
Cull flock rams	81	$1.00	4.00%	$12.10	$64.46

3.5.3 Results and discussion

3.5.3.1 Flock output

The flock model predicted ewe deaths to be 70/annum or 2.00% of female breeding stock maintained for the year. The application of the data for reproduction efficiency and mortality rates to the flock model produced an expected average weaning rate of 113.55% (i.e., lambs from all ewes mated). The flock produced about 4,335 weaner lambs from 3,818 females mated and sold 4,271 head/annum. Cull female sales made up 48.94% of total sales.

Table 73 indicates the flock gross margin after interest for the meat sheep enterprise. Selling lambs between 6 and 12 months of age at an average paddock weight of 53 kg, combined with 1,149 of the weaner ewes being culled prior to mating produced the highest expected flock gross margin.

Table 73 – Flock parameter summary

Parameter	Meat sheep flock
Total dry sheep equivalents (DSE)	9,000
Total sheep carried	4,610
Weaner ewes retained	1,018
Total ewes mated	3,818
Total ewes mated and kept	3,477
Total lambs weaned	4,335
Weaners/total ewes mated	113.55%
Overall ewe deaths	2.00%
Female sales/total sales %	48.94%
Total ewes sold	2,078
Maximum ewe culling age	6
Ewe joining age	1
Weaner ewe sales	53.02%
One-year-old ewe sales %	20%
Two-year-old ewe sales %	5%
Total wether lambs sold	2,167
Maximum wether turnoff age	0
Average female price	$134.45
Average wether price	$122.37
Capital value of flock	$718,219
Imputed interest on flock value	$35,911
Net sheep sales	$552,471
Direct costs excluding rams	$9,535
Ram replacement	$58,000
Flock gross margin	$484,937
Flock gross margin less interest	*$443,541*

The application, in the flock models. of the selected sale prices, sale weights, selling costs, treatment costs and ram replacement strategy, produced the summary of the optimised flock gross margin shown in Table 74.

Table 74 - Flock gross margin summary for the representative, base meat sheep enterprise

Parameter	$/flock	$/head	$/DSE
Net sheep sales	$552,471	$119.84	$61.39
Husbandry costs	$9,535	$2.07	$1.06
Net ram replacement	$58,000	$12.58	$6.44
Gross margin	$484,937	$105.19	$53.88
Gross margin less interest	*$443,541*	*$96.21*	*$49.28*

DSE, dry sheep equivalent

The opening value of the land and fixed improvements for the constructed property was taken as $6,000,000. The opening value of the total value of land, plant and improvements for the meat sheep enterprise investment was $6,298,500. The opening value of the sheep inventory was $1,158,738. Table 75 indicates the expected average annual performance parameters for the meat sheep enterprise calculated as a steady state in MeatSheepDynama. The rate of return on total capital of 3.85% was the greatest of all enterprises, although similar to that for rangeland meat goats (3.74% Section 3.6). However, the lack of published data for production of meat sheep breeds in the central-western rangelands region available to inform the assumptions for this analysis indicates that caution is required in the extrapolation of these results.

Table 75 - Expected value of annual outcomes for the sheep meat enterprise

Parameter	Value
Dry sheep equivalents (DSE)	9,000
Operating profit	$285,487
Rate of return on total capital	3.85%

3.5.3.2 Sensitivity of operating profit to change in model parameters

A set of key assumptions about the prices paid and received and the level of flock productivity underpin the results of the analysis. Table 76 shows the sensitivity of the level of operating profit predicted for the meat sheep enterprise to relevant levels of change in these assumptions.

Table 76 - Expected impact on average operating profit of changing model parameter values for the self-replacing meat sheep flock

Parameter	Value	Change to base	% change relative to base
Sheep meat flock	$285,487	Base	Base
Sheep meat price minus 20%	$168,019	-$117,468	-41%
Sheep meat price plus 20%	$402,955	$117,468	41%
Fixed costs 20%	$304,987	$19,500	7%
Fixed costs plus 20%	$265,987	-$19,500	-7%
Treatment costs minus 20%	$287,394	$1,907	1%
Treatment costs plus 20%	$283,580	-$1,907	-1%
Mortality rate minus 50%	$292,258	$6,771	2%
Mortality rate plus 50%	$278,563	-$6,924	-2%
Lambing rate minus 5%	$275,100	-$10,387	-4%
Lambing rate plus 5%	$303,809	$18,322	6%
Growth rate meat sheep minus 5%	$268,425	-$17,062	-6%
Growth rate meat sheep plus 5%	$279,386	-$6,101	-2%

The level of profit generated by the meat sheep enterprise was most sensitive to the meat price received. A 1% change in price had almost six times the impact on profit of any other factor. The negative outcome shown for a positive change in the expected growth rate of lambs is due to rounding of flock numbers as they are transferred from Breedewe (meat sheep version) to the dynamic flock model. The increased growth rate of lambs would be expected to produce a similar result to that of the beef enterprise due to the changed DSE weighting of growing sheep reducing the overall flock numbers and maintaining about the same level of operating profit.

It should be noted that parameters such as the expected rates of growth, mortality and weaning would require an investment of either time or capital to change their average level and that this investment would reduce the impact of the level of response, depending upon the investment strategy chosen. The impact of changing the assumed level of a factor underpinning the output of the meat sheep enterprise was based on no change in costs relevant to achieve that level of change and therefore should be treated with great caution. There are nearly always additional costs incurred or saved that can greatly impact the predicted level of benefit or change in the level of operating profit. The absolute and relative changes in the level of operating profit for the meat sheep enterprise can be compared to the impact of similar levels of change in key assumptions for the alternative livestock enterprise for the constructed property.

3.6 Meat goat production activity

3.6.1 Introduction

Diversification into rangeland goat production has occurred in the semi-arid rangelands since the 1990s. As the value of the goat meat industry in Australia has increased over recent decades, so has the interest in managed production systems, rather than harvesting wild populations (Hacker and Alemseged 2014; Robertson *et al*. 2020). In the Queensland rangelands, various levels of management intensity are currently applied following containment of goats with suitable fencing. This may include (1) mating rangeland does with selected or introduced bucks including rangeland, Boer or Kalahari Red breeds, (2) control of mating period, (3) weaning and (4) supplementation.

Part of the demand for goats in the central-western Mitchell grass region comes from land holders who would like to graze goats on plants like prickly acacia (*Acacia nilotica*) or other woody weed regrowth. Goats will select a substantial proportion of browse in their diet (Hacker and Alemseged 2014; Pahl 2019b) and the belief of local landholders is that woody weeds can be reduced through the correct application of grazing pressure via goats.

3.6.2 Methods

This meat goat analysis was constructed as if the entire property were managed as a rangeland meat goat enterprise. This may or may not be possible in this region. Hacker and Alemseged (2014) reported that, at that time, few grazing businesses in Australia’s southern rangelands were currently based solely on a goat enterprise. It was assumed that the property had sufficient boundary, internal fencing and other infrastructure in place to manage the herd of goats efficiently and that the boundary fencing was sufficient to protect the property from wild dogs. The assumption was made that internal fences were sufficient to contain goats in specific areas of the property, although possibly not within specific paddocks, and that classes of weaner goats could be separated from the breeding herd and maintained as separate mobs of goats.

The meat goat activity was a self-replacing breeding and growing activity that relied on the production of weaner kids by a breeding herd. Weaner bucks were not castrated and entered a growing system that varied in size with the period of time bucks were retained prior to sale. Weaner does were used to maintain the breeding herd or were culled and sold. Breeding does were culled on age. Herd bucks were retained in the breeding herd for an average of 5 years. Weaner does were separated from bucks and expected to have their first kids after a yearling mating.

The property employed no permanent labour other than the owner/manager. The allowance for operator's labour and management was set at $70,000 per annum. An allowance of $20,000 per annum was allocated to contract wages and other mustering expenses for the property when it was run solely as a meat goat enterprise.

3.6.2.1 Kid growth assumptions

To simplify the analyses, all pre-weaning and post weaning growth rates for female kids were set at 5% lower than for male kids, consistent with assumptions for cattle and sheep in this analysis. Table 77 indicates the expected post-weaning seasonal performance for young bucks. Bucks were assumed to gain weight at about 0.078 kg/head.day on grass pastures to achieve 28 kg/head.annum post weaning and does to gain ca. 0.074 kg/head.day to achieve 27 kg/head.annum post weaning.

Table 77 - Expected post-weaning growth rates for male rangeland goat kids

Month	Days	Daily liveweight gain (kg/d)	Total liveweight gain (kg)
Jan	31	0.15	4.7
Feb	28	0.15	4.2
Mar	31	0.15	4.7
Apr	30	0.01	0.3
May	31	0.0	0.0
Jun	30	0.0	0.0
Jul	31	0.05	1.6
Aug	31	0.05	1.6
Sep	30	0.075	2.3
Oct	31	0.085	2.6
Nov	30	0.090	2.7
Dec	31	0.125	3.9
Average/Annual	*365*	*0.078*	*28.36*

3.6.2.2 Goat herd DSE assumptions

The DSE ratings were calculated for a period of time, not for a point in time. Except for weaners and sale stock, this was 12 months, e.g., from age 12 to 24 months. The weaner group was rated for 7 months (age 5 to 12 months) for 'keepers', and less for those sold. This was even though the kids may not be weaned at 5 months old. All sale stock were rated from their nominal birth month to their sale month, e.g. bucks sold at age 18 months were rated for 6 months (age 12 to 18 months) in their sale year. Table 78 shows the DSE ratings for all classes of goats retained in the herd for the entire 12-month period.

Table 78 – Dry sheep equivalent (DSE) ratings for goats held 12 months[A]

Description at start of rating period	Age at start (months)	Age at end (months)	Goats carried through whole year			
			Months rated	Lowest or start liveweight (kg)	Highest or end liveweight (kg)	DSE/head rating
Extra for does weaning a kid	n/a	n/a	n/a	n/a	n/a	0.42
Kids 5 months	5	12	7	16	41	0.37
Does 1-2 years	12	24	12	41	50	1.01
Does 2-3 years	24	36	12	50	60	1.22
Does 3 years+	n/a	n/a	12	60	60	1.33
Bucks 1 year	12	24	12	41	70	1.23
Herd bucks all ages	n/a	n/a	12	80	80	1.78

n/a, not applicable.

[A]In the herd and economic modelling the standard weight of one DSE = 45 kg; (AE : DSE of 1 : 8.4).

The DSE ratings for breeding stock were based on weight, plus a loading for a doe that weans a kid. This loading represents the extra nutritional requirement of a doe that rears a kid, relative to a dry doe. The loading for rearing one kid was 0.35 DSE. This covers the extra load of pregnancy, lactation, and pasture consumed for one weaner up to age 5 months, at which point the weaner begins to be rated in its own right. The loading was increased by the ratio of the herd weaning rate to 100% to allow for does that have multiple kids. Table 79 shows the DSE ratings for all classes of goats sold from the herd during the 12-month period.

Table 79 - Dry sheep equivalent (DSE) ratings for goats sold during the year[A]

Description at start of rating period	Sale stock carried past rating boundary				
	Sale month	Months rated	Start liveweight (kg)	Paddock liveweight at sale (kg)	DSE/head rating
Kids 5 months	6	2	16	17	0.06
Does 1-2 years	6	7	41	50	0.59
Does 2-3 years	7	8	50	55	0.78
Does 3 years+	7	8	60	60	0.89
Bucks 1 year	12	1	41	41	0.08
Herd bucks all ages	7	8	80	75	1.15

[A]In the herd and economic modelling the standard weight of one DSE = 45 kg; (AE : DSE of 1 : 8.4).

3.6.2.3 Husbandry costs and treatments

Table 80 shows the treatments applied to the various classes of goats held for 12 months in the herd model. Sale stock may or may not have received the treatment depending upon the timing of sale. Labour costs were deducted as an operating cost later in the analysis.

Table 80 - Treatments applied and cost per head

Treatment	Kids	Does 1-2 years	Does 2-3 years	Does 3+ years	Herd bucks
Tags	$0.35	-	-	-	-
Hay (yards)[A]	$1	$1	$1	$1	$1

[A]Hay fed as mobs are gathered prior to sale.

3.6.2.4 Other herd performance parameters

There is little data available to describe the performance of Rangelands goats in the rangelands of central-western Queensland. Data to describe the reproduction efficiency of the herd was based on the discussions held with local goat producers. The expected reproductive performance and mortality rates are summarised in Table 81. This data set was seen as being closest to the expected performance of a herd of rangeland goats located in the central-western rangelands near Longreach and run with a reasonable level of management input and selection for growth.

Although there is some evidence that younger does outperform older does in this environment, the initial model maintained the performance expectation at the same level for each age class of doe. There is also some evidence that goats selected for meat production (such as the Boer breed) may not match the reproduction efficiency of local rangeland goats but are likely to grow faster and have more consistent sale weights.

Table 81 - Reproduction performance and mortality rates for rangeland goats near Longreach

Goat age year start	Weaners	1	2
Goat age year end	**1**	**2**	**6**
Expected conception rate for age group (%)	n/a	90	90
Expected kid loss from conception to weaning (%)	n/a	10	10
Sales after mating, % of number mated	n/a	10	10
Proportion of pregnants sold (%)	n/a	0	0
% of does with twins	n/a	50	50
Kids weaned/does retained (%)	n/a	135	135
Female death rate (%)	5.0	5.0	5.0
Male death rate (%)	3.0	3.0	3.0

n/a, not applicable; PTE, pregnancy tested empty (i.e., not in kid).

3.6.2.5 Prices

The hypothetical, constructed property was located near Longreach with no local selling centre or abattoirs available for sale stock. Slaughter values were underpinned by the MLA 'Queensland over the hooks (OTH)' goat prices database (MLA monthly market statistics database at http://statistics.mla.com.au/Report/List). The OTH indicators are calculated as a weighted average of Eastern States processor grids and saleyards. Transport and other selling costs were estimated for Charleville (ca. 600 km distance).

Prices for sale goats have shown large variability over the last 4 years with a substantial increase in the prices paid compared to the average of the previous years. Figure 15 shows the price of goat meat over time since 2010. Once carcass weights are above 8 kg there is little to no differentiation in prices. However, goats above 40 kg carcass weight incur a price penalty at Charleville abattoirs.

Figure 15 – Goat meat prices from 2010 to 2020

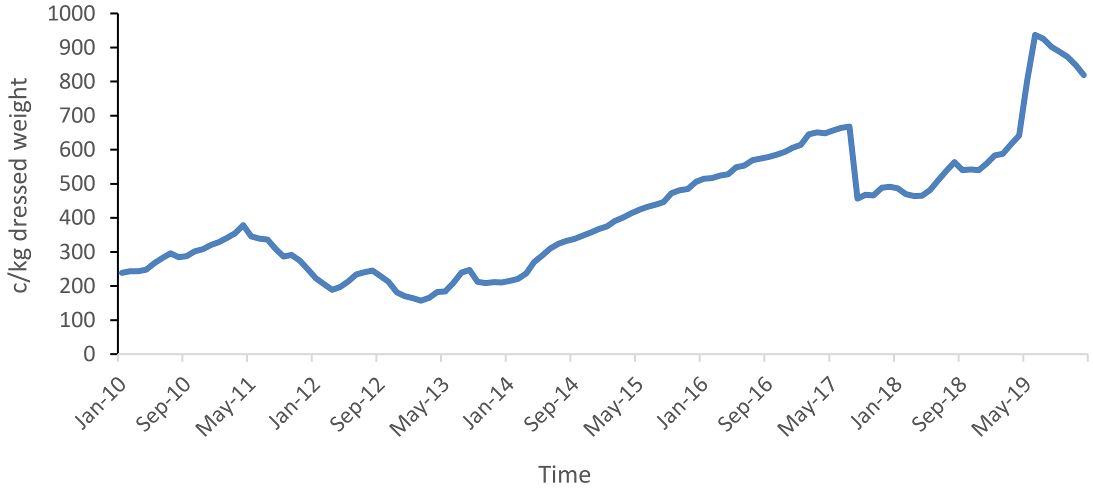


Table 82 shows the price data and selling costs for each class of stock retained in the goat meat models. All bucks were sold between 1 and 2 years old. An allowance for 5% weight loss was made between the paddock weights and the sale weights. A dressing percentage of 45% was applied to convert dressed weight prices to liveweight prices.

Table 82 - Prices worksheet showing selling costs, gross and net prices for meat goats

Group description	Sale liveweight (kg/head)	Dressing %	Dressed price ($/kg)	Live price ($/kg)	Other selling costs ($/head)	Freight ($/head)	Net price
Does 1 year	48	45	$6.00	$2.70	$0.37	$4.84	$123.04
Does 2 years	52	45	$6.00	$2.70	$0.37	$4.84	$135.86
Does 3 years	57	45	$6.00	$2.70	$0.37	$4.84	$148.69
Bucks 1-2 years	39	45	$6.00	$2.70	$0.37	$4.65	$100.14
Cull herd bucks	71	45	$6.00	$2.70	$0.37	$4.84	$187.16

3.6.2.6 Adding value through agistment

The value of sending weaner goat wethers on agistment for the 12 months post-weaning was assessed as a sub-scenario, using expected market prices and costs. The liveweight gain shown in the example (Table 92) is that estimated for a pasture infested with prickly acacia.

3.6.3 Results and discussion

3.6.3.1 Herd outputs

Table 83 shows the parameters for the self-replacing rangeland goat system.

Table 83 – Steady-state rangeland goat parameters

Parameter	Value
Herd size (DSE)	9,000
Age at first mating (1 or 2 years)	1
Doe casting age	4
Total does joined	3,611
Total kids weaned	4,387
Kids weaned/does mated (%)	121.5
Doe weaners retained	2,194
Surplus doe weaners sold	0
Mature does sold	1,921
Weaner bucks sold	0
Yearling bucks sold	2,128

Table 84 indicates the herd structure for the chosen buck sale age.

Table 84 – Herd structure and key parameters at buck sale age of 1-2 years

Parameter	Age of buck turnoff of 1-2 years
Total dry sheep equivalents (DSE)	9,000
Total goats carried	7,745
Weaner does retained	2,194
Total breeders mated	3,611
Total breeders mated and kept	3,250
Total kids weaned	4,387
Weaners/total does mated	121.5%
Weaners/does mated and kept	135%
Overall breeder deaths	5.00%
Female sales/total sales %	47.45%
Total does sold	1,921
Maximum doe culling age	4
Doe joining age	1
Weaner doe sale and spay	0.00%
One-year-old doe sales %	10.00%
Two-year-old doe sales %	63.80%
Total bucks sold	2,128
Maximum buck turnoff age	1
Average female price	$138.96
Average buck price	$100.14

Table 85 shows the female herd structure for a buck sale age of 1-2 years. Expected doe deaths were 162/annum or 5.00% of female breeding stock maintained for the year. The application of the data for reproduction efficiency and mortality rates to the herd model produced an expected average weaning rate of 121.5% (i.e., kids from all does mated). The herd of goats produced about 4,387 weaners from 3,611 females mated and sold 4,055 head/annum. Cull female sales made up 47.45% of total sales.

Table 85 – Female herd structure for the self-replacing goat enterprise and buck sale age of 1-2 years

Doe age start year **Doe age end year**	**1** **2**	**2** **3**	**3** **4**	**4** **5**
Does available start year	2,084	1,782	704	602
Sales unmated, % start year does	0.00%	53.80%	0.00%	0.00%
Does sold	208	1041	70	602
Does mated in each age group	2,084	823	704	-
Mated does retained in each group	1,875	741	633	-
Kids weaned from each group	2,532	1,000	855	-

Table 86 shows the buck herd structure for the self-replacing herd of goats. The total bucks sold per annum was 2,128 at an average price of $100.14/head.

Table 86 – Buck herd structure for the goat enterprise

Buck age in months	**5 to 11**	**12 to 23**	**24 to 35**	**36 to 47**
Number available at start year	2,194	2,128	0	0
Number reserved as herd bucks	0	0	0	0
Optional sales %	0%	0%	0%	0%
Transfers to buck herd	0	0	0	0
Sales at each age	0	2,128	0	0

The estimated herd buck requirements are shown in Table 87.

Table 87 – Herd buck requirements

Parameter	**Value**
Herd buck/does to be used (%)	3
Herd bucks required per year	108
% of herd bucks replaced annually (15; $250/head)	16
Herd bucks sold per year ($234/head)	5
Herd bucks deaths or destruction (10%)	11
Net herd buck replacement costs/year	$3,048
Net herd buck cost/kid weaned	$0.69

The classes of goats in the herd culling 1-2-year-old does are presented in Table 88.

Table 88 - Classes of goats in the herd

Age at start of rating period	Number kept whole year	Number sold	DSE/head kept	DSE/head sold	Total DSEs
Extra for does weaning a lamb.	n/a	n/a	0.42	n/a	1,843
Weaners 5 months	4,387	0	0.37	0.06	1,621
Does 1 year but less than 2	1,875	208	1.01	0.59	2,019
Does 2 years but less than 3	741	1,041	1.22	0.78	1,715
Does 3 years plus	633	672	1.33	0.89	1,442
Bucks 1 year but less than 2	0	2,128	1.23	0.08	162
Herd bucks all ages	108	5	1.78	1.15	199
Total number	*7,745*	*4,055*	-	-	*9,000*

n/a, not applicable. DSE, dry sheep equivalent.

The herd gross margin for the self-replacing rangeland meat goat enterprise is presented in Table 89.

Table 89 - Herd gross margin for the self-replacing herd of rangeland meat goats

Parameter	$/herd	$/goat	$/DSE
Net goat sales	$480,741	$64.57	$53.42
Husbandry costs	$6,651	$0.89	$0.74
Net buck replacement	$3,048	$4,000	$0.54
Gross margin	$470,090	$63.14	$52.23
Gross margin less interest	*$439,209*	*$58.99*	*$48.80*

DSE, dry sheep equivalent

The opening value of the land and fixed improvements for the example property was taken as $6,000,000. This makes the opening value of the total value of land, plant and improvements for the goat enterprise investment, $6,298,500. The opening value of goats was $1,095,512.

Table 90 indicates the expected average annual performance parameters for the rangeland goat enterprise. The meat goat production activity resulted in a rate of return on total capital of about 3.75%. This result was based on the assumption that the property was already protected from wild dogs with appropriate fencing infrastructure. The costs of implementing cluster fencing, or similar, were not included in this analysis.

Table 90 - Expected value of annual outcomes for the self-replacing herd of goats

Parameter	Value
Dry sheep equivalents (DSE)	9,000
Operating profit	$275,640
Rate of return on capital	3.75%

3.6.3.2 Sensitivity of operating profit to change in model parameters

A set of key assumptions about the prices paid and received and the level of flock productivity underpin the results of the analysis. Table 91 shows the sensitivity of the level of operating profit predicted for the meat goat enterprise to relevant levels of change in these assumptions. The impact of changing the assumed level of a factor underpinning the output of the meat goat enterprise was based on no change in costs relevant to achieve that level of change and therefore should be treated with great caution. There are nearly always additional costs incurred or saved that can greatly impact the predicted level of benefit or change in the level of operating profit. The absolute and relative changes in the level of operating profit for the meat goat enterprise can be compared to the impact of similar levels of change in key assumptions for the alternative livestock enterprise for the constructed property.

A 1% change in the price of goat meat appears to have five- or six-times greater effect on the level of farm operating profit than changing any of the other main parameters in the model by 1%. A strategy to reduce the rate of mortality in meat goats could have a much larger impact on farm profit than a strategy to reduce treatment costs.

Table 91 - Expected impact on average operating profit of changing model parameter values for the self-replacing rangeland goat herd

Parameter	Value	Change to base	% change relative to base
Meat goats	$275,640	Base	Base
Goat meat price minus 20%	$175,347	-$100,293	-36%
Goat meat price plus 20%	$375,932	$100,292	36%
Fixed costs minus 20%	$296,140	$20,500	7%
Fixed costs plus 20%	$255,140	-$20,500	-7%
Treatment costs minus 20%	$276,970	$1,330	0%
Treatment costs plus 20%	$274,310	-$1,330	0%
Mortality rate minus 50%	$292,158	$16,518	6%
Mortality rate plus 50%	$258,532	-$17,108	-6%
Kidding rate minus 5%	$259,554	-$16,086	-6%
Kidding rate plus 5%	$288,296	$12,656	5%
Growth rate goats minus 5%	$275,834	$194	0%
Growth rate goats plus 5%	$287,871	$12,231	4%

3.6.3.3 Adding value through agistment

Table 92 details example gross margin calculations for agistment of wether goats on a pasture infested with prickly acacia.

Table 92 – Calculation of gross margin for agistment of wether goat on a pasture infested with prickly acacia

Factor	**Per head**	**Total**
Number of livestock into the agistment paddock		500
Initial liveweight (kg)	20	
Price ($/kg; net of sale costs if owned)	$3.00	
Agistment costs		
Cost of livestock into the enterprise	$60.00	$30,000
Transport of livestock to agistment (130 head/deck, 200 km at $1.40/km)	$2.15	$1,077
Agistment cost ($0.50/week for 52.14 weeks)	$26.07	$13,036
Interest cost on livestock purchases (5%)	$3.00	$1,500
Interest cost on treatment expenses (5%)	$0.70	$351
Weight gain (kg/day	0.082	
Final weight (kg)	50	
Losses (% of purchased number)		3
Mustering and travelling costs	$2.00	$1,000
Total costs of agistment	*$93.93*	*$46,964*
Total number of goats sold		485
Selling price ($3.00 /kg live at 50 kg liveweight)	$150.00	$72,750
Selling costs		
Livestock levy	$0.38	$183
Freight	$5.00	$2,425
Yard fees	$0.00	$0
Commission on sales (0%)	$0.00	$0
Net income from sales	$144.62	$70,142
Gross margin after interest	*$46.36*	*$23,179*

The gross margin per DSE after interest for the goat agistment exercise was $55.97 at $0.50/head.week. The sensitivity analysis of changing agistment cost (Table 93) shows that doubling the cost of agistment does not make the agistment exercise unviable. However, as indicated in Table 94, a significant fall in the expected sale price over the agistment period will have a large impact on the profitability of the exercise. Furthermore, as shown in Table 95, achieving a sound weight gain per head over the period of agistment is important for good returns.

Table 93 - Sensitivity of gross margin per head after interest to changing agistment cost

Parameter	**% change in agistment cost**				
	-50%	**-25%**	**Base**	**50%**	**100%**
Agistment cost ($ head /week)	$0.25	$0.38	$0.50	$0.75	$1.00
Gross margin per head	*$59.72*	*$53.04*	*$46.36*	*$33.00*	*$19.63*

Table 94 - Sensitivity of gross margin per head after interest to changing sale price

Parameter	**% change in sale price**				
	-50%	**-25%**	**Base**	**10%**	**20%**
Sale price ($/kg live)	$1.50	$2.25	$3.00	$3.30	$3.60
Gross margin per head	*-$26.39*	*$9.98*	*$46.36*	*$60.91*	*$75.46*

Table 95 - Sensitivity of gross margin per head after interest to changing weight gain per day

Parameter	% change in weight gain				
	-50%	-25%	Base	10%	20%
Liveweight gain (kg/head.day)	0.04	0.06	0.08	0.09	0.10
Gross margin per head	*$2.71*	*$24.53*	*$46.36*	*$55.09*	*$63.82*

Although further work needs to be done to verify the assumptions underlying this analysis, placing wether goats on a pasture infested with edible woody weeds for a 12-month period and achieving sound weight gains could not only reduce the weed infestation but also improve the profitability of both the manager making the agistment available and the goat producer taking advantage of the agistment opportunity. Whether there were any savings in weed treatment costs would need to be investigated but this potential benefit to the owner of the agistment paddock has not been considered in this analysis.

4 Strategies to improve profitability and resilience

The previous section (Section 3) identified the relative profitability of beef cattle, wool sheep, meat sheep, and meat goat enterprises in steady-state analyses. In this section (Section 4), partial discounted cash flow budgets were applied to consider the value to the constructed property of integrating or fully adopting several of the alternative enterprises from a starting base production system. The scenarios included:

1) Converting from a self-replacing beef herd to a self-replacing Merino wool sheep flock with investment in exclusion fencing and repairs to sheep infrastructure;
2) Converting from a self-replacing beef herd to production of rangeland meat goats with investment in exclusion fencing;
3) Converting from a self-replacing Merino wool sheep flock to 50% self-replacing wool sheep and 50% rangeland meat goat production with investment in goat infrastructure.

The economic and financial effect of implementing each strategy was assessed by comparison to the starting base enterprise for that scenario. In each scenario, the strategies were implemented as quickly as possible (i.e., over 2 years). An investment period of 30-years was applied to consider the change in profit and risk generated by alternative management strategies. Changes in herd or flock structure, labour, capital and the implementation phase were included in the investment analysis.

The results of this section relate to the hypothetical property outlined in this report and the associated assumptions made for the expected production responses to changing the management strategy. Different results may be gained for different properties/production systems and hence it is recommended that property owners, managers or their advisors use the tools and models developed in this study to conduct their own analyses specific to their circumstances.

The information provided here should be used, firstly, as a guide to an appropriate method to assess alternative strategies aimed at improving profitability and drought resilience of a property with similar characteristics to the hypothetical property located in the rangelands of central-western Queensland. Secondly, this report indicates the data required to conduct such an analysis and indicates the potential level of response to change revealed by relevant research and the opinion of producers and extension officers. Whilst every effort was made to ensure the assumptions used in each scenario were validated with industry participants, relevant experts or published scientific studies, the results presented should be viewed as indicative only.

4.1 Converting from a self-replacing beef herd to a self-replacing Merino wool sheep flock

4.1.1 Introduction

A number of properties in the rangelands of central-western Queensland run self-replacing beef breeding herds that grow steers and surplus breeding cattle to a weight and condition suitable for sale. Most of these properties have previously supported a mixture of sheep and cattle production, although few now retain the sheep infrastructure (fences, yards and shearing sheds) in good enough condition to allow the property to run sheep for wool production without some additional investment. Due to the prevalence of wild dogs in the region any beef producer returning to, or newly establishing, a sheep enterprise, will most likely need to construct an exclusion fence around part of, or the entire, boundary of their property and implement a dog control programme.

Each specialist beef property will face different challenges, costs and benefits when considering a change to a new sheep enterprise, or to reinstate a previous sheep enterprise. The farm-management economics framework can be applied to investigate scenarios applicable to individual circumstances as well as to examine hypothetical, example scenarios as we have done here.

4.1.2 Method

In this analysis the constructed property with the self-replacing beef cattle herd was converted to a property with a self-replacing Merino wool sheep enterprise. The target for the wool sheep enterprise was the same flock structure and farm profit as that identified for the steady-state self-replacing wool flock enterprise in Section 3.3. The main costs associated with the changeover were the construction of an exclusion fence on the boundary of the property and a reconstruction of sufficient sheep and wool infrastructure to allow efficient management of the sheep enterprise. The cost of constructing the exclusion fence was estimated as $435,000 (54 km at $8,000/km). Additionally, $250,000 was invested to renew the existing wool sheep infrastructure on the property.

A multi-enterprise, dynamic herd and flock model was structured to sell down the existing beef breeding herd in the first 2 years of a 30-year period. The steer component of the beef herd was sold as target weights were reached. The wool sheep flock was established through the purchase of sufficient breeding ewes of mixed ages at the start of the 2nd year to provide a full complement of female sheep for the property, with the exception of ewe lambs. The lambs produced by the purchased breeding sheep in their 1st and 2nd years on the property were retained to build up flock numbers, including the targeted wether flock size and age structure. Once the flock achieved the structure and size identified in the steady-state, self-replacing wool sheep flock structure, the expected culling strategy was applied to maintain the average stocking rate over time.

The purchase price of the breeding ewes was based on the value applied to calculate the sale value of the ewes in each age class in the steady-state wool flock model with the expected cost of transport to the property added. All other husbandry, selling costs, selling prices and sale weights and fleece weights for sheep were maintained at the same value as the classes maintained in the steady-state, self-replacing wool flock model.

The transition from beef cattle to sheep was implemented in steps to maintain the total grazing pressure applied to the property at about 9,000 DSE and was completed over the first 24 months. Table 96 indicates change in the grazing pressure applied, the sale of the beef herd and the purchase of the sheep flock over the initial years of the transition from beef to sheep. The purchased sheep were expected to produce lambs but no large amount of wool during the first year they were on the property.

Table 96 – Grazing pressure applied, sales and purchases during the transition from a self-replacing beef herd to a self-replacing Merino wool flock

Herd and flock summary	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Total DSE carried[A]	6,206	9,246	8,036	9,000	9,000	9,000
Cattle total sales number	952	450	0	0	0	0
Sheep total purchase number	0	7,222	26	26	26	26
Total new lambs	0	3,521	3,521	3,521	3,521	3,521
Net beef cattle sales	$907,670	$521,401	$0	$0	$0	$0
Net sheep purchases	$0	$1,185,767	$26,000	$26,000	$26,000	$26,000
Net sheep sales	$0	$110,619	$173,052	$347,340	$347,340	$347,340
Net wool sales	$0	$6,545	$246,441	$294,893	$294,893	$294,893

DSE, dry sheep equivalent.

[A]In the herd and economic modelling the standard weight of one DSE = 45 kg; (AE : DSE of 1 : 8.4).

4.1.3 Results and discussion

Table 97 indicates the extra returns generated by transitioning from the beef cattle breeder beef herd to the self-replacing wool flock operation. At the selected discount rate of 5% the marginal returns on the additional capital were negative. The investment generated a return of about 3% over the 30 years of the analysis, which is less than the 5% opportunity cost of the extra capital invested and therefore produced a negative NPV.

However, there are less tangible benefits associated with transitioning from a beef breeder operation to wool sheep operation that are difficult to quantify in an analysis such as this. Most importantly, local producers suggest that wool sheep are more drought tolerant in this region and are less likely than beef cattle to require complete destocking during dry periods. Furthermore, wool sheep have an advantage in that each animal produces a return from wool every year and meat products at life’s end. A slump in the price of meat products may not have any impact on wool prices and vice versa, providing some diversification and stability of income sources over time.

A self-replacing wool flock does require more labour than a self-replacing beef herd on the same property, but we accounted for the additional expense by allowing for an increase in casual labour and increasing the allowance for owner’s labour and management in the budget to the amount outlined in the whole farm analysis for the self-replacing wool flock. Even so, the different skills and knowledge required to manage a wool sheep flock in this region may prove challenging for some beef cattle managers and that aspect is difficult to cost. A less effective level of management applied to the sheep flock would make the payback period longer and the risks greater than that indicated by our analysis. This requirement for a new set of management skills to effect the change is, by itself, likely to prevent many current beef producers converting either quickly, or completely, to a self-replacing wool sheep enterprise.

Table 97 - Returns for moving from a self-replacing beef cattle herd to a self-replacing wool flock operation

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5%
NPV	-$311,378
Annualised NPV	-$20,256
Peak deficit (with interest)	-$1,637,496
Year of peak deficit	20
Payback period (years)	not calculable
IRR	2.99%

4.2 Converting from a self-replacing beef herd to a rangeland meat goat herd

4.2.1 Introduction

The complete conversion from a beef herd to a herd of meat goats on the constructed property is something we can imagine in the model. Whether it is a realistic proposition to convert an entire property to meat goat production in the rangelands of central-western Queensland region will be decided by time and by the building of experience in the management of rangeland goats run in large mobs under extensive and controlled (not semi-feral) conditions. To convert from beef to goat production, property managers would need to invest in an external exclusion fence to provide protection from wild dogs and to contain the goat herd. Investment in some internal fencing and infrastructure would also be required to manage goats.

4.2.2 Method

In this analysis the constructed property with the self-replacing beef cattle herd was converted to a property with a self-replacing rangeland meat goat herd. The target for the meat goat enterprise was the same herd structure and farm profit as that identified for the steady-state self-replacing rangeland meat goat enterprise in Section 3.6. The main costs associated with the changeover were the construction of an exclusion fence on the boundary of the property and a reconstruction of sufficient infrastructure to allow efficient management of the goat enterprise.

The cost of constructing the exclusion fence was estimated as $435,000 (54 km at $8,000/km). Although the optimum way to run a large mob of goats is still under discussion, it is expected that substantial changes and additions will also be required to the existing internal fencing and livestock infrastructure, even if useable sheep yards are available. An amount of $120,000 was allocated to capital expenditure to remediate internal fences and convert a set of existing sheep yards to handle goats. It should be noted that if no useable sheep yards were available for modification, additional expenditure, to what has been outlined here, would be required to install one or more sets of goat yards. In our analysis we assumed that investment in specialist goat handling equipment was also required at a cost of $15,000. Therefore, the minimum capital cost to convert from the constructed beef property, which had some sheep infrastructure still in place, to a goat property with an exclusion fence and suitable internal infrastructure was expected to be $570,000. This is ca. $100,000 less capital than that required for the conversion to wool sheep.

The combined meat goat and beef model was structured to sell down the existing beef breeding herd in the first 2 years of the 30-year period. The steer component of the beef herd was sold as target weights were reached. The goats were established through the purchase of sufficient breeding does of mixed ages at the start of the 2nd year to provide a full complement of female goats for the property. The kids produced by the purchased breeding goats in their 1st and 2nd years on the property were retained to build up numbers. Once the herd of goats achieved the structure and size identified in the steady-state, self-replacing meat goat model structure, the expected culling and sale strategy was applied.

The purchase price of the does was based on the value applied to calculate their sale value in each age class in the steady-state, meat goat model with the expected cost of transport to the property added. All other husbandry, selling costs, selling prices and sale weights were maintained at the same value as the classes maintained in the steady-state meat goat model.

The transition from beef cattle to goats was implemented to maintain the total grazing pressure applied to the property at about 9,000 DSE and was completed over the first 24 months. Table 98 indicates change in the grazing pressure applied, the sale of the beef herd and the purchase of the goats over the initial years of the transition from beef to goats.

Table 98 – Grazing pressure applied, sales and purchases during the transition from a self-replacing beef cattle herd to a self-replacing rangeland meat goat herd

Herd and flock summary	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Total DSE carried	6,206	9,673	8,834	8,996	8,996	8,996
Cattle total sales number	952	450	0	0	0	0
Goats total purchase number	0	6,869	16	16	16	16
Total new kids	0	4,386	4,386	43,86	4,386	4,386
Net beef cattle sales	$907,670	$521,401	$0	$0	$0	$0
Net goat purchases	$0	$827,615	$4,000	$4,000	$4,000	$4,000
Net goat sales	$0	$177,449	$267,747	$480,756	$480,756	$480,756

DSE, dry sheep equivalent. In the herd and economic modelling, the standard weight of one DSE = 45 kg; (AE : DSE of 1 : 8.4).

In the second year of the analysis, there is a saving of about $360,000 in livestock capital when shifting to goats compared to wool sheep. This, together with the reduced need for infrastructure for meat goats, greatly offsets the extra capital required for meat goats compared to wool sheep. This would need to be closely checked with current prices by any manager considering these options as livestock value has changed in both relative and absolute terms for all of the livestock types in this analysis over the period during which we have conducted our work.

4.2.3 Results and discussion

Table 99 indicates the extra returns generated by transitioning from the breeder beef herd to the self-replacing meat goat operation. Compared to the transition from beef to wool sheep, a lower peak deficit was incurred to establish the meat goat model (-$682,000 cf. -$1.6 million) and more than a decade was required to break even with the current investment in the beef breeding and growing operation.

In addition to the improvement in returns from implementing this strategy, there are less tangible benefits associated with transitioning from a beef breeder operation to a meat goat operation that are difficult to quantify in an analysis such as this. Most importantly, rangeland goats have a more varied diet than either sheep or cattle and hence are considered to be more drought resilient (e.g., Hacker and Alemseged 2014). The common use of 'semi-feral' genetics as a base for the breeding does may make them more drought tolerant in this region, although the trade-off between possibly more productive genetics and drought tolerance is unknown.

A self-replacing herd of meat goats is likely to require more labour, especially during the steep learning curve phase at the beginning of the changeover, than a self-replacing beef herd or self-replacing sheep flock on the same property. We have accounted for the additional expense in the budget by allowing for an increase in casual labour to the level outlined in the steady-state analysis. Even so, the complete set of skills and knowledge needed to manage a property entirely running meat goats are yet to be fully defined in this region and a less effective level of management than applied in this analysis would make the payback period longer and risks greater.

Even though the returns and the level of resilience expected for a meat goat enterprise appear positive, it is unknown whether many managers would be likely to convert their entire production system to rangeland meat goats. The unknown aspects of managing and producing large numbers of goats in this environment suggests that adoption of a conservative 'trial and error' approach, with small mobs of goats initially, would be most appropriate.

Table 99 - Returns for moving from a self-replacing beef cattle herd to a self-replacing meat goat operation

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5%
NPV	$702,304
Annualised NPV	$45,686
Peak deficit (with interest)	-$681,884
Year of peak deficit	3
Payback period (years)	12
IRR	12.83%

4.3 Converting from a self-replacing Merino wool sheep flock to a mixed sheep flock and goat herd

4.3.1 Introduction

The partial conversion of a self-replacing Merino wool flock to an integrated operation running a herd of meat goats appears to be something that is more likely to occur in the central-western rangelands than a full conversion to meat goats. To partially convert an existing sheep and wool operation to rangeland meat goat production, additional internal fencing and infrastructure would be required.

4.3.2 Method

In this analysis the constructed property was converted from one running 100% Merino wool sheep to 50% wool sheep and 50% meat goats. The constructed property did not require investment in the external exclusion fence as this was assumed to be already in place. However, it was assumed that substantial changes and additions were required to the existing internal fencing and sheep infrastructure to allow effective management of rangeland goats. As for conversion of the beef property to goats, $120,000 was allocated to capital expenditure to remediate internal fences and convert a set of sheep yards to handle goats. Specialist goat handling equipment was also purchased at a cost of $15,000. Therefore, the minimum capital cost to convert from the constructed wool sheep property, which had sheep infrastructure in place, to a 50% meat goat and 50% wool sheep property was expected to be $135,000. This is the same amount as allocated to convert the entire beef herd to goats, even though double the number of goats were expected to be run under that scenario. In this scenario, the goats are assumed to still access the entire property at different times and will require adequate infrastructure to match this requirement.

The integrated herd and flock model was structured to sell down half the existing wool sheep flock in the first 2 years of a 30 year period. The goats were then established through the purchase of sufficient breeding does of mixed ages at the start of the 2nd year to provide the complement of female goats for half of the carrying capacity of the property. The kids produced by the purchased breeding goats in their 1st and 2nd years on the property were retained to build up numbers. Once the herd of goats achieved the structure and 50% of the size identified in the steady-state, self-replacing meat goat structure, the expected culling and sale strategy was applied to maintain the long-term stocking strategy at the property level.

The purchase price of the breeding does was based on the value applied to calculate the gross sale value of the does in each age class in the steady-state, meat goat model with the expected cost of transport to the property added. All other husbandry, selling costs, selling prices and sale weights were maintained at the same value per head as the classes maintained in the steady-state meat goat model.

The transition from all wool sheep to 50% goats was implemented to maintain the total grazing pressure applied to the property at about 9,000 DSE and was completed over the first 24 months. Table 100 indicates change in the grazing pressure applied, the sale of the sheep flock and the purchase of the goats over the initial years of the transition from wool sheep to sheep and goats.

Table 100 – Grazing pressure applied, sales and purchases during the transition from 100% Merino wool sheep to 50% wool sheep and 50% rangeland meat goat production

Herd and flock summary	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Total DSE carried[A]	7,262	9,003	8,920	9,001	9,000	9,001
Sheep total sale numbers	6,354	2,454	1,600	1,600	1,600	1,600
Goats total purchase numbers	0	3,735	8	8	8	8
Total new kids	0	2,194	2,192	2,194	2,192	2,194
Net sheep sales	$698,117	$261,700	$173,763	$173,763	$173,763	$173,763
Net goat purchases	$0	$471,291	$4,000	$4,000	$4,000	$4,000
Net goat sales	$0	$133,406	$134,103	$240,522	$240,557	$240,522
Net wool sales	$292,094	$171,686	$147,460	$147,460	$147,460	$147,460

DSE, dry sheep equivalent.

[A]In the herd and economic modelling the standard weight of one DSE = 45 kg; (AE : DSE of 1 : 8.4).

4.3.3 Results and discussion

Table 101 indicates the extra returns generated by transitioning from a self-replacing wool sheep flock to a 50% self-replacing wool sheep flock and a 50% self-replacing meat goat operation. Based on the assumptions made, the transition from a self-replacing wool flock to a 50:50 wool and meat goat operation appears likely to slightly reduce the profitability of the property over the longer term. The key constraints are the capital expenditure associated with the transition and the similar profitability of the goat enterprise and the wool enterprise. The opportunity cost of the extra capital invested in goat infrastructure is greater than the extra return generated by the combined enterprises.

Goats preferentially select a more varied diet with a greater browse component than sheep when grazing the same landscape (Hacker and Alemseged 2014; Pahl 2019b). However, the level of diet cross-over, and the advantages to the total stocking rate applied, are not quantifiable at present for the region. Therefore, we have not incorporated any of this potential benefit in the analysis and maintained a direct swap of goat DSE's for sheep DSE's.

It appears likely that the factors underpinning the market for sheep and goat meat are similar so there would be little benefit from the incorporation of the goat enterprise in smoothing income variability. Incorporating goats into a specialist wool enterprise may actually increase income variability over time, as a larger proportion of property gross income would be dependent upon meat sales.

Table 101 - Returns for moving from a self-replacing Merino wool sheep operation to a 50% wool sheep and 50% self-replacing rangeland meat goat operation

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5%
NPV	-$99,531
Annualised NPV	-$6,569
Peak deficit (with interest)	-$419,531
Year of peak deficit	20
Payback period (years)	n/c
IRR	1.82%

5 General discussion

In this study we have applied scenario analysis to examine a number of alternative livestock enterprises applicable to building more profitable and drought resilient livestock businesses in the rangelands of central-western Queensland. The results of these analyses can be used to support informed decision making by property managers. The information provided here should be used, firstly, as a guide to an appropriate method to assess alternative strategies aimed at improving the profitability and resilience of grazing properties in the rangelands of central-western Queensland and, secondly, to indicate the potential level of response to change revealed by relevant research. Whilst every effort was made to ensure the assumptions used in each scenario were accurate and validated with industry participants, relevant experts or published scientific studies, the results presented should be viewed as indicative only. The production parameters assumed for the base property were intended to represent the long-term average expectation for this region for each enterprise type. However, there is an obvious challenge in adequately accounting for the high annual rainfall variability that occurs in this region. Additionally, there is currently a lack of measured data available to adequately describe managed rangeland goat production systems in this environment, necessitating a reliance on producer experience and expert opinion. Regardless, the example property and base livestock enterprises constructed in this study provide a broad understanding of the opportunities available for improvement, the potential response functions, and an appropriate framework to support decision making.

The major challenges facing livestock property managers in the central-western rangelands of Queensland are associated with the large inter-annual and decadal rainfall variability, and resulting major temporal variability in production and profitability (Nicholls and Wong 1990; Love 2005; O'Reagain and Scanlan 2013; Cobon *et al.* 2019). To remain economically viable, and to build resilience to droughts, floods and market shocks, livestock producers need to increase profit and equity. The key to improving the performance of individual beef, sheep or meat goat properties is the ability of management to recognise relevant opportunities and then being able to assess the trade-offs, responses, costs and benefits likely from the implementation of any opportunity on their property (Stafford Smith and Foran 1988; Foran *et al.* 1990; Stockwell *et al.* 1991). Considering the results of an analysis based on the circumstances of another property or an 'example' property, as used in this study, is a way of understanding the key factors in the decision but rarely an accurate indicator of the likely outcome for an individual property. Managers and their advisors can use the tools and models developed in this study to conduct their own analyses specific to their circumstances.

The broad understanding gained from the property-level, steady-state analyses was that the expected profitability of the discrete livestock enterprise types could be quite different at the same standard of management. (Table 1). Meat sheep and rangeland meat goat enterprises produced the greatest rate of return on total capital (3.85 and 3.74%, respectively) followed by self-replacing wool sheep (3.26%). However, an important assumption for the sheep and goat enterprise analyses was that wild dogs had minimal impact on the sheep or goat production system, i.e., that the property was already protected from wild dogs with suitable fencing. It was also assumed for the goat enterprise that internal fencing was already at a suitable standard to allow effective control of goats under rangeland conditions. Steer finishing, or a self-replacing beef herd, produced intermediate returns (2.76 and 2.41%, respectively) while wether wool production enterprises produced the lowest returns (1.34 and 0.58% for 8-months or 12-month shearing intervals, respectively). The lower wether performance in the steady-state analysis compared to the self-replacing Merino wool flock was largely due to relatively lower meat prices for mutton (cf. excess young female sheep produced by the self-replacing flock) in addition to the trading transaction costs of the wether enterprise.

Operating profit for all enterprises, other than Merino wethers, was most sensitive to the meat price (Table 2). For example, for the self-replacing beef enterprise, a 1% change in meat price had up to four times the impact on profit of any other factor. For the rangeland meat goat enterprise, a 1% change in the price of goat meat had five- or six-times greater effect on the level of farm operating profit than any of the other main parameters. Conversely, the relative unimportance of changes in the weaning rate and the growth rate of livestock on operating profit suggest that implementing high-cost strategies to improve the expected level of these parameters may not be worthwhile. It appears better to focus on low-cost strategies that maintain these two factors, and mortality rates, at their expected levels. This finding is in contrast to the commonly held belief that addressing these production limitations and improving outputs will lead to increased economic performance. For example, there has been considerable recent interest in improving reproductive performance of grazing livestock, in particular in identifying and addressing the causes of foetal and lamb/calf/kid loss, and thereby increasing weaning rates (e.g., McGowan *et al.* 2014; Allworth *et al.* 2017; Robertson *et al.* 2020). However, the assertion made in the present report, that increasing production does not always result in a profitable outcome at the property level, is in accord with the principle that the most profitable level of output is achieved when marginal cost almost equals marginal revenue, but never when production is maximised (Malcolm *et al.* 2005). Furthermore, it should be noted that the percentage changes to operating profit in a sensitivity analysis are ‘costless’. If an investment of either time or capital to change their expected level is required, this would reduce the impact of the level of response, depending upon the investment strategy chosen.

Diversifying sources of income can have the effect of both smoothing income over time and improving average profitability which, consequently, can reduce risks from climate variability and assist with drought preparedness and resilience (Buxton and Stafford Smith 1996; Freebairn 2019). The benefits to the rangelands livestock producer, of diversifying the enterprise mix and income streams on-farm, was highlighted in the sensitivity analyses conducted in this study. The analyses indicated that where the operating profit generated by alternative livestock enterprises is similar, incorporating the capacity of a self-replacing wool sheep flock, to moderate the expected variation in returns due to fluctuations in meat price, could be important. The trend relationship in meat prices for sheep, beef and goat meat, shown by the individual analyses of price over time, suggests that a falling or rising trend in meat prices will be reflected across all meat-based production systems in the rangelands. Therefore, having a component of the overall operating profit derived from wool sales may offset the variation in expected operating profit compared to if all income from the business was derived from meat sales. The sensitivity analyses indicated that even if the property was run solely as a self-replacing Merino wool sheep enterprise, the diversification of income streams, i.e., from meat and wool, could improve the stability of farm profit over time. A similar change in the expected level of price received for wool or sheep meat, or the expected amount of wool cut, had a similar impact on the expected operating profit of the property (Table 2). For example, the implication is that a 20% increase in sheep meat price could offset a 20% decrease in wool price.

The value of changing the enterprise on the property, or changing the enterprise mix, can only be assessed by comparing the expected future performance of the production system that is already in place with the expected future performance of the alternative enterprise or enterprise mix (Malcolm *et al.* 2005). An analysis that looks at alternative futures for the constructed property needs to include the implementation phase and all identifiable impacts on capital expenditure, changes in the amount and timing of costs (including opportunity costs) and income over time. Allowance may also need to be made for the extra management time and effort required by the property owner or manager to operate the changed production system, even though this may not be paid.

In the present study, where the constructed property was (1) operated as a beef property, (2) had some existing infrastructure to manage sheep or goats, but (3) required the construction of an exclusion fence to operate a sheep or goat enterprise, the relative profitability of the property could be improved over the long term with an investment in an exclusion fence and a switch to a meat goat enterprise. The significant constraint on this investment was the level of additional debt required to make the change (-$681,884 peak deficit) and the number of years (12) before the property would be back to the same financial position that it would have maintained without the investment. These aspects make the investment in an exclusion fence quite risky for the property where it is operated solely as a beef production enterprise. The better performance of the investment in the exclusion fence and conversion to a rangeland meat goat enterprise (compared to Merino wool sheep) is heavily dependent upon the assumptions that the capital adjustment to move from beef to goats will be lower than a move from beef to wool sheep and that the relative and absolute price of goat meat will be maintained over the longer term. In this analysis the greater capital adjustments required to convert to sheep (cf. goats) was largely due to the higher value of sheep in addition to an assumption of ca. $100,000 greater capital investment in internal infrastructure.

Our analysis of rangeland goat production systems was intended to reflect the level of performance and profitability possible when goats were managed to prevent overutilisation of the pasture resource, despite the relatively higher reproductive rates (121.5% weaning rate from females mated, in this analysis), and possibly better drought resilience compared to other livestock species due to their more flexible diet and better ability to select for diet quality (Hacker and Alemseged 2014). In our analyses we applied a sufficient standard of management to ensure continuity of sale of goats so as to maintain equivalent grazing pressure on the pasture compared to other livestock enterprises. In the absence of better information to quantify the diet selected by different livestock species under practical grazing situations, we assumed grazing pressure equivalency of cattle, sheep and goat animal units, based on energy requirements (as per McLennan *et al.* (2020)). Hence, our estimate of the number of goats able to run on the constructed property was conservative, given the preferential selection of proportionally more browse, when it is available, in the diet of goats relative to the other species (Hacker and Alemseged 2014; Pahl 2019b).

In this study we did not examine a change from a beef enterprise to a meat sheep enterprise. However, given that the profitability of the constructed meat sheep enterprise was similar to the rangeland meat goat enterprise (3.85 cf. 3.74% rate of return on total capital), and the basic infrastructure required also similar, it could be anticipated that results for a change from beef to meat sheep would be similar to implementing rangeland goats despite the greater capital value of meat sheep. As for a change to rangeland goats, where an exclusion fence is not already in place, any change to meat sheep production would be risky and the capital costs required to make the change likely to present a major impediment.

The relatively poor investment performance in this study of the conversion from a self-replacing Merino wool sheep flock, to a mixture of meat goats and wool sheep, is mainly due to the small difference between the expected returns of the two enterprises. The opportunity cost of the extra capital invested in goat infrastructure was greater than the extra return generated by the combined enterprises. However, this component of the analysis did not account for any potential synergies arising from running goats and sheep on the one property when it comes to either grazing land management or drought.

The importance of incorporating the implementation phase in any analysis of change in the management of grazing properties in northern Australia have been conclusively demonstrated in the studies of Chudleigh *et al*. (2016, 2017, 2019a,b), Bowen and Chudleigh (2018a,b,c, 2021), and Bowen *et al.* (2019a,b, 2020, 2021). These analyses, as well as our current study, have highlighted the importance of appropriately modelling the steps in moving from an existing base property and enterprise to an alternative situation. Additionally, the studies have identified the critical importance of correctly incorporating any change in the timing and/or amount of benefits and costs when implementing alternative strategies. These analyses, like the present study, indicated that capital constraints and perceived risk are likely to play a large role in the level and rate at which a strategy is likely to be adopted and implemented. Applying a method that appropriately highlights the financial risks associated with the implementation of a strategy, as well as the potential economic benefits, is necessary to assist understanding of the nature of the alternative investments. This assertion was also made by Foran *et al.* (1990) who concluded that the 'whole-of-property' approach is essential for both comparing management options and for setting priorities for research and development in the Australian rangelands.

A key insight from our analyses is that the value of any change in management to build resilience depends upon the circumstances of the manager and the property considering the change. It is necessary to apply the right planning framework and to reassess the strategy as change occurs. We suggest that beef, sheep and meat goat production systems which exhibit resilience are predominately those where managers spend considerable time and resources preparing for drought and frequently monitor their pastures, livestock, financial position, markets, options and wellbeing. We propose that having the right production system in place prior to drought is a key factor in surviving drought, as is maintaining a clear framework for the timely assessment of options when responding to, and recovering from, drought.

6 Conclusions

The rangelands of central-western Queensland experience high levels of climate variability and have a history of suffering extended and extensive droughts. Our analysis identified that, at the predicted prices and costs for each livestock enterprise, the self-replacing Merino wool sheep flock was likely to be one of the more profitable and resilient enterprise alternatives. However, key to this result was the assumption that sufficient infrastructure, including an exclusion fence, was already in place to achieve the predicted levels of flock performance. Variation of the key assumptions in the sensitivity analysis revealed that a significant and sustained improvement in the relative beef price would be required before an existing wool sheep producer with a self-replacing flock would be better off changing to beef production. The sensitivity analysis also indicated that an integrated enterprise, that included a significant component of income derived from a self-replacing wool flock enterprise, was likely to be more resilient in terms of maintaining an average level of profit in the face of the expected fluctuations in meat price and wool price. Where full investment in an exclusion fence around the majority of the property was required to facilitate a shift from beef to some form of sheep or goat production, the investment was likely to increase the riskiness of the overall enterprise and thus would be unlikely to be undertaken by many existing beef producers in the region. This was the case even when the long-term profitability and resilience of the property could be substantially improved, e.g., by a change to rangeland meat goats. The lack of reliable data for rangeland meat goat production in this region limits the confidence in conclusions about the role of rangeland goats, long-term. However, maintenance of the demand for goat meat, together with increased knowledge of effective goat management strategies, could see rangeland goats play a very important role in maintaining profitable and resilient production systems in the future. The steady-state analysis indicated that the profitability of the meat sheep enterprise was the greatest of all livestock alternatives for this region. However, as for rangeland meat goats, the lack of published data for production of meat sheep breeds in the central-western rangelands region indicates that caution is required in the extrapolation of these results.

The herd and flock modelling approach applied in this study allowed the integration of alternative livestock enterprises within the one investment model and enabled a whole-of-business analysis of the effect of change on productivity and profitability at the property level. The property-level, regionally-specific herd and business models developed in this project are available to be used by consultants, advisors and producers to assess both strategic and tactical decisions for their own businesses.

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8 Glossary of terms and abbreviations

AE	Adult equivalent. In the Breedcow and Dynama (BCD) software an AE was taken as a non-pregnant, non-lactating beast of average weight 455 kg (1,000 lbs) carried for 12 months (i.e., a linear AE, not adjusted for metabolic weight). An additional allowance of 0.35 AE was made for each breeder that reared a calf. This rating was placed on the calves themselves, effectively from conception to age 5 months, while their mothers were rated entirely on weight. To estimate grazing pressure equivalence between cattle, sheep and goats in our analysis we adopted the approach of McLennan *et al.* (2020) where the energy requirements of a standard animal unit (defined AE or DSE) are assumed to represent equivalent grazing pressure. A ratio of DSE : AE of 8.4 : 1 was adopted.
Amortise	An amortised value is the annuity (series of equal payments) over the next *n* years equal to the Present Value at the chosen relevant compound interest rate.
Break-even	The break-even point is the point at which total cost (including opportunity cost) and total revenue are equal. At the break-even point there is neither profit nor loss.
BCD	Breedcow and Dynama software. A herd budgeting program designed to evaluate the profitability and financial risk of alternative management strategies for extensive beef businesses, at the property level. This software can be downloaded free from https://breedcowdynama.com.au/. In the analyses documented in this report, herd and flock models and analyses have been compiled in a modified version of the Breedcow and Dynama suite of programs to allow comparison of beef, sheep and goat enterprises. Please contact the authors if you would like a copy of any of the files.
Climate normal	Statistics calculated over standard periods of 30 years are called 'climate normals' and are used as reference values for comparative purposes. A 30-year period is considered long enough to include the majority of typical year-to-year variation in the climate but not so long that it is significantly influenced by longer-term climate changes. In Australia, the current reference climate normal is generated over the 30-year period 1 January 1961 to 31 December 1990.
Constant (real) dollar terms	All variables are expressed in terms of the price level of a single given year.
Cumulative cash flow	Cumulative cash flow is the predicted final bank balance of the property at the end of the investment period due to the implementation of the strategy.

Current (nominal) dollar terms	All variables are expressed in terms of the year in which the costs or income occur. The impact of expected inflation is explicitly reflected in the cash flow projections.
DAF	Department of Agriculture and Fisheries, Queensland Government
DCF	Discounted cash flow. This technique is a way of allowing that when money is invested in one use, the chance of spending that money in another use is gone. Discounting means deducting from a project's expected earnings the amount which the investment funds could earn in its most profitable alternative use. Discounting the value of money to be received or spent in the future is a way of adjusting the future net rewards from the investment back to what they would be worth in the hand today.
Depreciation (as applied in estimating operating profit)	A form of overhead cost that allows for the use (fall in value) of assets that have a life of more than one production period. It is an allowance that is deducted from gross revenue each year so that all of the costs of producing an output in that year are set against all of the revenues produced in that year. Depreciation of assets is estimated by valuing them at either current market value or expected replacement value, identifying their salvage value in constant dollar terms and then dividing by the number of years until replacement. The formula used in this analysis is: (replacement cost – salvage value)/number of years until replacement.
Discounting	The process of adjusting expected future costs and benefits to values at a common point in time (typically the present) to account for the time preference of money. With discounting, a stream of funds occurring at different time periods in the future is reduced to a single figure by summing their present value equivalents to arrive at a 'Net Present Value' (NPV). Note that discounting is not carried out to account for inflation. Discounting would still be applicable in periods of nil inflation.
Discount rate	The interest rate used to determine the present rate of a future value by discounting.
DM	Dry matter. DM is determined by oven drying feed or faecal material in an oven until constant weight is reached (i.e., all moisture is removed).
DMD	Dry matter digestibility. DMD is the intake of DM minus the amount in the corresponding faeces, expressed as a proportion of the intake (or as a percentage).
DSE	Dry sheep equivalent. This standard unit represents a 2-year old, 45 kg Merino sheep (wether, or non-lactating, non-pregnant ewe) at maintenance. In the Breedewe and Sheepdyn programs a linear DSE was calculated, i.e., not adjusted for metabolic weight. To estimate grazing pressure equivalence between cattle, sheep and goats in our analysis we adopted the approach of McLennan *et al.* (2020) where the energy requirements of a standard animal unit (defined AE or

	DSE) are assumed to represent equivalent grazing pressure. A ratio of DSE : AE of 8.4 : 1 was adopted.
Economic analysis	Economic analysis usually focusses on profit as the true measure of economic performance or how efficiently resources are applied. The calculation of profit includes non-cash items like opportunity costs, unpaid labour, depreciation and change in the value of livestock or crop inventory. NPV and amortised NPV are both measures of profit.
Equity capital	The value of the owner's capital. This is equal to total capital minus total liabilities.
Financial analysis	Financial analysis focusses on cash flow and the determination of whether all business and family cash costs can be met. Financial analysis can also include analysis of debt servicing capacity.
Fixed (or overhead) costs	Defined as costs which are not affected by the scale of the activities in the farm business. They must be met in the operation of the farm. Examples include: wages and employee on-costs, repairs, insurance, shire rates and land taxes, depreciation of plant and improvements, consultant's fees and the operators allowance for labour and management. Some fixed costs (such as depreciation or operator's allowance) are not cash costs. It is usual to count the smaller amounts of interest on a typical overdraft or short-term working capital as an operating expense (fixed cost) and deducted in the calculation of operating profit. The returns to lenders of fixed capital (interest, rent, lease payments) are deducted in the calculation of net profit.
GRASP	A dynamic, point-based biophysical pasture-animal growth model developed for northern Australia and rangeland pastures. The model simulates soil moisture, pasture growth and animal production from daily inputs of rainfall, temperature, humidity, pan-evaporation and solar radiation.
Gross margin	The gross income received from an activity less the variable costs incurred. Gross margins are only the first step in determining the effect of a management decision on farm or business profitability. To determine the value of a potential strategy to the whole farm or business, a more complete economic analysis is required in the form of a marginal analysis that considers the effect of alternative strategies at the property or business level.
IRR	Internal rate of return. This is the discount rate at which the present value of income from a project equals the present value of total expenditure (capital and annual costs) on the project, i.e. the break-even discount rate. This indicates the maximum interest that a project can pay for the resources used if the project is to recover its investment expenses and still just break even. *IRR can be expressed as either the **return on the total investment** or the **return on the extra capital***

Land condition	The capacity of the land to produce useful forage, arbitrarily assessed as one of four broad categories: A, B, C or D, with A being the best condition rating. Three components are assessed: 1) soil and 2) pasture condition, and 3) extent of woodland thickening/tree basal area or other weed encroachment.
Marginal	Extra or added return. Principle of marginality emphasises the importance of evaluating the changes for extra effects, not the average level of performance.
ME	Metabolisable energy. The energy from a feed source remaining for use by a ruminant after losses in faeces, urine and methane gas are subtracted.
MLA	Meat and Livestock Australia. MLA delivers research, development and marketing services to Australia's cattle, sheep and goat producers. MLA is funded by industry levies.
n/a	Not applicable or not able to be calculated
n/c	Not able to be calculated
Net profit	This is the reward to the farmers own capital. Net profit equals operating profit less the returns to outside capital. The returns to lenders of fixed capital (interest, rent, leases) are deducted from operating profit in the calculation of net profit. It is available to the owner of the business to pay taxes or to provide living expenses (consumption) or it can be used to reduce debt. Net profit minus income tax minus personal consumption (above operator's allowance if it has already been deducted from operating profit) = change in equity
NLIS	National livestock identification system. Australia's tagging system for identification and traceability of cattle, sheep and goats.
NPV	Net present value. Refers to the net returns (income minus costs) over the life of an investment, expressed in present day terms. A discounted cash-flow allows future cash-flows (costs and income) to be discounted back to a NPV so that investments over varying time periods can be compared. The investment with the highest NPV is usually preferred. NPV was calculated at a 5% rate of return which was taken as the real opportunity cost of funds to the producer. NPV can be expressed as the total business returns or as the marginal returns. Marginal NPV is the extra return received as a result of the investment. Annualised NPV converts the NPV to an amortised, annual value. *The **annualised NPV** can be considered as an approximation of the **average annual change in profit over 30 years**, resulting from the management strategy.*
NRM region	Natural Resource Management region. NRM regions across Australia are based on catchments or bioregions. The boundaries of NRM regions are managed by the Australian Government and used for statistical

	reporting and allocation and reporting of environmental investment programs.
Operator’s allowance	An allowance for the owner’s labour and management; it can be estimated by reference to what professional farm managers/overseers are paid. Although it is often not paid in the farm accounts, it is an input required to generate the operating profit and must be deducted if a true estimate of operating profit and the return to the total capital in the business/property is to be calculated. It is generally not equal to the irregular wages paid to or drawings made by the owners. If some wages have been paid to the owners in the farm accounts and they are already included in the calculation of fixed costs, then the only difference between the wages paid and the true opportunity cost of their labour and management will need to be allowed for when calculating operating profit.
Operating profit	This is the return to total capital invested after the variable and overhead (fixed) costs involved in earning the revenue have been deducted. Operating profit represents the reward to all of the owners of the capital tied up in the enterprise. Operating profit equals (total receipts minus variable costs equals’ total gross margin) minus overheads. When operating profit is expressed as a percentage return to total capital it indicates the efficiency of the use of all of the capital invested in the farm enterprise.
Opportunity cost	The benefit foregone by using a scarce resource for one purpose instead of its next best alternative use.
OTH	Over-the-hooks. Where cattle are sold direct to the processing plant (abattoir) and the producer is paid on a price grid. The weight of the processed carcass along with the carcass grade is used to determine price. Over-the-hook indicators reported by Meat and Livestock Australia (MLA) are calculated as a weighted average of northern processor grids. North Queensland is defined by MLA for these indicators as north of, and including Rockhampton.
Pasture condition	Pasture condition is one of three components of land condition. In the pasture growth model GRASP percent perennial grass is used as an indicator of pasture condition and varies between a maximum of 90% and a minimum of 1%. Changes to simulated percent perennial grass are a function of utilisation of pasture growth and are calculated once a year.
Pasture utilisation	The proportion of pasture consumed by grazing livestock. The utilisation can be expressed as a proportion of annual pasture biomass growth or of total standing dry matter (TSDM). In the pasture growth model GRASP changes in pasture condition are a function of the utilisation of simulated annual pasture growth. In this study, the utilisation of simulated total standing dry matter (TSDM) at May 1 was used to set stocking rates.

Payback period	The number of years it takes the cumulative present value to become positive. Other things being equal, the shorter the payback period, the more appealing the investment.
Peak deficit	This is an estimate of the peak deficit in cash flow caused by the implementation of the management strategy. It assumes interest is paid on the deficit and is compounded for each additional year that the deficit continues into the investment period. It is a rough estimate of the impact of the investment on the overdraft if funds for the development are not borrowed but sourced from the cash flow of the business.
PTE	Pregnancy tested empty (not pregnant)
Rate of return on total capital	An estimate of how profitable a business is relative to its total capital. It is the operating profit expressed as a percentage of the average of the total capital employed for the period under review (usually a year).
Safe carrying capacity	A safe carrying capacity for a property is defined as a strategic, i.e., long-term (e.g., 20-30 years) estimate of livestock numbers that can be carried without any decrease in pasture condition and without accelerated soil erosion.
Safe stocking rate	A safe stocking rate is a short-term, tactical (seasonal or annual) stocking rate based on seasonal forage budgeting principles and safe utilisation rates of pasture. A safe stocking rate may be higher or lower than the long-term safe carrying capacity due to seasonal variability in rainfall.
TSDM	Total standing dry matter. This refers to the pasture presentation yield (on a dry matter basis) measured at a point in time in the paddock and is the net result of pasture growth, death, detachment, consumption and trampling. In this study, a specified proportion of GRASP-simulated TSDM at 1 May was used to set stocking rates.
Variable costs	These costs change according to the size of an activity. The essential characteristic of a variable cost is that it changes proportionately to changes in business size (or to change in components of the business).
Year of peak deficit	The year in which the peak deficit is expected to occur.

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10 Appendix 1. Breedcow and Dynama software

The Breedcow and Dynama herd budgeting software (BCD) was developed for cattle herds. For the current analyses, we developed similar models, to those in the BCD software, to assess alternative livestock enterprises including self-replacing wool sheep flocks, wool producing flocks based on wether trading, meat sheep, and rangeland goats for meat production. Using these spreadsheets tools beef, sheep and goat enterprises can be modelled individually or as components of a mixed rangelands enterprise. The BCD software is described below but the same principles were applied in the models developed for alternative livestock enterprises. The software is described in more detail in Holmes *et al.* (2017).

10.1 Brief description of the Breedcow and Dynama software

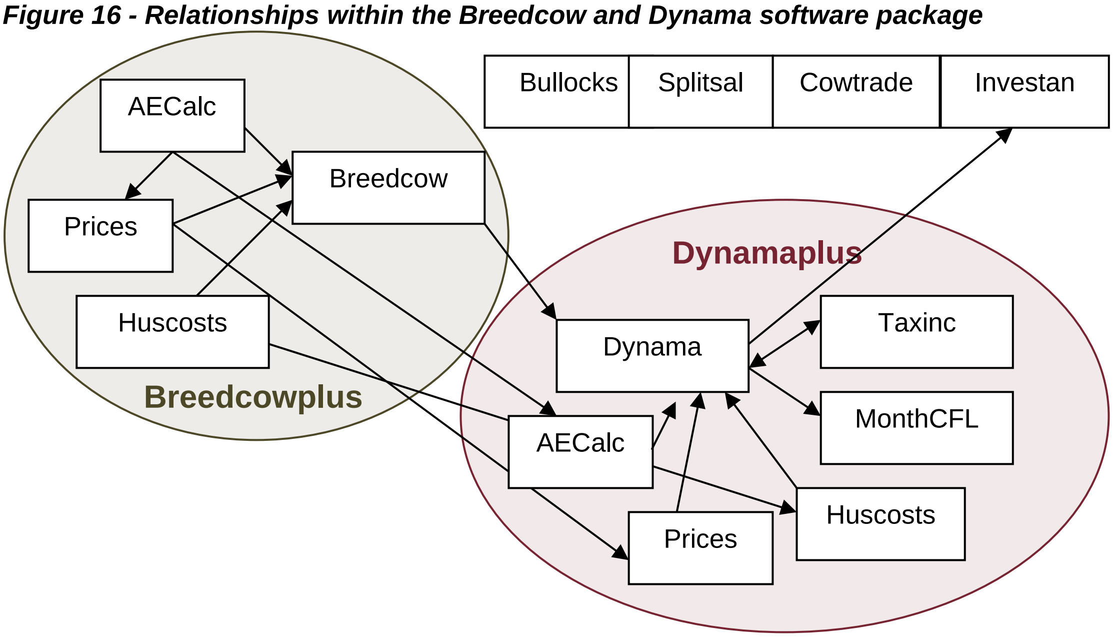
The BCD package of software programs is used to assess choices for the management of beef cattle herds run under extensive conditions. **It is not an accounting package or a paddock records package and does not record individual animals**. It presents budgeting processes, adapted to the special needs of extensive beef producers.

Breedcow and Dynama programs are based on four budgeting processes:

1. Comparing the likely profitability of the herd under different management or turnoff systems (Breedcowplus program);
2. Making forward projections of stock numbers, sales, cash flow, net income, debt and net worth (Dynamaplus program);
3. Deciding what to sell when the plan goes sour or what to buy when there is an opportunity. (Bullocks and Cowtrade programs); and
4. Evaluating investments in herd or property improvement to determine the rate of return on extra capital, the number of years to breakeven and the peak debt (Investan program).

In short, Breedcowplus is a steady-state herd model that generates its own structure around a starting number of weaner heifers retained and Dynamaplus program is a 10-year herd budgeting program that usually starts with the current herd numbers and structure. The term ‘herd budgeting’ is used to emphasise the central role of herd dynamics in cattle enterprise budgeting. Figure 16 indicates the relationships between the individual components of the BCD software package. A menu system within Dynamaplus enables data from Breedcowplus to be imported. The flow of data is indicated by the arrows shown in Figure 16.

Figure 16 - Relationships within the Breedcow and Dynama software package



10.2 Summary of the components of the Breedcow and Dynama software

The package currently comprises six separate programs: Breedcowplus, Dynamaplus, Investan, Cowtrade, Bullocks and Splitsal.

10.2.1 Breedcowplus

The Breedcowplus program can quickly determine the best strategies for a beef breeding herd run under extensive conditions. It is a steady-state herd model that generates its own structure around a starting number of weaner heifers retained. The overall herd size is adjusted by altering the starting number of weaner heifers and the final herd structure depends on the weaning and death rates chosen and the sales from each age group.

Breedcowplus is used to test the most profitable turnoff age for male cattle, the most profitable balance between heifer culling rate and the sale of mature cows and the comparative profitability of new cattle husbandry or pasture management practices. The outputs of the Breedcowplus program are herd structure, herd value, turnoff, and gross margins.

The Breedcowplus program contains Prices, AECalc, Huscosts and Breedcow as separate worksheets that can be used to record the detail of how sale prices, husbandry costs or adult equivalents have been calculated.

- The **AECalc** sheet records the weights and expected weight gain of each livestock class in the breeding herd and calculates AE from this data. Adult equivalent ratings are used when comparing herds of differing composition to ensure that ratios such as gross margins (per adult equivalents) are based on the use of the same amount of (forage) resource.
- The **Prices** sheet calculates net cattle selling prices from estimates of sale weight, price per kilogram, selling costs (as percentage of value or per head) and freight costs per head. The

program also includes a transport cost calculator to help in the estimation of transport costs to alternative destinations.

- The **Huscosts** sheet has a similar role to the Prices sheet in that it can be used to store the detail of assumptions made concerning the treatment and other costs incurred by the various classes of livestock included in the model.
- The **Breedcow** sheet collects the various inputs from the AECalc, Prices and Huscosts sheets then allows users to complete the herd model by adding information about breeder performance, losses, total adult equivalents and the variable costs incurred by the management strategy under consideration. Once all of the variables have been entered a herd structure, turnoff and gross margin are produced.

10.2.2 Dynamaplus

The Dynamaplus program is a 10-year herd budgeting program that usually starts with the current herd numbers and structure. It has a structure similar to the Breedcowplus program with individual worksheets for the calculation of AE, prices and husbandry costs. It also has additional worksheets that provide a detailed analysis of the expected monthly cash flow for the herd (MonthCFL) and the approximate taxable income generated by the herd over time (Taxinc).

Dynamaplus is used exclusively once planning moves out of ‘policy’ and into the real world. The core use for Dynamaplus is cash flow budgeting starting with the existing herd structure. The composition of most herds usually is to some extent out of balance from the last drought or some other recent disturbance. The budgeting process may be a tug-of-war between trying to get the herd restabilised and meeting loan service commitments.

- The **AECalc and Prices** sheets are as previously described for the Breedcowplus program except that they can now have up to 10 years of data entered in each worksheet.
- The **Huscosts** sheet stores the annual average variable costs of the beef enterprise by classes of livestock.
- The **Dynama** sheet projects carryover cattle numbers for each year based on starting numbers, expected weaning rates, death rates and sales. It tracks herd structure and growth, cash flow, debt, net income and net worth for up to 10 years.
- The **MonthCFL** sheet produces monthly cash flow summaries and calculates closing overdraft balances for each month. This also enables a more accurate estimate of overdraft interest than that calculated in the Dynamaplus program.
- The **Taxinc** sheet uses herd data from the Dynama worksheet to calculate livestock trading accounts, plus other information to produce approximations of taxable income.

10.2.3 Investan

Investan is an investment analysis program that compares scenarios developed in the Dynamaplus program starting with the same herd and asset structure, but with one Dynamaplus scenario involving additional investment or income sacrifice to implement a program of change. Investan calculates the NPV and IRR for the ‘change’ option relative to ‘without change’ or ‘business as usual’. Investan compares Dynamaplus scenarios showing year by year differences in cash flow and the end-of-budget difference in non-cash assets. Investan calculates NPV, IRR and the annualised return on these differences and calculates peak deficit and displays the year in which it occurs.

10.2.4 Cowtrade, Bullocks and Splitsal

Cowtrade, Bullocks and Splitsal are separate programs to Breedcowplus and Dynamaplus and have no direct linkages to other programs.

The Cowtrade program is used when seasons and prices are out of line with long-term expectations. It can be used to set sales priorities when drought or financial crisis requires abnormal sales. Cowtrade can also be used to assess breeder purchase options. The Bullocks program focuses on selecting the most profitable turnover cattle, but it may be also used to evaluate forced sales options or whether to keep the slow steers until they finish or sell them early. Cowtrade and Bullocks are used independently of the other programs and cover a budgeting need not met by the other programs - namely comparing selling and buying options to minimise the financial damage from forced sales, maximise the profit from trading or make better decisions on restocking.

Splitsal is a program to provide estimates of numbers (and average weights) above and below a certain cut-off weight, when mob average weight and range of weights are known. This can be used for male turnoff over two seasons or for estimating numbers and weights from the tail or lead of a group of heifers or steers.

11 Appendix 2. Discounting and investment analysis

In undertaking investment analysis, it is necessary to make predictions of cash inflows and outflows for a future time period. A key feature of investment analysis is the process of discounting these future cash flows to present values. Discounting is used to evaluate the profitability of an investment whose life extends over a number of years. Discounting is also used when selecting among investments with differing lives and cash flow patterns.

11.1 The need to discount

Investors generally prefer to receive a given amount of money now rather than receiving the same amount in the future. This is because money has an opportunity cost. For example, if asked an amount of money they would just prefer to receive in 12 months' time in preference to $100 now, most people would nominate a figure around the $110 mark (certainly more than $100!). In other words, money has an opportunity cost of around 10% to the general population. At an opportunity cost of 10%, an amount of $100 now has a future value of $110 in 12 months' time ($100 x 1.1). It would have a future value of $121 in two years' time (i.e. $100 x 1.1 x 1.1). For similar reasons, society puts an opportunity cost on funds employed in public sector development projects making discounting equally important in the allocation of public funds.

Because of the time preference for money (opportunity cost), it is difficult to compare money values received at different points of time. To compare and aggregate money values over time, it is first necessary to discount them to their 'present value' equivalents. Thus, $121 in two years' time has a present value of $100 at an opportunity cost (discount rate) of 10%.

The general formula for discounting a future amount to its present value is:

$$\text{present value} = A / (1+i)n$$

and where A = future amount; i = discount rate; n = number of periods in the future

The stream of funds occurring at different time periods in the future is then reduced to a single figure by summing their present value equivalents.

It is important to recognise that discounting is not carried out to account for inflation. Discounting would still be applicable in periods of nil inflation. It is common, however, to remove the inflation component from discount rates when undertaking investment analyses. Nominal interest rates are those quoted on cash investments. Real discount rates have the inflation component removed from this nominal rate. It is necessary in investment analysis using real discount rates that future cash inflows and outflows are expressed in real (constant) terms i.e., they should not include an allowance for inflation. If, alternatively, cash inflows and outflows are expressed in current (nominal) dollar terms a nominal (inflation included) discount rate should be used.

11.2 Profitability measures

Three profitability criteria can be calculated. They are:

- Net present value (NPV) - the stream of future cash flows is reduced to a single figure. The NPV is the difference between the present value (PV) of the investment inflows and the PV of the investment outflows. An investment is acceptable if the NPV is positive.
- Benefit-cost ratio (B/C ratio) - the PV of the investment inflows divided by the PV of the investment outflows. An investment B/C ratio greater than one is required.

- The internal rate of return (IRR) - the discount rate at which the PV of inflows equals the PV of outflows. It is internal because it is calculated independently of the cost of borrowed funds. It represents the maximum rate of interest that could be paid if all funds for the investment were borrowed and the investment was to break even.

The three decision criteria are interrelated. For example, Table 102 presents an example of the range of values expected for each profitability criteria at a discount rate of 8%.

Table 102 - Relationship between profitability measures at a discount rate of 8%

Factor	Relative value		
NPV	Negative	Zero	Positive
IRR	< 8%	8%	>8%
B/C ratio	Less than 1	1	Greater than 1

The criterion of choice in investment analysis is the NPV or IRR although NPV is usually the preferred measure. The NPV for individual investments can be converted to an annuity and presented as the 'net annual economic benefit generated during the next x years. The IRR is useful in comparing the likely returns of alternative investments. The B/C ratio, i.e., benefits in relation to costs, is generally less used in investment analysis but is widely used in processes like benefit costs analysis (BCA). A calculated B/C ratio of greater than one indicates a profitable investment.

Having a consistent time horizon is one of the essential requirements for comparing or ranking investments by NPV and IRR. The other requirements for consistent ranking are that the options are not mutually exclusive and have the same investment outlay.

Discounted cash flow analyses do not include allowances for opportunity costs of capital. These opportunity or imputed costs are commonly applied to average results (e.g., average gross margin, average net profit) to give a rough indication of whether the average is able to cover those unpaid costs. However, the calculus of the discounting procedure that is used to calculate NPV and IRR is based on assessing whether the flow of net returns over the time horizon is adequate to cover the capital outlays that are involved. For example, if the calculated NPV is positive at a discount rate that reflects the cost of capital then it indicates that the capital has been recovered. Including allowances for opportunity interest on capital (e.g., livestock) in the annual cost calculations of a multi-year cash flow analysis represents a case of double-counting.

NPV estimates, applied in the context of comparing alternative beef production systems on the same property, carry two separate opportunity cost components, one of which might not be appreciated. The first component is that adopting the structural changes under a given scenario necessarily foregoes the opportunity to capture the baseline productivity and profitability (hence the use of the 'marginal' terminology and approach). The second component is the assumption that the net outcome of the change above the baseline performance can out-yield the opportunity foregone of either not investing the capital outlays in some alternative investment or borrowing the funds at a particular rate – the discount rate. The procedure also assumes that the net annual returns are being reinvested each year from when they occur at this opportunity return (discount) rate. The IRR is a manipulation of the NPV formula which drives the NPV to zero implying that the present value of the cumulative gain from a scenario over the first opportunity cost (baseline performance) is of no additional value above the present value of the second opportunity cost (return on equivalent outlays that are invested at the discount rate). The calculated IRR also assumes that the annual cash flows are continuously reinvested at that rate (which is rarely the case).

So, when the impact of a particular scenario is described along the lines of 'the profitability of the beef system was substantially improved compared the baseline with additional returns of $X and Y%' (i.e. large positive NPV value, IRR well in excess of the assumed discount rate) it is correct that the investment in the scenario option ticks the criteria check boxes (NPV > 0, IRR > discount rate); this is an economically sound investment. However, it may not be well understood that this economic construct is not the actual gain in profit above the baseline that would be obtained, but represents the value of a lesser sum that is above the baseline but minus the opportunity cost of the discount rate earning alternative investment.

In the context of a multi-period investment analysis, it can be difficult for those not conversant with economic methodology to appreciate what a single absolute NPV value might mean in terms of the average annual performance of that investment. The 'annualised NPV' procedure that has been adopted in our report is intended to address that issue, by calculating a series of equal annual values for which the present value of their sum is equivalent to the single NPV estimate for the whole period. However, these amortised values do not really measure the average annual profit advantage of the investment; they are an indication.

11.3 'With' and 'without' scenarios

There are two critical questions that must be considered in any investment analysis:

1. What is likely to happen with the change? (Or for ex post analyses - what happened with the change?)
2. What is likely to happen without the change? (Or for ex post analyses - what happened without the change?). This is also known as the 'counterfactual' or 'baseline scenario' and often is represented by an enterprise or investment structure that is currently in place.

Since the 'with' change scenario is hypothetical by definition, specifying it is necessarily subjective, and consequently more problematic than the 'without' change scenario. It should be inferred from the best available information, and the necessarily subjective underlying assumptions made explicit. The specification of a counterfactual or baseline scenario is a key part of any impact analysis. Use of the 'with' and 'without' principle forces formal consideration of the net impact of the investment.

11.4 Compounding and discounting

Future costs and benefits can be valued in real (constant) or nominal (current) prices. In the real terms approach, all variables are expressed in terms of the price level of a single given year. While any year may be used, the present year will usually carry most meaning as a base. Note that if an entire analysis is conducted in the prices of the year in which the analysis takes place, it is being carried out in real terms. The method assumes that the current relationship between costs and prices will be maintained for the period of the analysis. If there are good reasons for thinking that particular cost or benefit streams will not follow general price movements, those changes in relative prices should be built into the analysis. If land rents, for example, in the context of a property evaluation, are expected to exceed the rate of inflation by 2%/annum for the next three years, the analysis should include this parameter. Assumptions regarding expected relative price changes should be made explicit.

In the nominal price approach, the impact of expected inflation is explicitly reflected in the cash flow projections. As in the real price case, different inflation rates can be applied, if necessary, to different cost and benefit streams. Because of the demanding nature of the data requirements under this approach (inflation rates need to be estimated for the entire project period), the approach is not generally used.

As already noted, when using constant values, it is usual to accept the prices of the first year of the project. However, when the cost-benefit analysis is undertaken as part of an ex post evaluation, the convention is to use the prices of the final year of the project.

The Australian Bureau of Statistics publishes numerous implicit price deflators (IPDs) which may be used to convert nominal net benefits to real net benefits (see Australian National Accounts – National Income and Expenditure, annual, ABS Catalogue No. 5204.0). However, unless a specific IPD seems applicable, a general deflator such as the Gross Non-Farm Product IPD may appropriately be used.

It is important that real prices and nominal prices are not confused in the analysis. In particular, when the analysis is presented in nominal prices, the discount rate should be adjusted for inflation. This captures the point that investors require compensation for anticipated inflation as part of the price of making funds available. With annual compounding, the formula for converting a real discount (r) into a nominal one (n) is:

$$n = (1 + r)\,(1 + \text{inflation rate}) - 1.$$

Thus, with a real discount rate of say 6%, and an expected annual rate of price inflation of 3%, the correct nominal discount rate is 9.2%. Note that the ‘intuitive’ alternative of summing the real discount rate and the inflation rate (to give 9%), slightly underestimates the correct value.

Conversely, to convert nominal discount rates into real discount rates, the equation is:

$$r = (1 + n) / (1 + \text{inflation rate}) - 1$$

Thus, if the nominal discount rate is 9% and the expected inflation rate is 3%, the corresponding real discount rate is 5.8%. Note here that an intuitive ‘subtraction’ approach overestimates the correct value.

For most investment analyses, all benefits and costs should be expressed in constant dollar terms and discounted or compounded by the discount rate to the current year.