Northern Downs beef production systems

Preparing for, responding to, and recovering from drought

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Summary

This report details the analysis of the economic implications of management decisions to prepare for drought in the Northern Downs region of 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, herd management and business practices necessary to manage seasonal variability. The property-level, regionally-specific herd and business models which 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 examine a range of management strategies and technologies that may contribute to building more profitable and drought resilient beef properties in the Northern Downs region. In doing this, we developed property-level, regionally-specific herd and business models for a constructed, example beef cattle property based on relevant herd data from industry surveys and research. The constructed, base property was 16,000 ha of predominately Mitchell grass pastures on representative land types and carried ca. 2,000 adult equivalents (AE). The management features of the self-replacing breeding herd included controlled mating with two weaning rounds. Over the 30-year analysis period the average mortality rate of the base herd was 2% and the average weaning rate from all cows mated was 65%. The average annual post-weaning weight gain for steers was ca. 140 kg/head. The starting herd size, herd performance and approach to pasture management was assumed to represent the current status of local properties that have adopted a sustainable approach to pasture management. These average performance values need to be considered in the context of the very high annual variability in rainfall, liveweight gain and stocking rate for this region which may result in different average performance over a future sequence of years than the averages chosen in our analysis.

Management strategies or technologies that can be applied to improve the profitability and resilience of a beef property to drought are generally of a strategic nature. The Breedcow and Dynama herd budgeting software was used to develop integrated herd models and discounted cash flow budgets for each alternative management strategy. The economic and financial effect of implementing each strategy was assessed by comparison to a base production system for the constructed property. Property-level productivity and profitability was assessed over a 30-year investment period and incorporated the change in profit and risk generated by alternative operating systems, the changes in unpaid labour, herd structure and capital, and included the implementation phase.

Management decisions considered in response to, or recovery from, drought need consideration of both short term and long term implications. These were examined in our previous analyses for the Fitzroy, Northern Gulf and Central West Mitchell Grasslands regions and those reports contain detailed examples of drought response and recovery analysis (Bowen and Chudleigh 2018b, Bowen *et al.* 2019a,b). We have not repeated this exercise for the Northern Downs region 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.

Preparing for drought by improving profit and resilience

The major challenges facing beef producers in the Northern Downs 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, beef 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 summary of the analysis of management strategies for their ability to improve profitability and resilience, and hence prepare for drought, is given in Table 1. The table shows the net difference in returns between the constructed, base property and the same property after investing in the specified management strategy. The results are a guide to possible strategies that may build profit and resilience prior to drought. It is important to note that a negative net present value (NPV) does not necessarily indicate that a property implementing such a strategy is unprofitable, just that the strategy causes the property to be less profitable than the base scenario.

A key insight gained from the analysis is that appropriately managed beef cattle properties in this region (as modelled for the constructed, base property) have been historically profitable, with that profit applied over time to build resilience to manage the inherent variability of the region. The recent, and apparently ongoing, escalation in capital values, combined with the decoupling of asset values and rates of return on investment, suggests that building resilience in the future through an increase in the size of holdings within the region may be more risky than it has been in the past. For the same reason, both of the scenarios that looked at property purchase outside of the region were shown to be inherently risky and unlikely to be the best investment available.

However, many existing businesses operate a breeding property in the Northern Gulf region in association with a growing property located in the more productive Northern Downs region. The Northern Gulf property commonly turns off weaner steers to the Northern Downs property for growing out to market weights. At the long term average prices applied in this analysis, it was found to be most profitable to operate the properties as separate entities, turning off steers at the optimal age for each region (i.e. live export steers from the Northern Gulf property and feed-on steers from the Northern Downs property). All strategies for operating the properties as integrated breeding and growing operations, with transfer of steers from the Northern Gulf property to the Northern Downs property, either did not improve or reduced the expected total business profit generated by operating the properties as separate entities.

The remaining options considered to improve the efficiency of the constructed Northern Downs property showed that selecting an appropriate market (age of turnoff) for steers and deciding on the balance between the relative size of a breeder herd and a more flexible steer growing or turnover operation were key strategies for further analysis. This balance underpins the capacity of the property to appropriately respond to the unpredictable feed supply typical of the production system. The analysis showed that moving to a steer turnover operation was more profitable than a combination breeding and steer growing operation (by $62,500/annum). Furthermore, a steer turnover operation lends itself to more timely destocking during dry periods. However, it is impossible to prescribe what a suitable balance might be between a breeding component and a steer growing/turnover component for any individual property as this is principally dependent by 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.

Strategies that involved improving the nutritional status of cattle by providing energy and protein supplements to steers or breeders always reduced profitability and resilience of the property despite improving steer growth rates or breeder reproduction performance. Other strategies that improved breeder herd efficiency, such as genetic improvement of weaning rate or reducing foetal/calf loss (should an effective technology or management strategy be identified), had relatively minor effects on business profitability. The lack of capacity to identify alternative investments that improve breeder herd efficiency highlights the critical importance of implementing low cost strategies to get body condition and herd structure right as key factors in being drought prepared.

The exotic woody weed, prickly acacia (*Acacia nilotica*), is spread over millions of hectares of Mitchell grasslands in the central west and north west of Queensland, including the Northern Downs region. It is having an ongoing negative effect on livestock carrying capacity and the associated productivity of affected properties. The analysis conducted to examine the returns for investment in property-level control, where 80% of the property had infestation levels ranging from low to high, indicated positive returns of 8-13% IRR which were negatively related to number of years prior to the onset of wet years capable of causing prickly acacia spread. However, the requirement for >$1.3 million to be invested over the first 4 years of treatment is unlikely to enable many managers to adopt property-level control if it were to be self-funded. The alternative approach of targeting a set amount of capital ($10,000 in this example) in Year 1 to prickly acacia control with ongoing maintenance over 30 years, also showed positive returns of 6-20% IRR, dependent on level of infestation and the number of years prior to the onset of wet years. This analysis indicated that it is most economically efficient to treat and maintain areas with minimal infestation first, moving on to the increasingly higher levels of infestation as funds allow. The critical criteria would be that 1) each treated area needs to be effectively maintained with follow-up treatment, and 2) re-infestation from the more heavily infested paddocks on the property must be strictly prevented.

The challenges for the management team in maintaining control in the face of considerable production uncertainty and volatility was highlighted by the collective analyses detailed in this report. The central understanding gained was that the capacity of the management team to deal with variability is key and that the application of a logical, rational framework is critical to evidence-based decision making.

Table 1 – Profitability and financial risk of implementing alternative strategies to improve profitability and drought resilience of a constructed, example beef property in the Northern Downs region

The analysis was conducted for a 30-year investment period using current input costs and average cattle prices over the period July 2008-June 2019

Scenario	Annualised NPV[A]	Peak deficit (with interest)[B]	Year of peak deficit	Payback period (years)[C]	IRR (%)[D]
Increasing age of steer turnoff from weaners to 31 mths[E] (p. 43)	$71,100	-$122,100	2	2	n/c
Optimising cow and heifer culling age (p. 47)	$200[F]	n/a	n/a	n/a	n/a
Hormonal growth promotant for steers (p. 49)					
Same price, heavier weight	$9,500	-$12,700	2	3	67%
10 c/kg penalty, heavier weight	-$5,200	-$223,300	never	never	n/c
Molasses production mix for steer tail (p. 52)	-$5,100[F]	n/a	n/a	n/a	n/a
First mating heifers as yearlings (p. 58)	$8,700	-$23,900	10	13	n/c
Supplementing first calf, yearling heifers to improve re-conception rates[G] (p. 63)	-$11,100	-$479,500	never	never	n/c
Genetic improvement of weaning rate[G] (p. 67)					
Immediate changeover of bulls	-$1,800	-$136,600	6	never	1%
Gradual changeover of herd bulls	$1,800	$0	6	7	28%
Home-bred bulls (p. 71)	$10,000	-$17,300	2	3	53%
Reducing foetal/calf loss by 50% by spending (p. 72)					
$5/breeder	$4,800	-$7,100	1	1	102%
$7.50/breeder	$1,300	-$10,600	1	4	25%
$10/breeder	-$2,200	-$96,200	never	never	n/c
$50,000 capital	$8,700	-$50,000	1	7	26%
$75,000 capital	$7,200	-$75,000	1	7	17%
$100,000 capital	$5,600	-$100,000	1	13	12%
Converting from breeding to steer turnover (p. 76)	$62,500	-$576,700	2	9	18%
Purchasing a N Gulf breeder property (p. 80)					
As a calf factory	-$275,700	-$14,658,000	never	never	-0.40%
Run separately	-$254,400	-$13,716,600	never	never	-0.06%
Run separately (last 5 yrs prices maintained)	-$220,000	-$12,491,100	never	never	0.61%
Purchasing a steer growing and finishing property in the Dawson Callide (p. 84)					
Run separately	-$117,900	-$7,403,400	never	never	1.40%
Run separately (last 5 yrs prices maintained)	-$28,400	-$4,375,400	never	never	4.06%
Transferring steers to the N Downs property from a N Gulf property in the same business[H] (p. 87)					
Transfer weaners, hold 24 mths	-$900[I]	n/a	n/a	n/a	n/a
Transfer 18 mths, hold 12 mths	-$52,600[I]	n/a	n/a	n/a	n/a
Transfer 18 mths, hold 24 mths	-$6,800[I]	n/a	n/a	n/a	n/a
Transfer 30 mths, hold 12 mths	-$300[I]	n/a	n/a	n/a	n/a
Managing prickly acacia, property level (p. 98)					
5 years to wet years	$129,300	-$1,328,300	4	13	13%
10 years to wet years	$92,000	-$1,328,300	4	17	11%
20 years to wet years	$44,600	-$1,328,300	4	n/c	8%

Scenario	Annualised NPV[A]	Peak deficit (with interest)[B]	Year of peak deficit	Payback period (years)[C]	IRR (%)[D]
Managing prickly acacia, investment of $10,000 in Year 1 plus maintenance (p. 98)					
High density infestation (treat 40 ha)	$1,900	-$16,000	5	25	6%
Moderate density (treat 100 ha)					
5 years to wet years	$25,500	-$13,100	3	11	16%
10 years to wet years	$20,800	-$13,100	3	13	14%
20 years to wet years	$14,300	-$13,100	3	14	12%
Low density (treat 200 ha)					
5 years to wet years	$50,600	-$13,600	3	10	20%
10 years to wet years	$36,600	-$13,600	3	13	16%
20 years to wet years	$19,100	-$13,600	3	15	12%
Minimal density (treat 4,000 ha)					
5 years to wet years	$130,100	-$34,700	8	12	18%
10 years to wet years	$103,700	-$39,400	8	15	16%
20 years to wet years	$63,100	-$39,400	8	17	13%

mths, months; n/c, not calculable; n/a, not applicable; N Gulf, Northern Gulf of Queensland; yrs, years.

[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.

[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. n/c indicates that the IRR model was unable to identify a value.

[E]The base herd for this comparison was turning off weaner steers. For all other scenarios the base herd was turning off 31-month old steers.

[F]Annual gross margin difference only, not an NPV value.

[G]The base herd in these two scenarios was a herd with heifers first mated as yearlings. For all other scenarios, the base herd was one with heifers first mated at 2 years of age.

[H]The comparison was to a base where both the Northern Gulf and the Northern Downs properties were run separately with the representative age of turn-off for the base properties (sale of two cohorts at 29 and 41 months for Northern Gulf, and 31 months for Northern Downs).

[I]Annual operating profit difference only, not an NPV value.

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1 General introduction

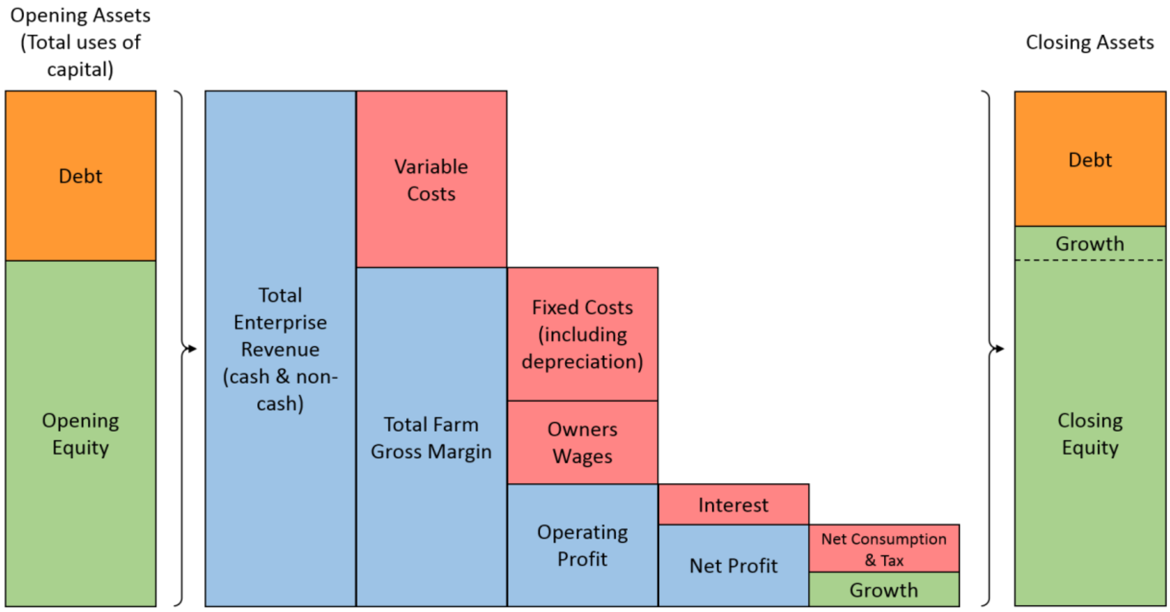
More than 80% of Queensland's total area of 173 million ha is used for grazing livestock on lands extending from humid tropical areas to arid western rangelands (QLUMP 2017). Most extensive grazing enterprises occur on native pastures. Introduced (sown) pastures constitute less than 10% of the total grazing area and occur on the more fertile land types (McIvor 2005; QLUMP 2017). Grazing industries make an important contribution to the Queensland economy. In 2017-18 the beef cattle industry accounted for ca. 41% ($5.5 billion) of the total gross value of Queensland agricultural production while sheep meat and wool accounted for ca. 0.8% ($0.1 billion), (ABS 2019b).

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 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 (McCosker *et al.* 2010; McLean *et al.* 2014; ABARES 2019).

To remain in production, and to build drought resilience, beef and sheep properties need to be environmentally sustainable, profitable and build equity (Figure 1). Building resilience usually means investments must be made and alternative management strategies considered well before encountering extended dry spells or drought. To make profitable management decisions graziers need to appropriately assess the impact of the strategy on profitability, the associated risks, and the period of time before benefits can be expected. The effect of such alternative management strategies is best assessed using property-level herd 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 the application of a framework to assess the relative value of the alternatives available over both the short and medium term. Recovery from drought is also a challenging period when decision making should include a suitable blend of the strategic – returning to the most profitable herd structure, and tactical - 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 beef or sheep 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.

The objective of this project, 'Delivering integrated production and economic knowledge and skills to improve drought management outcomes for grazing enterprises', was to improve the knowledge and skills of advisors and graziers in assessing the economic implications of management decisions which can be applied to (i) prepare for, (ii) respond to, or (iii) 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 and business models, incorporating 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 analysis of the economic implications of management decisions in the Northern Downs region of Queensland.

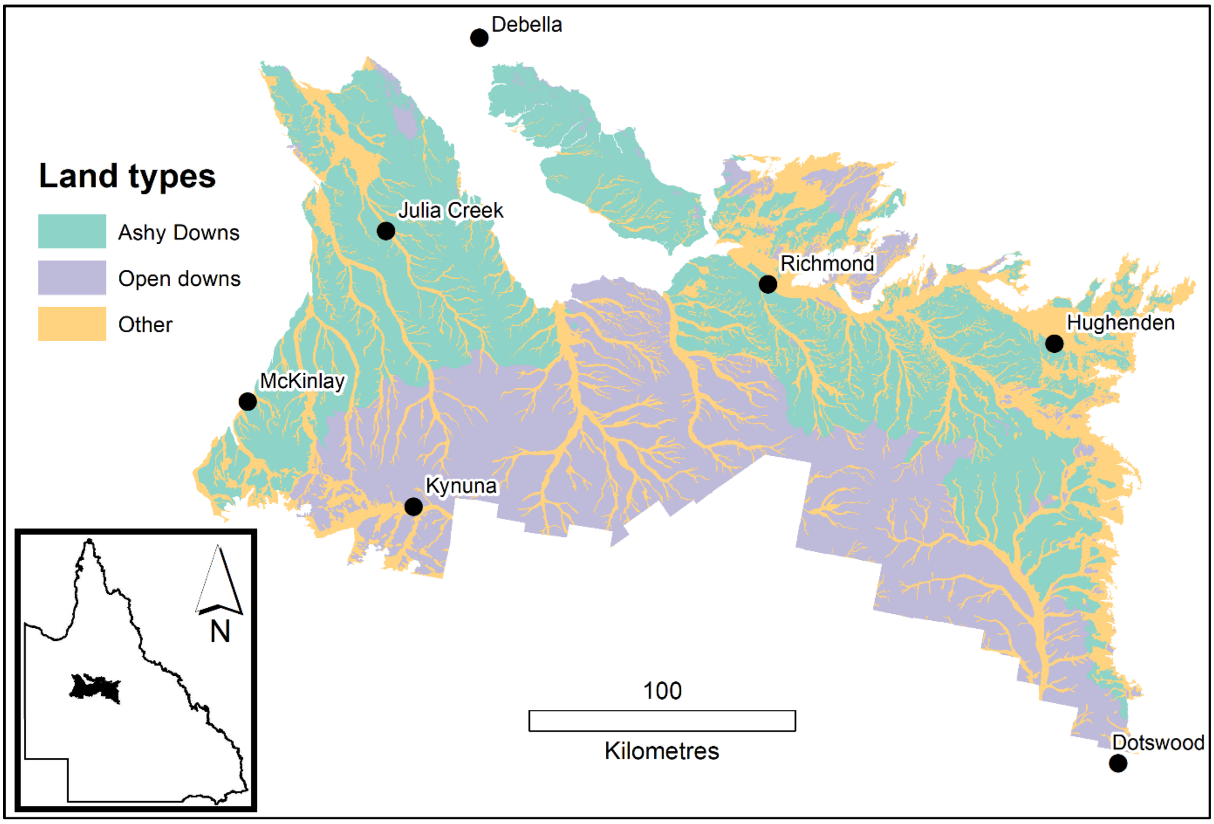
1.1 The Northern Downs region of Queensland

1.1.1 The land resource

The Northern Downs target region for this report encompasses 4.4 million ha of grazing land (DNRM 2010; DNRM 2017) used largely for cattle production (Figure 2). The region falls within the Flinders River catchment of the Southern Gulf catchments of Queensland. The Northern Downs 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 broader 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 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 as well as the introduced perennial grass, buffel (*Cenchrus ciliaris*).

Figure 2 – Map of the Northern Downs region of Queensland showing the distribution of the major land types on land used for grazing

The Northern Downs region includes the Mitchell grasslands bioregion sub-IBRAs MGD06, MGD07 and MGD08 but with the southern boundary set as the ABS Outback North statistical division boundary



1.1.2 Rainfall and drought

The Northern Downs region is 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. The expected pasture growing season, and highest quality of forage, typically lasts for 8-10 weeks during summer (Bray *et al.* 2014). Examples of seasonal distribution of rainfall are shown for four locations across the region (BOM 2019; Table 2). Annual rainfall in the region ranges from 454 mm at Hughenden to 333 mm at McKinlay. The variability of annual rainfall in the Northern Downs region is classed as 'moderate to high' (scale low to extreme) based on an index of variability determined by percentile analysis (BOM 2018; Figure 3). Examples of rainfall variability, expressed as the coefficient of variation of the mean annual rainfall figures, are presented for four locations across the region (BOM 2019; Table 3). Another example of the variability in annual rainfall in the region is provided in Figure 4 for Richmond which has the longest continuous rainfall data records in the region. Over the 129-year period, 1890-2018, with two missed years of data (1994 and 2006) the annual rainfall ranged from 108 mm (1952) to 1,160 mm (1891). The average and median rainfall over this 129-year period were 474 and 431 mm, respectively.

Table 2 - Median seasonal distribution of rainfall (mm) at four locations across the Northern Downs region for the 30-year 'climate normal' period 1961-1990 (BOM 2019)

Town	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Hughenden	102.1	76.3	41.1	8.5	7.7	2.1	1.3	0.3	0.6	10.2	14.4	69.3	454.3
Richmond	97.3	73.3	41.5	11.0	4.4	0.3	0.0	0.0	0.0	7.8	12.1	56.2	422.1
Julia Creek	76.3	92.4	49.5	2.8	1.8	0.0	0.0	0.0	1.0	7.3	20.2	55.0	420.9
McKinlay Roadhouse	64.5	70.8	23.2	2.6	0.0	0.0	0.0	0.0	0.0	6.2	12.0	40.9	332.8

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

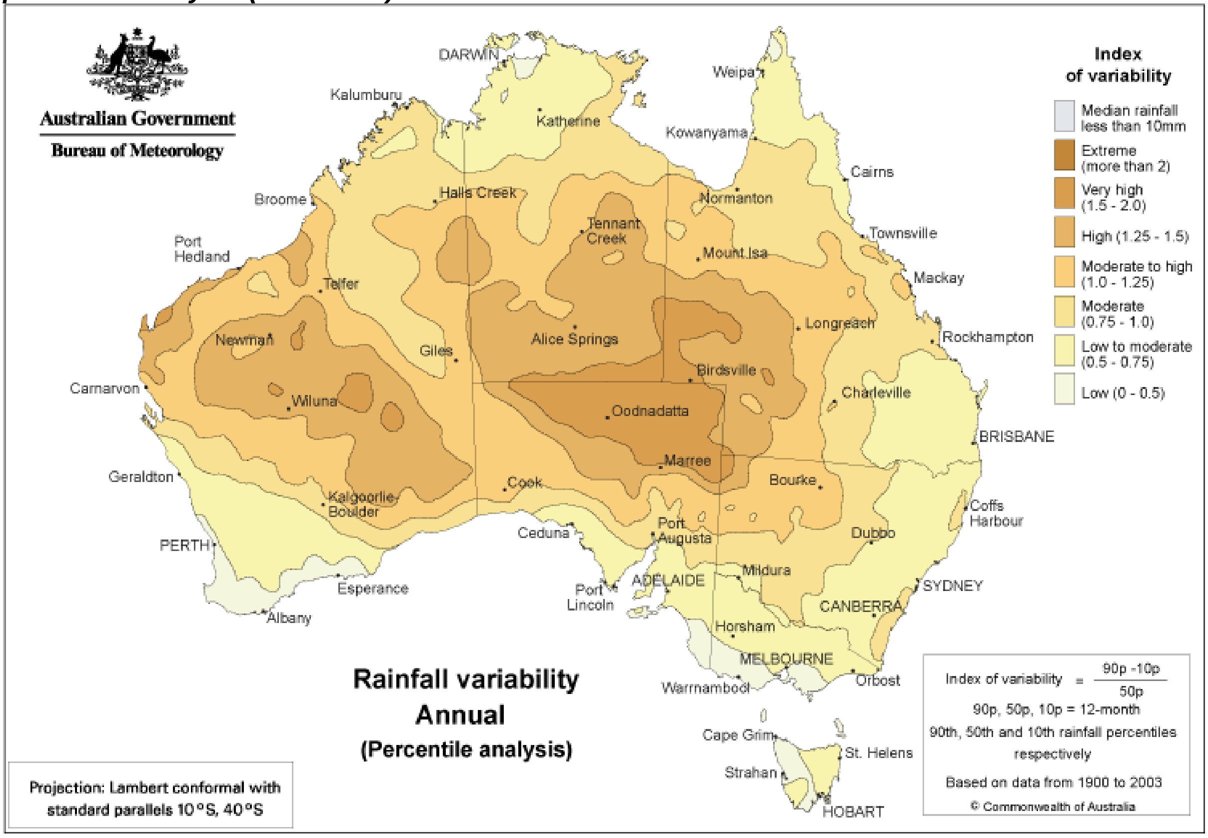
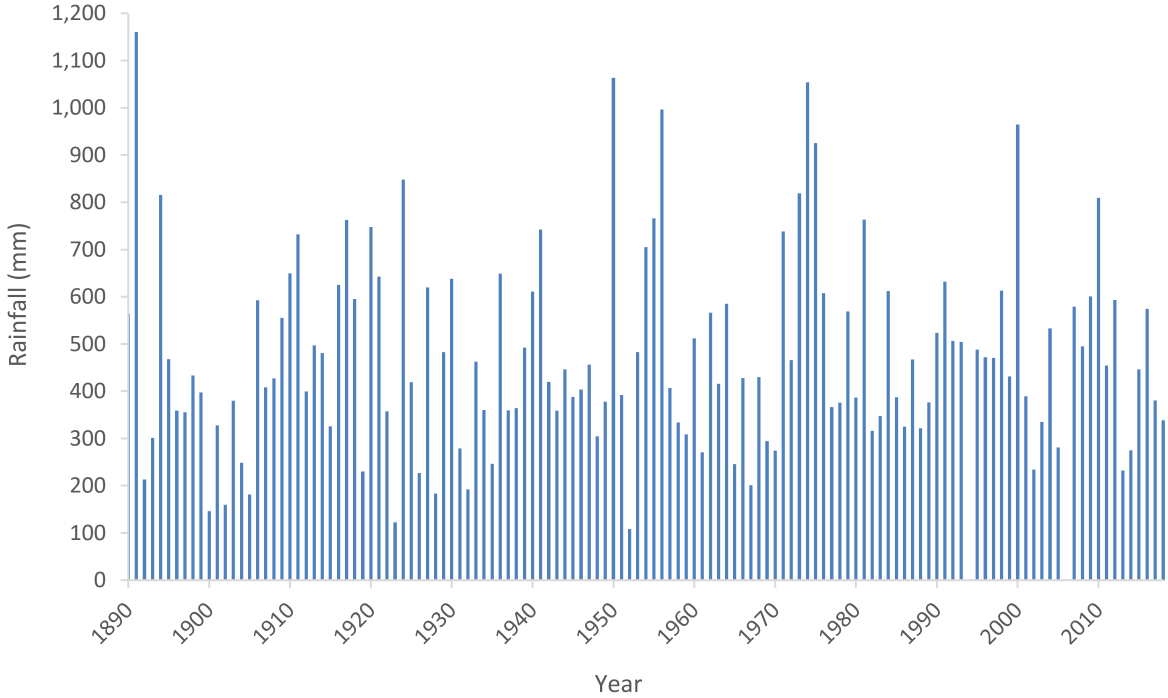


Table 3 – Mean annual rainfall (mm) and rainfall variability (coefficient of variation) at Julia Creek, Richmond, Hughenden and McKinlay Roadhouse for the 30-year 'climate normal' period 1961-1990 (BOM 2019)

Town	Mean annual rainfall (mm)	Rainfall variability expressed as the Coefficient of variation (%)
Hughenden	493	41
Richmond	482	43
Julia Creek	479	42
McKinlay Roadhouse	391	52

Figure 4 – Annual rainfall at Richmond over the 129-year period 1890-2018



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 Richmond (Table 4). Using this definition, there have been 33 droughts at Richmond since 1900, the longest lasting 20 months.

Table 4 - Historical droughts (1900–2018) at Richmond 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	Mar 1902 - Oct 1903	20	0	213
2	Jan 1952 - Dec 1952	12	0	112
3	Mar 1926 - Jan 1927	11	0	185
4	Feb 1923 - Jan 1924	12	0.8	141
5	Apr 1969 - Nov 1969	8	2.5	22
6	Jun 1905 - Jan 1906	8	3.4	133
7	Feb 1935 - May 1935	4	1.7	23
8	May 1931 - Nov 1931	7	2.6	118
9	May 2013 - Oct 2013	6	3.4	14
10	Dec 1900 - Feb 1901	3	0	91
11	Mar 1988 - Jul 1988	5	3.4	60
12	Mar 1978 - Jun 1978	4	4.2	23
13	Jun 1928 - Oct 1928	5	5.9	3
14	Jan 1967 - May 1967	5	5.1	102
15	Nov 1932 - Jan 1933	3	4.3	108
16	Nov 1967 - Jan 1968	3	2.6	46
17	Jul 1965 - Nov 1965	5	6	8
18	Feb 1983 - Mar 1983	2	3.4	35
19	Feb 2016	1	2.5	8
20	Jan 1960	1	3.4	29
21	Feb 1947	1	3.4	85
22	Dec 1928	1	4.2	69
23	Mar 1919 - Apr 1919	2	6.8	9
24	Dec 2002 - Feb 2003	3	6.8	211
25	Feb 1971	1	5.9	29
26	Nov 1915	1	6.8	7
27	Jan 1949 - Feb 1949	2	8.5	92
28	Dec 2013	1	7.6	35
29	Oct 1935 - Nov 1935	2	8.5	10
30	Mar 1905 - Apr 1905	2	9.3	37
31	Aug 1935	1	9.3	1
32	Dec 1919	1	9.3	10
33	Sep 1967	1	9.4	0

[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 2018).

1.1.3 Northern Downs region beef production systems

Extensive grazing, primarily on Mitchell grass and associated native pastures, is the principal land use across the Northern Downs region. The Northern Downs falls within the Southern Gulf Natural Resource Management (NRM) region which is a total of 16,358,711 ha and supports 291 meat cattle businesses and 43 sheep businesses (ABS 2019a). The Southern Gulf NRM region has a total meat cattle herd size of ca. 1,254,296, representing 5% of Australia's and 11% of Queensland's meat cattle numbers and producing $574,337,182 or 5% of Australia's and 10% of Queensland's gross value of cattle in 2017-18 (ABS 2019a,b). The meat and wool sheep flock in the region totals 58,382, representing 0.08% of Australia's and 3% of Queensland's total sheep flock and producing $2,987,425 or 0.03% of Australia's and 2.7% of Queensland's gross value of sheep (ABS 2019a,b).

While historically Merino sheep production systems were dominant in the Northern Downs, and the Queensland Mitchell grasslands more broadly, cattle numbers increased during the 1980s so that by 2010 very few wool sheep remained north of Longreach (Bray *et al.* 2014). Economic factors as well as increases in wild dog numbers have contributed to the decline in sheep production in the region. With the increase in lamb and wool prices in recent years there has been some interest in a return to sheep production in the area. However, the requirement for substantial infrastructure redevelopment, particularly wild dog exclusion fences, to support sheep production has limited the extent of conversion back to sheep, with cattle remaining the dominant livestock in the region.

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 (Partridge 1996; Commonwealth of Australia 2008). 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 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 a potential risk to land condition over time (Bray *et al.* 2014). It has been suggested that this trend towards increased pasture utilisation is linked to financial pressures of graziers, as well as increased total grazing pressure from macropods and feral animals such as goats, and increasing density and area of native and weedy woody vegetation which decreases pasture growth (Commonwealth of Australia 2008; Bray *et al.* 2014).

Beef producers in the region target the live export, slaughter and United States grinding beef markets. Low female mortalities, sound reproductive performance and moderate annual liveweight gains are characteristic of the region (Bortolussi *et al.* 1999; Bortolussi *et al.* 2005; McGowan *et al*. 2014). Published liveweight gain data for growing cattle, over a number of years at one site to indicate annual variability, is limited for the Northern Downs region. Dixon (2007) reported annual liveweight gain for three drafts of *Bos indicus* crossbred yearling steers at Toorak Research Station, 50 km south of Julia Creek, over 2002-2004: 117, 228 and 162 kg/annum, respectively (average 169 kg/annum). The stocking rate averaged 7 ha/adult equivalent (AE) on average (range 5.4-7.8 ha/AE). These years experienced below-average rainfall: 200, 308 and 319 mm, respectively, over the July-June period. Eight years (2011-2019) of producer demonstration site data from near Richmond (Walk-over weighing PDS; R. Gunther, pers. comm.) indicates an average of 173 (range 133-224) kg/annum over 325 (range 282-417) days of grazing per annum with 6 years of weight gain records. However, the paddock was de-stocked in 2 of the 8 years over this period. If these 2 years of de-stocking (0 kg liveweight gain/annum) are included in the average, the annual liveweight gain result can be considered 130 kg/annum. The stocking rate at the Richmond PDS site averaged 11 (range 7-17) ha/AE over the grazed periods and the 6 years during which it was stocked.

2 General methods – approach to economic evaluation

2.1 Summary of approach

The implications of alternative management strategies on the capacity of a beef enterprise to prepare for, respond to, and recover from drought were investigated for a constructed, example beef cattle property in the Northern Downs region of Queensland using scenario analysis. The levels of production associated with this constructed, base 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 Department of Agriculture and Fisheries, Queensland (DAF) staff. An exhaustive approach, of conducting workshops, training events and discussions with skilled and experienced scientific and extension colleagues, has been applied to develop the assumptions and parameters applied in the modelling. This has involved an iterative process of obtaining feedback and then applying adjustments to the models to ensure that the models have been adequately structured and calibrated for the base property and for each scenario.

The analysis applied an expected values approach that relied on estimating the expected, average level of production and performance over the investment period. This approach was considered equally as capable of predicting the relative differences between the alternative strategies 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 strategies and 2) identifying the strategies most capable of building resilience over time.

The standard methods of farm management economics (Malcolm *et al.* 2005) were applied to test the relative and absolute value of alternative management strategies for the same property using the Breedcow and Dynama herd budgeting software (Version 6.02; Holmes *et al.* 2017). In all cases, a change to the existing herd management strategy was considered. That is, there was an investment and a herd already in place and the analysis considered options/alternatives that may improve the efficiency of that system. Hence, the scenario analysis was undertaken as a marginal analysis using partial budgeting, over a uniform investment period of 30 years. The term marginal has the meaning of ‘extra’ or ‘added’. The principle of marginality emphasises the importance of evaluating change for extra effects, not the average level of performance.

The scenarios/strategies were assessed for their potential impact on:

- the current net worth of the beef property (impact measured as net present value (NPV) of change);
- the maximum cumulative cash deficit/difference between the two strategies (peak deficit);
- the number of years before the peak deficit is achieved (years to peak deficit) and
- the number years before the investment is paid back (payback period).

Although the Breedcow and Dynama programs can be used to evaluate changes in equity and risk levels as well as avenues to finance the beef property, these critical aspects of managing a beef property were not included in this analysis. Therefore, the relative profitability and financial risk of strategies analysed for the Northern Downs region should be interpreted in the context of debt and risk exposure of individual beef businesses. It is also important to note that many properties in the region with similar characteristics to our constructed property can be part of larger beef businesses that may involve a number of properties in the same region or across multiple regions. The same processes and strategies applied in this analysis can be applied to identifying the optimal management strategy for individual properties within a portfolio prior to optimising the overall portfolio. It is necessary to look at the individual property and its optimum management prior to looking at how it is best managed within a portfolio of properties.

Components of the Breedcow and Dynama suite of programs were applied in an integrated manner during the model building process. Initially Breedcowplus was used to identify the optimal herd structure resulting from the most profitable age of sale for steers and age of culling for heifers and cows. Breedcowplus is a 'steady-state' herd model that applies a constantly recurring pattern of calving, losses and sales for a stable herd with a pre-determined grazing pressure constraint that effectively sets the property or herd size (total number of AE). Breedcowplus is 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 structure, performance or production. As most change scenarios in the northern beef industry require consideration of such factors over time, it is necessary to undertake the scenario analysis in the Dynamaplus model. Dynamaplus considers herd structures and performance with annual time steps and can import modelled herd structures, costs, AE ratings and prices from Breedcowplus thereby facilitating the analysis of any change in the herd costs, incomes or management strategy over time.

In this study, Breedcowplus was applied to identify a) optimal or current herd structures for the start of each scenario, and b) each annual change in herd structure or herd performance expected to occur for as long as it took to implement change and reach the expected herd structure. The incremental Breedcowplus models were transferred to the Dynamaplus model, thereby accurately modelling the impact of the change over time on an annual basis and allowing optimal herd structures and sales targets to be maintained.

Once the herd structure for both a) a herd that did not change, and b) a herd that did change were fully implemented in separate Dynamaplus models over a period of 30 years, the difference between the two Dynamaplus models was identified with the Investan program (also within the Breedcow and Dynama suite). To take full account of the economic life and impact of the investments modelled, the capability of the Dynamaplus and Investan models were extended to 30 years.

In summary, for each scenario, the regionally-relevant herd was applied in the Breedcow and Dynama suite of programs to determine and compare expected and alternative productivity and profitability over a 30-year investment period. The uniform 30-year investment period was chosen to match the expected economic life of some of the more long lived investments and to provide sufficient time for the benefits of investments in improved nutrition or herd productivity to be fully realised. Having a consistent time horizon is one of the essential requirements for comparing or ranking investments by NPV and internal rate of return (IRR), the others being that the options are not mutually exclusive and have the same initial investment outlay. This latter requirement is met by starting each analysis with the same land, herd, and plant and equipment investment. Change was implemented by altering the herd performance and inputs of the base scenario in annual increments 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.

Discounted cash flow (DCF) techniques were applied using an extended version of the Investan program (Holmes *et al.* 2017) to look at the net returns associated with any additional capital or resources invested. 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), except for livestock prices, which were calculated as the average over the past 11 years and applied at this level to incorporate the expected long-term impact of the ongoing decline in the terms of trade experienced by Australian livestock producers. It was assumed that future inflation would equally affect all costs and benefits.

The discounted cash flow analysis was calculated at the level of operating profit where: *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 benefit resulting from all of the capital managed by the property. The calculation of operating profit included an allowance for the labour and management supplied by the owner as a fixed cost, even though it is often unpaid or underpaid. For a true estimate of farm profit, this allowance needs to be valued appropriately and included as an operating cost. Our definition of an operator's allowance was that it is the value of the owner's labour and management and is estimated by reference to what professional farm managers/overseers are paid to manage a similar property. Another fixed cost deducted in the calculation of annual operating profit was depreciation. This is not a cash cost. It is a form of overhead or fixed cost that allows for the use or fall in value of assets that have a life of more than one production period. It is an allowance 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.

The annual figures applied in the calculation of operating profit were modified to calculate the NPV for the property or each strategy. For example, depreciation 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. Opening and salvage values for land, plant and livestock were applied at the beginning and end of the discounted cash flow analysis to capture the opening and residual value of assets. Residual land values were not modified where strategies may lead to improved stocking rates occurring at the end of the 30-year investment period. Our view was that, for the strategies assessed that are likely to improve carrying capacity, it may be too generous in this risky production environment to extend their impact past 30 years in the form of an increase in closing land value.

The Breedcow and Dynama herd models can be downloaded free from: https://www.daf.qld.gov.au/animal-industries/beef/breedcow-and-dynama-software. The 30-year version of the models applied in this analysis are available from the authors of the report. A summary of the role of each component of the Breedcow and Dynama suite of programs is provided in Appendix 1. Breedcow and Dynama software. Additional detail and description of the Breedcow and Dynama suite of programs is provided by Holmes *et al*. (2017).

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 the IRR. A present value model is a mathematical relationship that depicts the value of discounted future cash flows in the current period. It provides a measure of the net impact of the investment in current value terms and accounts for the timing of benefits and costs over the life of the investment. NPV is the sum of the discounted values of the future income and costs associated with the change in the herd 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 determined. The 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 (5%) over the investment period to assist in communicating the difference between the constructed, base property and the property after the management strategy was implemented. This measure is different to the average annual difference in operating profit between any two strategies but is automatically calculated in the Investan program and presented to users of the program as a measure of the average annual difference between 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 amortised NPV is discounted back to a present value whereas the average annual change in operating profit is undiscounted. The amortised 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 beef property started with no debt but over the 30 year analysis period 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 continues 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 additional capital invested in developing an existing operation.

2.3 Constructed, base beef cattle property

The base property, herd and business characteristics were informed by industry surveys and research relevant to the region (Bortolussi *et al.* 1999; Bortolussi *et al.* 2005; Dixon 2007; Bray *et al.* 2014; McGowan *et al.* 2014; Beef CRC herd performance data, M. Sullivan, pers. comm.; Richmond Walk-over-weighing PDS, R. Gunther, pers. comm.) as well as consultation with regional producer groups and experienced DAF staff. The production parameters assumed for the base property were intended to represent the long-term average expectation for this region. However, there is an obvious challenge in adequately accounting for the high annual rainfall variability that occurs in this region given limited published data. Regardless, the parameters and strategies adopted for the example property are considered adequate to provide a broad understanding of the range of opportunities available for improvement, the potential response functions and an appropriate framework to support decision making.

The constructed, example property was modelled as a total area of 16,000 ha of Mitchell grass and associated native pastures growing on primarily Open downs and Ashy downs land types (The State of Queensland 2019; Figure 2) with a long-term, average carrying capacity of ca. 2,000 AE. The assumption was that at the long-term, average stocking rate of 8 ha/AE the property would maintain land condition and carrying capacity even with the highly variable climate of this region.

A self-replacing *B. indicus* crossbred breeding herd (ca. 50% *B. indicus*) primarily grazed the Open downs and Ashy downs land types which were considered adequate in phosphorus (P) on average (>8 ppm bicarbonate extracted P (Colwell 1963) in the top 100 mm soil). Dry season, urea-based, non-protein nitrogen (N) supplements were fed during the dry season with the aim of reducing breeder liveweight loss. Replacement heifers were separated from the breeding herd until they were first mated at about 2 years of age. Steers mostly grazed similar land types to the breeders until they were sold to the 'feed-on' market (450-480 kg average liveweight in the paddock).

Controlled mating was practiced and bulls were placed with the breeding herd in January and removed at the first weaning in June. Two main musters of the breeding herd were undertaken to wean calves and identify cull breeding cows with the second round muster in September/October. Data used to describe the reproduction efficiency of the breeder herd reflected the expected conception rates of breeders and the typical loss of calves between conception and weaning experienced by breeders grazing in this region (Table 5; McGowan *et al.* 2014). An average mortality rate between 1.5-4% was applied to the various classes of livestock to reflect industry expectations and other anecdotal evidence related to the impact of drought across the region over the long term. The resulting average mortality rate across the base herd was 2%. The reduced culling percentage, of 90%, was applied to the 3-4 year breeder age group to balance the herd model with this age group of females considered more likely to be given a 'second chance' than other age groups of females.

Table 5 – Initial reproduction parameters and mortality rates for the Northern Downs base herd

Initial cattle age **Final cattle age**	**Weaners** **1**	**1** **2**	**2** **3**	**3** **4**	**4** **8**	**8** **11**
Expected conception rate for age group (%)	n/a	0	80	55	75	76
Expected calf loss from conception to weaning (%)	n/a	0	14.9	4.7	7.2	9.3
Proportion of empties (PTE) sold (%)	n/a	0	100	90	100	100
Female death rate (%)	1.5	1.5	4	3	3	4
Male death rate (%)	1.5	1.5	1.5	1.5	1.5	n/a

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

The application of the data for reproduction efficiency and mortality rates to the herd model produced an expected average weaning rate of 64.97% (weaners from all cows mated). This is lower than the median 'contributed a weaner' figure of about 72% identified for the CashCow project, Northern Downs region (McGowan *et al.* 2014) but is seen as incorporating more of the variability in herd performance experienced locally. The base property produced about 673 weaners from 1,035 females mated and sold 631 head/annum. Cull female sales made up 47.94% of total sales. The combination of growth, mortality and reproduction rates, and total AE in the herd model, resulted in the herd structure shown in Table 6.

Table 6 – Average herd structure for the base property

Age at start of period	Number kept for the whole year	Number sold	AE/head kept	AE/head sold	Total AE
Extra for cows weaning a calf	n/a	n/a	0.35	n/a	235
Weaners 5 months	673	0	0.22	0.03	150
Heifers 1 year but less than 2	326	5	0.57	0.33	186
Heifers 2 years but less than 3	257	64	0.86	0.50	253
Cows 3 years plus	498	231	1.21	0.67	757
Steers 1 year but less than 2	331	0	0.59	0.34	196
Steers 2 years but less than 3	0	326	0.90	0.52	170
Bullocks 3 years but less than 4	0	0	1.21	0.70	0
Bulls all ages	31	5	1.54	0.90	52
Total number	*2,116*	*631*	-	-	*2,000*

AE, adult equivalent; n/a, not applicable.

The average weaning weight at 6 months of age was estimated to be ca. 181 kg for steers and 173 kg for heifers. Average, annual post-weaning weight gain was assumed to be ca. 140 kg/head for steers and 133 kg/head for heifers. Figure 5 shows the estimated average growth path for steers and heifers. It was assumed that 100% of each steer cohort were sold at an average of 31 months old and ca. 474 kg liveweight in the paddock.

Figure 5 - Estimated average steer and heifer growth paths for the base property

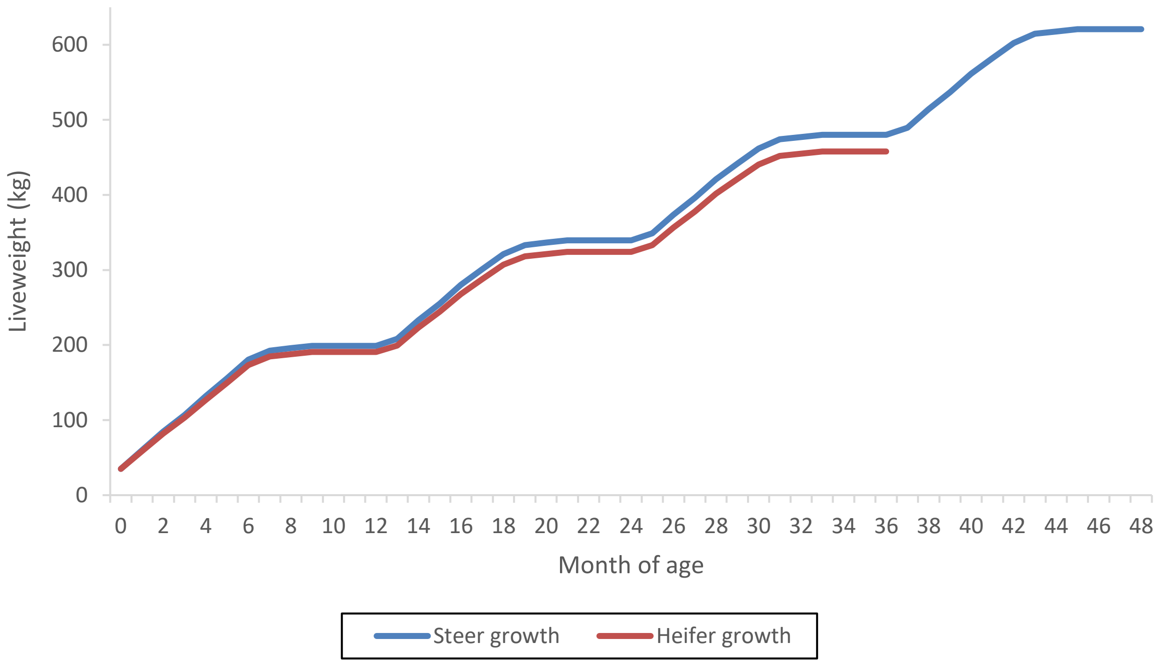


Table 7 shows the treatments applied to the various classes of cattle held for 12 months in the model. Sale stock may or may not have received the treatment depending upon the timing of sale.

Table 7 - Husbandry treatments applied and cost per head for the base property

Treatments	Weaners	Females 1-2 years	Females 2-3 years	Females 3+ years	Steers 1-2 years	Steers 2-3 years	Bulls
Weaner hay	$15	-	-	-	-	-	-
Dry season loose lick	$9.70	$10.95	$10.95	$10.95	-	-	$10.95
NLIS Tags	$3.50	$0.35	$0.35	$0.35	$0.35	$0.35	$0.35
Leptospirosis vaccine	-	$2.60	$1.30	$1.30	-	-	-
Vibriosis vaccine	-	-	-	-	-	-	$10.00
Pregnancy Testing	-	-	$5.00	$5.00	-	-	-

2.3.1 Cattle price data

The hypothetical, base property was located near Julia Creek with a number of selling centres and abattoirs available for sale stock. While it is recognised that large volumes of cattle in the region are sold into Cloncurry, detailed price data is available for the Roma livestock selling centre (ca.1,150 km distance), Townsville abattoirs and related north Queensland sale yards (ca. 650 km distance on average) and Darwin live export markets. As these centres are relevant indicators of market prices for beef producers in the Northern Downs region, they were used to calculate net sale values at Julia Creek, i.e. the ‘farm gate’ price net of freight.

Price data by sale class was analysed for Roma, Darwin and Townsville markets and for north Queensland over-the-hooks markets (see Meat and Livestock Australia (MLA) market statistics database at http://statistics.mla.com.au/Report/List). The price data for Roma has been included as beef producers located in the Northern Downs region may also target southern Queensland markets, including feedlots. Average prices for each point of sale have been converted to c/kg liveweight equivalent on-property (at Julia Creek) to allow comparison of the relative prices available for the various markets over recent years. Transport and other selling costs were estimated for each class of cattle and each selling center.

The slaughter values were derived from the MLA North Queensland over-the-hooks (OTH) prices data base (MLA market statistics database at http://statistics.mla.com.au/Report/List). The OTH indicators are calculated as a weighted average of northern processor grids. Figure 6 shows price trends for selected classes of sale cattle since 2008. Prices for sale stock 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 6 – Weekly cattle prices over time for slaughter cattle in north Queensland

A-E = carcass grading; cwt = carcass weight

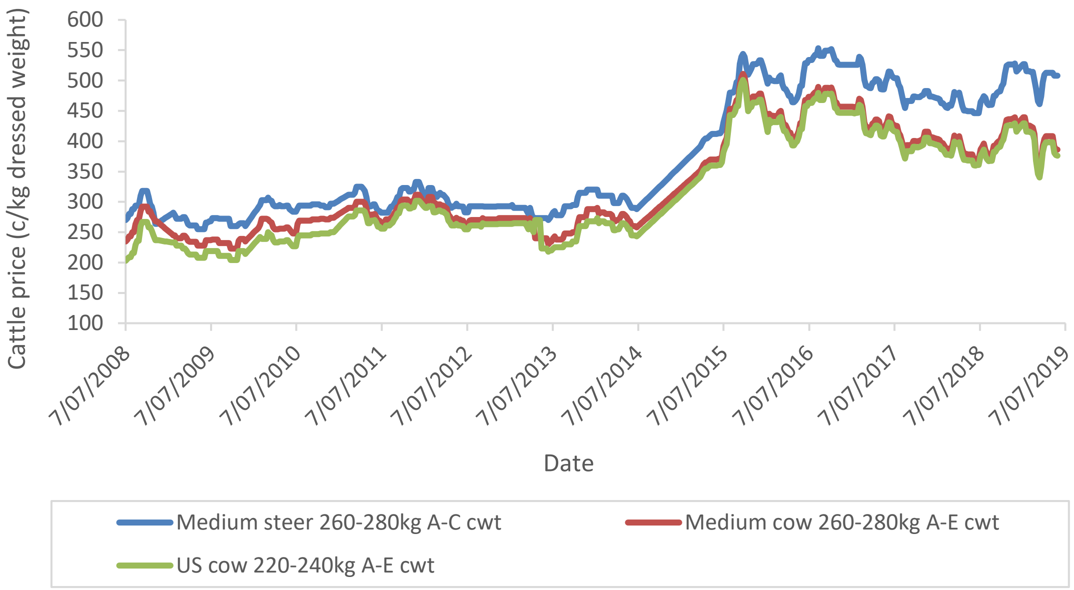


Table 8 and Table 9 show available price data for the 11 years to June 2019 and the 5 years to June 2019 for north Queensland OTH prices. The 5-year averages were calculated to allow comparison with north Queensland sale yard prices which only have data for about the last 5 years on the MLA database. Prices paid at the abattoirs have been converted from a 'dressed weight' to a 'liveweight' basis by assuming a 52% dressing percentage for steers and a 50% dressing percentage for females. In this analysis, Julia Creek was selected as the point of origin for transport of livestock from the Northern Downs region to the point of sale.

Table 8 - Julia Creek values (c/kg liveweight) for slaughter stock based on MLA North Queensland over-the-hooks weekly price data for July 2008 to June 2019 (last 11 years)

Parameter	**Medium steer** **260-280 kg A-C** **(carcass weight)**	**Heavy steer** **300-400 kg A-C** **(carcass weight)**	**US cow** **220-240 kg A-E** **(carcass weight)**	**Medium cow** **260-280 kg A-E** **(carcass weight)**
Weight in the paddock (liveweight)[#]	565	707	483	567
Weight loss to get to works	5.00%	5.00%	5.00%	5.00%
Weight at works	537	671	459	539
Sale price at works ($/kg live)[#]	$1.93	$1.98	$1.58	$1.64
Gross sale price ($/head)	$1,039	$1,330	$724	$886
Commission and insurance % on sales	0.00%	0.00%	0.00%	0.00%
Commission and insurance ($/head)	$0.00	$0.00	$0.00	$0.00
Transaction levy, yard dues etc.	$5.00	$5.00	$5.00	$5.00
Transport cost calculation				
Distance (km)	650	650	650	650
$ per km	$1.90	$1.90	$1.90	$1.90
Rate on truck	22	16	25	21
Transport cost ($/head)	$56.14	$77.19	$49.40	$58.81
Value net of selling expenses	$977.60	$1,247.99	$669.56	$822.16
Paddock weight	565	707	483	567
Selling cost ($/kg)	$0.11	$0.12	$0.12	$0.12
Net value in the paddock ($/kg)	*$1.73*	*$1.77*	*$1.39*	*$1.45*

[#]carcass weight and sale prices converted to liveweight equivalent at 52% dressing for steers and 50% dressing for cows. The midpoint of each weight range is applied to calculate values.

Table 9 - Julia Creek values (c/kg liveweight) for slaughter stock based on available MLA North Queensland over-the-hooks weekly price data for the last 5 years

Parameter	**Medium steer 260-280 kg A-C (carcass weight)**	**Heavy steer 300-400 kg A-C (carcass weight)**	**US cow 220-240 kg A-E (carcass weight)**	**Medium cow 260-280 kg A-E (carcass weight)**
Weight in the paddock (liveweight)#	565	707	483	567
Weight loss to get to works	5.00%	5.00%	5.00%	5.00%
Weight at works	537	671	459	539
Sale price at works ($/kg live)#	$2.42	$2.47	$1.96	$2.01
Gross sale price ($/head)	$1,300	$1,661	$900	$1,085
Commission and insurance % on sales	0.00%	0.00%	0.00%	0.00%
Commission and insurance ($/head)	$0.00	$0.00	$0.00	$0.00
Transaction levy, yard dues etc.	$5.00	$5.00	$5.00	$5.00
Transport cost calculation				
Distance (km)	650	650	650	650
$ per km	$1.90	$1.90	$1.90	$1.90
Rate on truck	22	16	25	21
Transport cost ($/head)	$56.14	$77.19	$49.40	$58.81
Value net of selling expenses	$1,238.93	$1,578.50	$845.55	$1,020.80
Paddock weight	565	707	483	567
Selling cost ($/kg)	$0.11	$0.12	$0.12	$0.12
Net value in the paddock ($/kg)	*$2.19*	*$2.23*	*$1.75*	*$1.80*

#carcass weight and sale prices converted to liveweight equivalent at 52% dressing for steers and 50% dressing for cows. The midpoint of each weight range is applied to calculate values.

Sale yard price data collated by MLA for north Queensland is only available for the period October 2014 to the end of May 2019. Table 10 indicates the farm gate price at Julia Creek for a range of stock categories sold through the sale yards. There appears to be a close relationship between on-farm values for similar classes of stock sold through either the yards or the abattoirs over the past 5 years.

Table 10 - Julia Creek values (c/kg liveweight) for sale stock based on MLA 'North Queensland saleyards' weekly price data from October 2014 to June 2019 (approximately the last 5 years)

Parameter	**Restocker steer 200-330 kg D2 (liveweight)**	**Restocker heifer 200-330 kg D2 (liveweight)**	**Light steer 330-400 kg D2 (liveweight)**	**Medium steer 400-500 kg D2 (liveweight)**	**Grassfed bullock 500-750 kg C-D4 (liveweight)**	**Medium cow 400-520 kg D3 (liveweight)**
Weight in the paddock	265	265	365	450	625	460
Weight loss to get to sale yards	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Weight at saleyards	252	252	347	428	594	437
Sale price at yards ($/kg live)	$2.87	$2.45	$2.71	$2.53	$2.64	$2.03
Gross sale price ($/head)	$723	$616	$939	$1,082	$1,566	$886
Commission and insurance %	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%
Commission and insurance ($/head)	$25.29	$21.56	$32.87	$37.86	$54.80	$31.01
Transaction levy, yard dues etc.	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
Transport cost/head calculation						
Distance (km)	650	650	650	650	650	650
$ per km	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90
Rate on truck	38	38	29	26	19	26
Transport cost ($/head)	$32.50	$32.50	$42.59	$47.50	$65.00	$47.50
Value net of selling expenses	$649.84	$547.02	$848.58	$981.25	$1,430.93	$792.57
Paddock weight	265	265	365	450	625	460
Selling cost ($/kg)	$0.29	$0.27	$0.26	$0.23	$0.23	$0.21
Net value in the paddock ($/kg)	***$2.45***	***$2.06***	***$2.32***	***$2.18***	***$2.29***	***$1.72***
Price difference to base ($/kg)	*Base*	*-$0.39*	*-$0.13*	*-$0.27*	*-$0.16*	*-$0.73*

The live export steer market is very important to many beef producers across the region. Figure 7 indicates that live export steers in Townsville have received lower prices on average than those exported from Darwin. For the period June 2014 to June 2019, the same weight range of steers were, on average, 27 c/kg liveweight lower (median 30 c/kg lower) in Townsville than Darwin. Long-term price data was not available for the period July 2008 to November 2013 for export steers from Townsville. Therefore, the price trends for Darwin, for the same class of steers, were applied to calculate representative long-term values, on-farm for Julia Creek for that period.

Figure 7 - Cattle prices over time (July 2008-January 2019) for live export steers at Darwin and Townsville

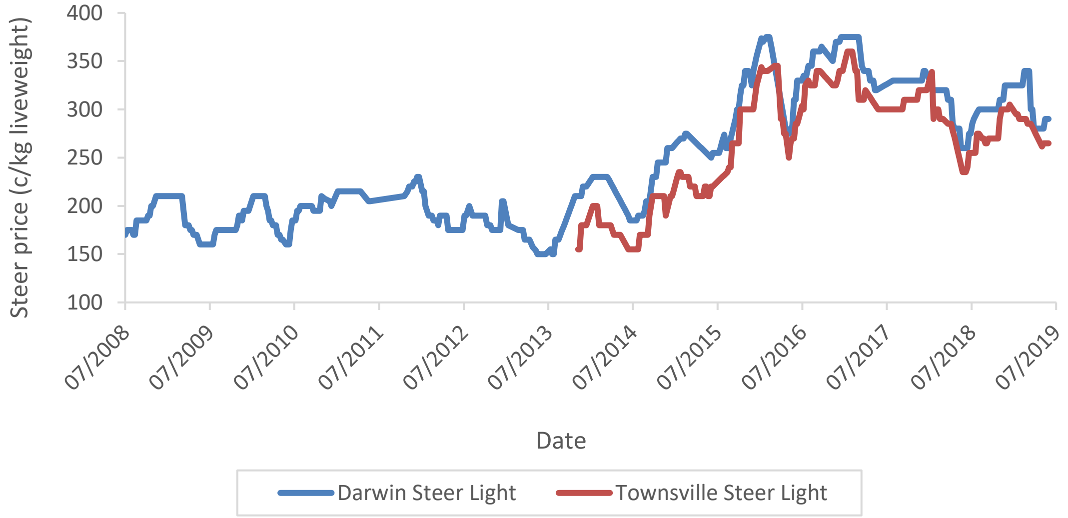


Table 11 and Table 12 indicate the on-farm prices for export steers sold (and transported) through Darwin or Townsville. The similarity of on-farm prices for steers suggests that the Darwin export price for steers sets the Townsville export steer price with the only real difference being the cost of freight. The data indicates, however, that the heifer price in Darwin may have been at a premium compared to Townsville prices over recent years.

Table 11 - Julia Creek values (c/kg liveweight) for sale stock based on MLA live export weekly price data October 2014 to June 2019 (last 5 years)

Parameter	**Darwin Heifer Light**	**Darwin Steer Light**	**Townsville Heifer Light**	**Townsville Steer Light**
Weight in the paddock	350	350	350	350
Weight loss to get to sale yards	5.00%	5.00%	5.00%	5.00%
Weight at saleyards	333	333	333	333
Sale price at yards ($/kg live)	$2.83	$3.05	$2.48	$2.77
Gross sale price ($/head)	$940	$1,014	$826	$922
Commission and insurance % on sales	3.50%	3.50%	3.50%	3.50%
Commission and insurance ($/head)	$32.91	$35.48	$28.90	$32.28
Transaction levy, yard dues etc.	$15.00	$15.00	$15.00	$15.00
Transport cost per head calculation				
Distance (km)	1,860	1,860	650	650
$ per km	$1.90	$1.90	$1.90	$1.90
Rate on truck	30	30	30	30
Transport cost ($/head)	$117.80	$117.80	$41.17	$41.17
Value net of selling expenses	$774.50	$845.46	$740.65	$833.97
Paddock weight	350	350	350	350
Selling cost ($/kg)	$0.50	$0.51	$0.26	$0.27
Net value in the paddock ($/kg)	*$2.21*	*$2.42*	*$2.12*	*$2.38*

Table 12 - Julia Creek values (c/kg liveweight) for sale stock based on MLA live export weekly price data for Darwin July 2008 to June 2019 (last 11 years)

Parameter	**Darwin Light Heifer**	**Darwin Light Steer**
Weight in the paddock	350	350
Weight loss to get to sale yards	5.00%	5.00%
Weight at saleyards	333	333
Sale price at yards ($/kg live)	$2.29	$2.49
Gross sale price ($/head)	$761	$827
Commission and insurance % on sales	3.50%	3.50%
Commission and insurance ($/head)	$26.65	$28.96
Transaction levy, yard dues etc.	$15.00	$15.00
Transport cost per head calculation		
Distance (km)	1,860	1,860
$ per km	$1.85	$1.85
Rate on truck	30	30
Transport cost ($/head)	$114.70	$114.70
Value net of selling expenses	$605.07	$668.63
Paddock weight	350	350
Selling cost ($/kg)	$0.47	$0.48
Net value in the paddock ($/kg)	*$1.73*	*$1.91*

Roma sale yards has shown similar price trends over time to the other north Australian cattle markets. Table 13 indicates the equivalent prices at Julia Creek for the typical classes of stock sold at Roma. There appears to be a close relationship between light steers at Roma and Darwin over the longer term, when compared on the basis of their net price on-farm at Julia Creek.

Table 13 - Julia Creek values (c/kg liveweight) for sale stock based on Roma sale yards price data July 2008 to June 2019 (last 11 years)

Parameter	Steers <220 kg	Steers 221-280 kg	Steers 281-350 kg	Steers 351-400 kg	Steers 401-550 kg	Heifers <220 kg	Heifers 221-280 kg	Heifers 281-350 kg	Heifers 351-400 kg	Cows 300-400 kg	Cows 401-500 kg	Cows >500 kg
Weight in the paddock	200	251	316	376	476	200	251	316	376	350	451	550
Weight loss to get to sale yards	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Weight at saleyards	190	238	300	357	452	190	238	300	357	333	428	523
Sale price at yards ($/kg live)	$2.47	$2.44	$2.35	$2.27	$2.22	$2.14	$2.10	$2.03	$1.98	$1.37	$1.58	$1.73
Gross sale price ($/head)	$470	$580	$704	$808	$1,003	$407	$500	$608	$705	$454	$675	$902
Commission and insurance % on sales	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%
Commission and insurance ($/head)	$16.44	$20.29	$24.64	$28.29	$35.12	$14.26	$17.51	$21.27	$24.67	$15.91	$23.64	$31.59
Transaction levy, yard dues etc.	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
Transport cost per head calculation												
Distance (km)	1,150	1,150	1,150	1,150	1,150	1,150	1,150	1,150	1,150	1,150	1,150	1,150
$ per km	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90
Rate on truck	40	38	32	29	25	40	38	32	29	30	26	22
Transport cost ($/head)	$54.63	$57.50	$68.28	$75.34	$87.40	$54.63	$57.50	$68.28	$75.34	$72.83	$84.04	$99.32
Value net of selling expenses	$383.61	$487.04	$596.01	$689.55	$865.83	$323.56	$410.23	$503.24	$589.91	$350.75	$552.80	$756.57
Paddock weight	200	251	316	376	476	200	251	316	376	350	451	550
Selling cost ($/kg)	$0.45	$0.39	$0.36	$0.33	$0.30	$0.44	$0.38	$0.35	$0.32	$0.31	$0.29	$0.28
Net value in the paddock ($/kg)	***$1.92***	***$1.94***	***$1.89***	***$1.84***	***$1.82***	***$1.62***	***$1.64***	***$1.60***	***$1.57***	***$1.00***	***$1.23***	***$1.38***
Price difference to base ($/kg)	*Base*	*$0.03*	*-$0.03*	*-$0.08*	*-$0.10*	*-$0.30*	*-$0.28*	*-$0.32*	*-$0.35*	*-$0.92*	*-$0.69*	*-$0.54*

Table 14 allows comparison of sale yard prices for Townsville and Roma once the approximate selling costs from Julia Creek have been accounted for. Sale yard prices are only available in the MLA format for Townsville for the last 5 years. It is not possible to account for differences in quality of stock sold at the two selling centers but the similarities between the prices for lightweight steers in Townsville or Roma suggests the live export price for this class of steers out of Darwin has been a major factor in setting prices for lightweight steers in northern Australia recently. Buoyant export markets for other products have underpinned the recent values for older slaughter stock.

Table 14 - Julia Creek values (c/kg liveweight) for sale stock based on Roma sale yards price data for July 2014 to June 2019 (last 5 years)

Parameter	Steers <220 kg	Steers 221-280 kg	Steers 281-350 kg	Steers 351-400 kg	Steers 401-550 kg	Heifers <220 kg	Heifers 221-280 kg	Heifers 281-350 kg	Heifers 351-400 kg	Cows 300-400 kg	Cows 401-500 kg	Cows >500 kg
Weight in the paddock#	200	251	316	376	476	200	251	316	376	350	451	550
Weight loss to get to sale yards	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
Weight at saleyards	190	238	300	357	452	190	238	300	357	333	428	523
Sale price at yards ($/kg live)	$3.07	$3.01	$2.92	$2.83	$2.75	$2.61	$2.58	$2.52	$2.46	$1.68	$1.94	$2.12
Gross sale price ($/head)	$583	$717	$875	$1,008	$1,244	$496	$613	$756	$876	$558	$830	$1,106
Commission and insurance % on sales	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%	3.50%
Commission and insurance ($/head)	$20.40	$25.09	$30.61	$35.28	$43.52	$17.36	$21.45	$26.45	$30.66	$19.53	$29.06	$38.72
Transaction levy, yard dues etc.	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00	$15.00
Transport cost per head calculation												
Distance (km)	1,150	1,150	1,150	1,150	1,150	1,150	1,150	1,150	1,150	1,150	1,150	1,150
$ per km	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90	$1.90
Rate on truck	40	38	32	29	25	40	38	32	29	30	26	22
Transport cost ($/head)	$54.63	$57.50	$68.28	$75.34	$87.40	$54.63	$57.50	$68.28	$75.34	$72.83	$84.04	$99.32
Value net of selling expenses	$492.90	$619.13	$760.79	$882.37	$1,097.61	$408.92	$518.89	$646.04	$754.88	$450.76	$702.12	$953.26
Paddock weight	200	251	316	376	476	200	251	316	376	350	451	550
Selling cost ($/kg)	$0.47	$0.41	$0.38	$0.35	$0.32	$0.46	$0.39	$0.37	$0.34	$0.32	$0.30	$0.29
Net value in the paddock ($/kg)	***$2.46***	***$2.47***	***$2.41***	***$2.35***	***$2.31***	***$2.04***	***$2.07***	***$2.05***	***$2.01***	***$1.29***	***$1.56***	***$1.73***
Price difference to base ($/kg)	*Base*	*$0.01*	*-$0.05*	*-$0.11*	*-$0.16*	*-$0.42*	*-$0.39*	*-$0.42*	*-$0.45*	*-$1.18*	*-$0.91*	*-$0.73*

Sale weight is calculated at the midpoint of the weight range for each class of stock

The recent volatility in prices made it very difficult to identify appropriate prices for budgeting purposes. In this analysis an 'historical averages' value was calculated for use in the economic analysis (Table 15). This involved determining the average of the July 2008 to June 2019 price data (last 11 years) for each possible selling center and bringing that back to an equivalent price in Julia Creek, net of selling costs. No adjustment was made for the possible impact of inflation on the current value of the prices received in early years of the data. The price data was applied in the herd model to calculate the net price per head of stock sold (Table 15).

Table 15 – Net sale prices applied in the analysis for the Northern Downs base property (based on last 11 years of price data; July 2008-June 2019)

Category	Sale month	Paddock weight	Net Price on farm	Price basis	Value per head on farm	Equivalent 11-year average market price
Weaner steers	6	181	$1.92	Base	$347.52	$2.47, Roma
Heifers 1-2 years	7	328	$1.60	-$0.32	$524.80	$2.03, Roma
Heifers 2-3 years	7	472	$1.39	-$0.53	$656.08	$1.58, Townsville
Cows 3 years onwards	7	500	$1.45	-$0.47	$725.00	$1.64, Townsville
Steers 1-2 years	7	344	$1.89	-$0.03	$650.16	$2.35, Roma
Steers 2-3 years	7	495	$1.82	-$0.10	$900.90	$2.22, Roma
Bullocks 3 years	7	646	$1.77	-$0.15	$1,143.42	$1.98, Townsville
Bulls all ages	7	750	$1.45	-$0.47	$1,087.50	$1.64, Townsville

2.3.2 Herd parameters and gross margin

The sale prices, sale weights, selling costs, treatment costs and bull replacement strategy identified previously for the base cattle herd and property were applied to the herd structure shown in Table 6 to produce the herd gross margin shown in Table 16.

Table 16 - Herd parameters and gross margin for the base property

Parameter	Starting herd
Total AE	2,000
Total cattle carried	2,116
Weaner heifers retained	336
Total breeders mated	1,035
Total breeders mated and kept	755
Total calves weaned	673
Weaners/total cows mated	64.97%
Weaners/cows mated and kept	89.07%
Overall breeder deaths	3.43%
Female sales/total sales	47.94%
Total cows and heifers sold	300
Maximum cow culling age	11
Heifer joining age	2
One year-old heifer sales	1.46%
Two year-old heifer sales	20.00%
Total steers and bullocks sold	326
Maximum bullock turnoff age	2
Average female price	$700.82
Average steer and/or bullock price	$862.68
Capital value of herd	$1,188,146
Imputed interest on herd value	$59,407
Net cattle sales	$491,992
Direct costs excluding bulls	$38,803
Bull replacement	$17,010
Gross margin for herd	$436,179
Gross margin after imputed interest	$376,772
Gross margin/AE	$218
Gross margin/AE less interest on livestock capital	*$188*

AE, adult equivalent.

Note: bull sales are included in net bull replacement, not net cattle sales.

2.3.3 Investment returns

The additional information required to complete an investment analysis includes fixed, capital and finance expenses incurred, together with the opening and closing value of the land, plant and improvements. Fixed (or operating) costs are those costs which are not affected by the scale of the activities but must be met in the operation of the beef property. Table 18 indicates the assumed fixed cash costs for the property. Non-cash fixed costs include part or all of the operators allowance and will be identified later.

Table 17 - Fixed cash costs for the base property

Item	Cost
Accounting	$4,000
Administration, computer, postage	$2,500
Electricity, power	$5,000
Fuel and oil	$25,000
Contract mustering	$25,000
Insurance	$7,500
Motor Vehicle	$15,000
Rates rents	$15,000
Repairs and maintenance	$25,000
Telephone	$4,000
Wages and associated costs	$15,000
Total	*$143,000*

Table 18 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 on the basis of 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 18.

Table 18 - Plant inventory, replacement cost and salvage value for the base property

Item	Market value	Years to replacement	Replacement cost	Salvage value
4WD ute old	$15,000	10	$20,000	$5,000
4WD ute new	$50,000	10	$50,000	$20,000
Body truck	$70,000	20	$100,000	$20,000
Tractor and bucket	$50,000	25	$80,000	$25,000
Grader	$20,000	25	$20,000	$5,000
Quad bike x 2	$25,000	3	$25,000	$2,000
Motorbike x 2	$6,000	5	$12,000	$2,000
Trailer	$2,500	15	$2,500	$500
Buggy	$20,000	5	$20,000	$2,000
Workshop and saddlery	$50,000	10	$50,000	$0
Total	*$308,500*	-	*$379,500*	-

The allowance for operators labour and management was set at $80,000. The value of the land and fixed improvements for the example property was taken to be $5,000,000. This resulted in an opening value of the total of land, plant and improvements for the beef enterprise investment of $5,308,500. The investment analysis identified that the beef property returned about 2.8% on the capital invested over 30 years (Table 19). No allowance for any potential change in the real value of the land asset (i.e. capital gain net of inflation) was included.

Table 19 - Expected value of annual outcomes for the base beef property

Parameter	Value
Adult equivalents (AE)	2,000
Cash flow for debt service	$211,254
Return on total capital	$184,054
Rate of return on total capital	2.79%

3 Strategies to improve profitability and drought resilience

The constructed, base beef production system was used to test key strategies for their ability to improve the long-term profitability and drought resilience of the Northern Downs property. The strategies examined in this section of the report have been identified by producers and industry as potentially useful when preparing for drought. They were assessed for their capacity to improve the drought preparedness of the base beef property through building resilience and profit over time. 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 or production systems and hence it is recommended that beef producers 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 beef property. Secondly, this report indicates the data required to conduct such an analysis and the potential level of response to change revealed by relevant research and the expert opinion of scientists and beef extension officers with extensive knowledge of the region and of the northern Australian cattle industry. Whilst every effort was made to ensure that 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.

3.1 Age of steer turnoff and market options

3.1.1 Introduction

The optimum age of male turnoff on beef properties in northern Australia is driven by the relative profitability of breeders and steers. This, in turn, is a function of breeder productivity, steer performance, available markets, and the relative price of steer and female beef (Holmes *et al.* 2017; DAF 2018a). Modelling exercises using the Breedcow and Dynama software (Holmes *et al.* 2017) have consistently indicated that sale of older steers was more profitable than sale of weaners in northern Australia, with the optimal age varying with region and the parameters identified above (DAF 2018a).

3.1.2 Methods

The effect of alternative steer sale ages was modelled by comparing the alternatives in a steady-state herd model consisting of 2,000 AE on the property. Figure 8 shows the potential average liveweight of the steers at weaning (6 months) and when they are 19, 31 and 43 months old. Initially, the effect on profit of selling steers at alternative ages (and restructuring the herd to maintain equivalent grazing pressure) was considered to determine the optimum age of turnoff. The average of prices over the last 11 years was used (July 2008 – June 2019) as described in Section 2.3.1. The steer sale age scenarios were modelled as follows:

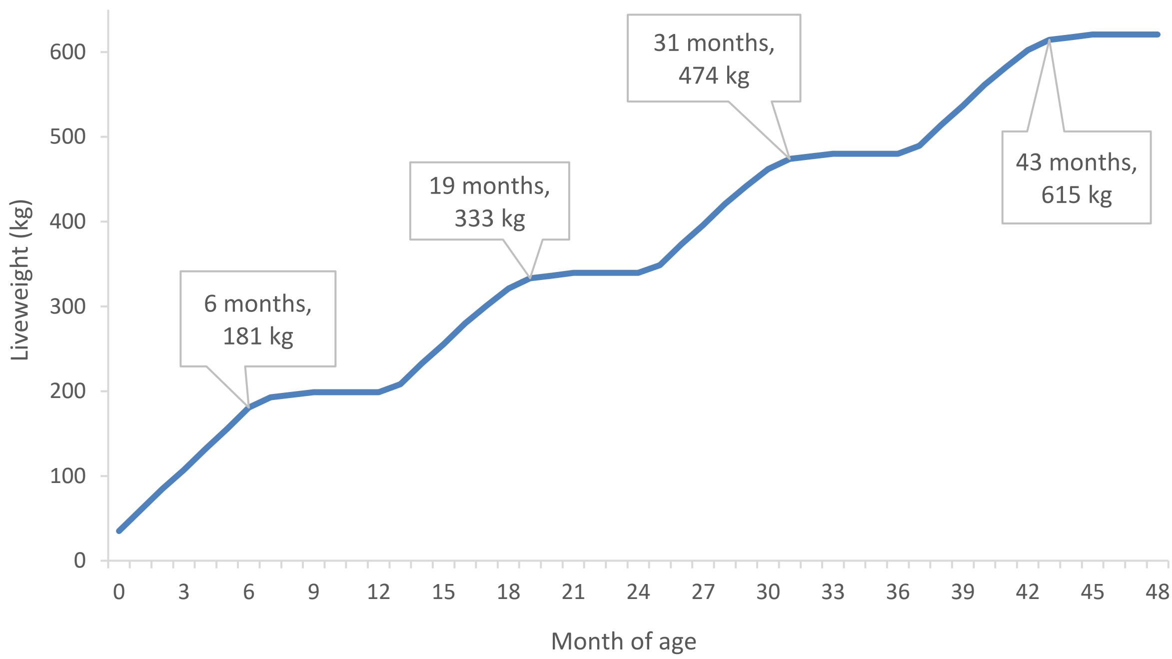
1. All steers were sold as weaners when 6 months old and 181 kg in the paddock. The net price on farm was $1.92/kg, 15 c/kg more than the long term price for slaughter steers.
2. All steers were sold at 19 months of age at an average of 333 kg liveweight in the paddock. The sale price, net on farm, was $1.89/kg, 3 c/kg less than the weaner steer price.

3. All steers were sold at an average of 474 kg liveweight when they were 31 months old. The net on farm price was $1.82, 10 c/kg less than the weaner steer price.
4. All steers were sold at an average of 615 kg liveweight when they were 43 months old. The net on farm price was $1.77, 15 c/kg less than the weaner steer price.

Secondly, a herd currently turning off weaner steers was modelled and used as a base for conversion to the optimum age of turn-off determined in the initial stage of this analysis. The latter analysis was conducted as some beef producers who currently target the production of weaner steers may consider targeting steer sales at an older age. There can be important impacts on cash flow, profit and investment returns when a change to an older age of turnoff is implemented.

Figure 8 – Northern Downs steer liveweight from birth to point of sale, showing alternative steer sale ages and weights

Boxes on the graph give steer age (months) and sale liveweight (kg)



3.1.3 Results and discussion

3.1.3.1 Optimising age of steer turnoff

In this strategy the effect on herd gross margin of selling steers at different ages: 6, 19, 31 and 43 months old, was considered. As indicated in Table 20 a steer sale age of 31 months was the most profitable over the most recent decade. This was the age of turn-off selected for the base beef herd (Section 2.3). Selecting a 43-month sale age for steers was less profitable but may reduce the exposure of the property to drought risk due to the slightly lower number of pregnant breeders maintained on the property due to the later age of sale for steers. Decreasing the proportion of breeders in the herd decreases drought risk due to the relatively greater nutritional demands of breeders related to reproduction, and the added complexity and expense of management interventions for heavily pregnant cows or cows with small calves. The results of the gross margin analysis indicated that the number of breeders retained on the property fell substantially as the age of turnoff of steers increased. A weaner steer producer may have about 50% more calving and lactating females during an extended dry season or drought than a producer selling slaughter weight steers. However, it is possible that as the number of steers on the property increase, the breeder component of the herd will be pushed back onto lesser quality country types, potentially leading to a fall in their performance.

Table 20 - Steer age of turnoff herd gross margin comparison with that for the base herd
The optimum age of steer turnoff was used as a base for comparison with alternatives

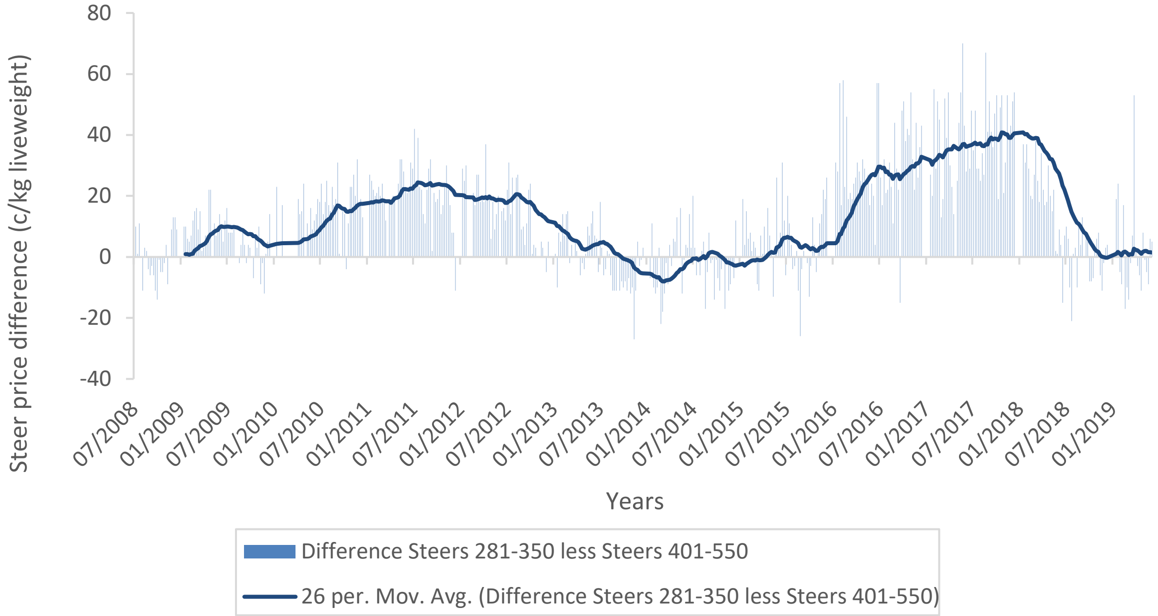
Parameter	Age of steer turnoff			
	6 months (Weaners)	**19 months**	**31 months (Base herd)**	**43 months**
Total adult equivalents (AE)	2,000	2,000	2,000	2,000
Total cattle carried	1,846	2,043	2,116	2,079
Weaner heifers retained	429	385	336	286
Total breeders mated	1,319	1,185	1,035	881
Total breeders mated and kept	962	864	755	643
Total calves weaned	857	770	673	573
Weaners/total cows mated	64.97%	64.97%	64.97%	64.97%
Weaners/cows mated and kept	89.07%	89.07%	89.07%	89.07%
Overall breeder deaths	3.43%	3.43%	3.43%	3.43%
Female sales/total sales	47.18%	47.56%	47.94%	48.32%
Total cows and heifers sold	383	344	300	256
Maximum cow culling age	11	11	11	11
Heifer joining age	2	2	2	2
Weaner heifer sale and spay	0.00%	0.00%	0.00%	0.00%
One year-old heifer sales	1.46%	1.46%	1.46%	1.46%
Two year-old heifer sales	20.00%	20.00%	20.00%	20.00%
Total steers and bullocks sold	429	379	326	274
Maximum bullock turnoff age	0	1	2	3
Average female price	$700.82	$700.82	$700.82	$700.82
Average steer/bullock price	$347.52	$629.37	$862.68	$1,088.55
Capital value of herd	$1,099,545	$1,121,494	$1,188,146	$1,251,164
Imputed interest on herd value	$54,977	$56,075	$59,407	$62,558
Net cattle sales	$417,221	$479,651	$491,992	$477,067
Direct costs excluding bulls	$38,718	$44,421	$38,803	$33,034
Bull replacement	$21,677	$19,472	$17,010	$14,482
Herd gross margin	$356,826	$415,757	$436,179	$429,551
Herd gross margin less interest on livestock capital	***$301,849***	***$359,683***	***$376,772***	***$366,993***
Difference to base herd	*-$74,923*	*-$17,089*	*Base*	*-$9,779*

The price differences between classes of steers have shown wide variation over the period of time modelled. Figure 9 indicates the weekly difference in prices between yearlings and feed-on steers at Roma sale yards over the past 11 years. There was, until recently, a substantial c/kg premium above that used in this analysis for steers that meet the live export or 'feed-on' (feedlot entry) criteria. This data suggests that the capacity to move a herd structure to a younger age of turnoff (19 months of age) may have been attractive over recent years based on the price premium for younger steers.

Even so, price premiums for younger steers are not a good indicator of the optimum age of steer turnoff for a breeding herd and retaining the 31 month steer sale age for the entire 11 years would have improved the profitability of the property compared to the 19 months of age turnoff scenario.

Figure 9 - Price margin of 281-350 kg liveweight steers compared to 401-550 kg liveweight steers at Roma saleyards (July 2008 – May 2019)

The bars indicate the price for lighter weight steers less heavier steers. The moving, 6-month, average of the difference is also shown



3.1.3.2 Moving from weaner steer production to an older age of turnoff

Table 21 shows the results of the 30-year analysis of the value of converting from weaner steer production to 2-3 year-old steer production (31 months). Implementing the change added ca. $71,100 to the annual profit of the enterprise. However, it can be seen that a substantial deficit occurred (-$122,100) due to the breeder herd reduction and the move to the older age of steer sale. The property manager considering the changed age of sale for steers would need to consider the impact of this deficit on the cash flow of the property. It was Year 2 before the cash flow issues were overcome.

Table 21 – Returns for converting from weaner steer production to 31 month-old steer production

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5.00%
NPV	$1,100,900
Annualised NPV	$71,100
Peak deficit (with interest)	-$122,100
Year of peak deficit	2
Payback period (years)	2
IRR	not calculable

The results for the Northern Downs region, indicating that weaner steer production is the least profitable age of turnoff, is in accord with results for the less productive Northern Gulf region (Bowen *et al.* 2019a) and the more benign central Queensland region (Bowen and Chudleigh 2018b). For all three regions, moving from a weaner turnoff production system to one producing older steers improved profit and drought resilience due to a reduction in the size of the breeder herd at the same grazing pressure. This result is, in part, due to low breeder efficiency (e.g. 65% weaning rate for the Northern Downs region) as well as the relatively higher value of steer compared to female beef. However, the peak deficit incurred while holding weaner steers to an older sale age would likely provide an obstacle to managers transitioning to an older turnoff target. High existing debt levels and associated interest payment commitments would further impede this age of turnoff transition for many producers.

3.2 Optimising cow and heifer culling and sale age

3.2.1 Introduction

As for age of male turnoff, the age of cow and heifer culling on beef properties in northern Australia can have an effect on the profitability of the business (Holmes *et al.* 2017; DAF 2018a). The optimum age of cow and heifer culling is driven by the relative sale price for breeders and heifers together with the expected reproduction efficiency and mortality for each class of females in the breeding herd.

3.2.2 Methods

The effect of alternative cow and heifer cull ages was modelled by comparing the alternatives in a steady-state herd model consisting of 2,000 AE on the property. The herd structure initially compiled to start the modelling process applied a 12-13 year cow culling age and indicated all non-pregnant cows could be culled from ages 2-3 to 12-13 years old with the exception of the 3 to 4 year-olds where 90% were culled. At this maximum cow culling age, only 14 (4%) of the yearling heifers were surplus to requirements and could be culled prior to mating. Once the initial herd was constructed and balanced so that sufficient weaner heifers were retained to maintain the herd structure, the 'Optimise Female Sales' macro in Breedcowplus was used to determine the optimum (most profitable) age of culling. This optimised age of culling was used in all subsequent scenarios except where yearling mating was applied as the base herd.

3.2.3 Results and discussion

The optimised female herd structure is shown in Table 22. Surplus heifers were culled in the same age group prior to mating except 1.46% were culled instead of 4.10%. The optimal final cull age for mature cows fell from 13 to 11 years. Even so, the improvement to final herd gross margin was minor ($211/annum).

Compared to the initial herd, the optimised herd mated and retained a similar number of cows, and produced about the same number of weaners. The small reduction in numbers of sale cattle was offset by the slight increase in the average sale value of cull females, and this resulted in the slightly increased herd gross margin. However, the key ingredient of risk not identified in the gross margin analysis is the increased risk of mortality presented by cows older than 10 years of age going into a drought. This important aspect is considered further in the accompanying reports for the Fitzroy and Northern Gulf regions (Bowen and Chudleigh 2018b and Bowen *et al.* 2019a, respectively) and in recorded presentations available from the project web 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/.

It is evident that a strategy of culling the majority of empty females at weaning does not allow many heifers to be culled pre-mating in a herd that averages a 65% weaning rate. The CashCow survey data for the Northern Downs country type (McGowan *et al.* 2014) indicated that although mortality rates slightly increased with increasing cow age, reproductive performance also improved slightly with increasing cow age (Table 5). In our modelling, sale weights and values were averaged for cull females 3-4 years and older as differences between age classes could not be substantiated with supporting data. These factors together with the prices paid for the various classes of female beef drive the result. Additional data that revealed more about the performance of cows as they aged would be required to change the answer. All breeders older than 8 years of age were grouped together as ‘aged cows’ in the CashCow data so some averaging of the data for aged and older cows may have occurred. It is possible that aged cows in the CashCow Northern Downs data represent a cohort of breeders that have been retained in the breeding herd due to continuing high levels of performance and resilience.

Although the difference between the initial herd structure and the optimised based herd structure was only small, the optimised herd was applied uniformly throughout all subsequent analyses as the base herd except where yearling mating was applied as the base herd for comparison with 1) yearling mating with genetic improvement, or 2) yearling mating with feeding first calf heifers.

Table 22 - Female herd structure after female sales optimisation

Important data highlighted grey

Parameter	Initial herd	Optimised base herd	Difference (Optimised minus Initial)
Total adult equivalents (AE)	2,000	2,000	0
Total cattle carried	2,113	2,116	3
Weaner heifers retained	337	336	-1
Total breeders mated	1,037	1,035	-1
Total breeders mated and kept	757	755	-2
Total calves weaned	674	673	-2
Weaners/total cows mated	65.07%	64.97%	-0.10%
Weaners/cows mated and kept	89.11%	89.07%	-0.04%
Overall breeder deaths	3.45%	3.43%	-0.01%
Female sales/total sales	47.94%	47.94%	0.00%
Total cows and heifers sold	301	300	-1
Maximum cow culling age	13	11	-2
Heifer joining age	2	2	0
Weaner heifer sale and spay	0.00%	0.00%	0.00%
One year-old heifer sales	4.10%	1.46%	-2.64%
Two year-old heifer sales	20.00%	20.00%	0.00%
Total steers and bullocks sold	327	326	-1
Maximum bullock turnoff age	2	2	0
Average female price	$695.09	$700.82	$5.73
Average steer and bullock price	$862.68	$862.68	$0.00
Capital value of herd	$1,187,410	$1,188,146	$736
Imputed interest on herd value	$59,370	$59,407	$37
Net cattle sales	$491,709	$491,992	$283
Direct costs excluding bulls	$38,745	$38,803	$58
Bull replacement	$17,033	$17,010	-$23
Gross margin for herd	$435,931	$436,179	$248
Gross margin less interest	***$376,560***	***$376,772***	***$211***
Gross margin/AE	$218	$218	$0
Gross margin/AE after interest	*$188*	*$188*	*$0*

3.3 Hormonal growth promotant for steers

3.3.1 Introduction

Hormone growth promotant (HGP) can increase growth rates of cattle by 10-30% and feed conversion efficiency by 10-15% depending on the period over which the cattle were treated and the nutrition available (Hunter 2009). The increased growth rates can have a substantial benefit, enabling the weight-for-age specifications of the target market to be met, particularly when cattle are grazing perennial grass-only pastures. However, cattle treated with HGP are excluded from the European Union (EU), Chinese and the Pasturefed Cattle Assurance System (PCAS) markets. In addition, HGP treatment can make it more difficult to achieve the Meat Standards Australia (MSA) grading specifications required to achieve maximum price per kg carcass weight, as HGP-treated cattle have a higher ossification score and receive an additional penalty in the MSA grading system. HGPs can increase carcass leanness by 5-8% which may not be beneficial when late-maturing genotypes are used to produce beef for markets requiring substantial fat levels at light carcass weights (Bowen *et al.* 2015). McLennan (2014) found that use of HGP implants continuously from weaning in *B. indicus* steers grazing native pastures in north Queensland, with or without molasses supplements, increased the net value added to the steers despite impeding compliance with MSA. Beef Central (2019) reported that the current demand for beef in China has led to substantial price premiums for non-HGP treated steers in both the grass-fed and grain-fed categories. Currently, Teys Australia applies a 10 c/kg dressed weight premium for non-HGP treated, grass-fed steers due to their extensive sales to China while JBS Australia does not apply a HGP grid distinction across generic grass-fed cattle classes (Beef Central 2019). Premiums for non-HGP treated, grain-fed steers can be as high as 30 c/kg dressed weight but such premiums are not uniformly applied across all steer classes or abattoirs.

3.3.2 Methods

The HGP strategy involved provision of HGPs continuously from weaning until sale as feed-on steers. This required two treatments with HGP that have effect over 400-day periods. Steers implanted with HGPs were assumed to have a growth rate 10% greater than steers in the baseline herd as per results of McLennan (2014) for *B. indicus* crossbred cattle grazing tropical pastures. Table 23 shows the monthly growth rates for steers with and without HGP treatment that were used in the analysis. Figure 10 shows the expected growth path of untreated steers and steers treated with HGP where the monthly growth rate was increased by 10%.

Table 23 - Monthly growth rate for steers with and without HGP treatment

Month	**Days**	**Steer growth rate (kg/d)**	
		Non-HGP treated steers	**HGP treated steers**
Jan	31	0.30	0.33
Feb	28	0.80	0.88
Mar	31	0.80	0.88
Apr	30	0.80	0.88
May	31	0.70	0.77
Jun	30	0.65	0.715
Jul	31	0.40	0.44
Aug	31	0.10	0.11
Sep	30	0.10	0.11
Oct	31	0	0
Nov	30	0	0
Dec	31	0	0
Total	*365*	*0.38*	*0.42*
		(140.2 kg/head.annum)	*(154.2 kg/head.annum)*

Figure 10 – Estimated steer growth paths from birth when grazing Mitchell grass pastures with or without HGP implants

In the first HGP scenario steers were sold at the same time as for steers in the base herd (ca. 31 months of age) but were 503 kg liveweight in the paddock (cf. 474 kg) and maintained the same price point. The herd model was adjusted to reflect the greater weight of steers in the herd and also the increased feed efficiency. It was assumed that the implanted steers had an increase in average feed conversion efficiency of 4.5% compared to non-implanted steers, meaning that implanted steers required 4.5% less feed than non-implanted steers to achieve the expected weight gain (Hunter 2009; McLennan 2014). The cost per HGP treatment was $8/head (400-day implant) and $2/head was incurred for the additional muster at yearling age to facilitate treatment. Steers were treated at no extra labour cost at weaning. The adjustments made for the use of HGPs in the steers resulted in the same allocation of the total property feed resources to the steers as for the breeders (Table 24).

Table 24 - Herd components for the base herd and with steers treated with HGP's

Herd component	Base herd	Herd with HGP
Total cows and heifers mated	1,035	1,036
Calves weaned	673	673
Weaner steers	336	336
Steers sold	326	326

As it is possible that feed-on steers treated with HGPs may receive price discounts, the impact of receiving a lower price for the treated steers was tested in a second scenario by reducing the expected average sale price at the yards by 10 c/kg liveweight.

3.3.3 Results and discussion

The predicted investment returns from implementing a strategy of HGP use from weaning until sale as feed-on steers at 31 months of age and using the same price for sale steers as for the base herd were positive (Table 25). The small peak deficit was caused by the requirement to adjust breeder numbers and the delay between spending on HGPs and selling the first lot of heavier steers. This moderate annualised NPV is consistent with the result obtained for HGP use for steers in central Queensland when a price penalty was not applied (Bowen and Chudleigh 2018b).

Table 25 – Returns for HGP use – heavier weight at 31 months and same price for sale steers as for base herd

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Interest rate for NPV	5.00%
NPV	$145,400
Annualised NPV	$9,500
Peak deficit (with interest)	-$12,700
Year of peak deficit	2
Payback period (years)	3
IRR	67%

The predicted investment returns from implementing a strategy of HGP use from weaning until sale as feed-on steers at 31 months of age but using a reduced price for sale steers (10 c/kg liveweight reduction at the sale yards) is shown in Table 26. The reduced sale price for steers made the use of HGPs unprofitable in this scenario. This result is also consistent with results for HGP use for steers in central Queensland when price penalty was applied (Bowen and Chudleigh 2018b). The move by several export markets to exclude meat treated with HGPs, and the subsequent implementation of lower price schedules for HGP-treated steers at some northern abattoirs, demonstrate the importance of getting the target market right when applying HGPs to improve steer growth rates.

Table 26 - Returns for HGP use – heavier weight at 31 months and reduced price for sale steers compared to the base herd

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Interest rate for NPV	5.00%
NPV	-$80,000
Annualised NPV	-$5,200
Peak deficit (with interest)	-$223,300
Year of peak deficit	never
Payback period (years)	never
IRR	not calculable

3.4 Production feeding a molasses mix to the steer 'tail'

3.4.1 Introduction

Steer growth rates in the Northern Downs region are often below genetic potential. This, in combination with the base herd scenario of often having to implement a second round of weaning for calves too light and young to wean at the first round, suggests that there will be a number of light steers in any age cohort that represent a ‘tail’. Nutritional supplements, to increase growth rates of these light steers which are unlikely to meet the target sale weights at the desired time, are commonly based on molasses.

Molasses is produced along the east coast of north Queensland and is a lower cost energy source than grains which have to be transported greater distances and have a substantial freight cost. Studies have demonstrated the inferior performance of rations based on molasses compared with those based on starch energy sources such as barley (e.g. McLennan 2014; Hunter and Kennedy 2016). However, McLennan (2014) demonstrated that the growth rates of weaner and yearling steers grazing native pastures could be markedly increased during the dry season by feeding a molasses-based production ration containing urea and a protein meal (supplement dry matter intakes of 1.0-1.2% liveweight/day): 0.40-0.44 kg/day additional liveweight gain compared to the non-supplemented control. The calculated conversion rates of molasses-based production mix to additional liveweight gain compared to un-supplemented cattle (kg DM supplement/kg additional gain) ranged from ca. 5.0 for weaner steers to 9.1 for yearling steers.

These more recent results support those from previous grazing trials using a similar supplement type (Lindsay 1996, 1998; Fordyce *et al.* 2009). They are also in line with results of pen studies where molasses-based production rations have been fed in conjunction with low quality tropical grass hays (e.g. Hunter 2012; Hunter and Kennedy 2016). However, McLennan (2014) found that, despite the younger age of turnoff of slaughter steers supplemented with the molasses-based production mix, the net value added to steers by supplementation was negative. This poor economic outcome from production feeding with a molasses mix was the result of the high cost of supplements required to attain the growth rate increases, the slim premiums paid for young vs. older steers at the abattoirs, the compensatory growth of steers which eroded the response to supplementation, and the changes in herd structure associated with slaughtering younger cattle, notably the higher numbers of cows and their associated higher drought risk.

3.4.2 Methods

In this scenario a molasses production mix was fed to a cohort of 2 year-old steers each year to increase their sale weight. The assumptions relating to the molasses mix, steer supplement intake and growth responses were informed with reference to published data (Lindsay 1996, 1998; Fordyce *et al.* 2009; Hunter 2012; McLennan 2014; Hunter and Kennedy 2016) and the experience of J. Rolfe and B. English (DAF, Mareeba). The composition and cost of the molasses mix is given in Table 27. The feed mix was expected to cost ca. $363/t on property.

Table 27 – Composition and cost of the molasses production mix fed to a cohort of 2 year-old steers annually

Ingredient	**Quantity (kg)**	**Cost ($/t)**
Molasses	1,000	$200
Copra	100	$600
Urea	40	$700
Kynophos	10	$1,000
Salt	10	$400
Rumensin	0.4	$8,000
Total weight of feed mix	1,160	-
Cost of feed mix	-	$263.01
Freight	-	$100
Total cost landed on property	-	*$363.01*

In this scenario 10% of steers (i.e. the tail of the mob) were drafted from the sale steers and fed the molasses production mix in the paddock for 90 days from mid-July. In the base herd model these light steers were sold at the same time as the heavier steers, but at lighter weights to free up paddock space. In this scenario the average number of steers fed the production mix annually was 32. They commenced feeding at an average liveweight of 425 kg and consumed ca. 1.2% of their liveweight/day as supplement DM (1.5%/day on an 'as-fed' basis). They were expected to gain 0.7 kg/head.day and reach 488 kg liveweight in the paddock at the end of the feeding period. The expected sale price was unchanged at $2.40/kg liveweight.

Costs of feeding included an allowance for the depreciation, repairs and maintenance on the equipment used to mix and hold the feed as well as the labour used to prepare and feed out the supplement, whether paid or unpaid. Steers were fed in a paddock and the major capital items were the feeding troughs and a feed mixer that were partly utilised by the feeding exercise and partly used for other purposes. Only 20% of the annual depreciation costs were allocated to this feeding exercise. The depreciation costs associated with the mixer and troughs were spread over 15 years which is considered to be their economic life and an allowance was made for the opportunity cost of any capital items required for the feeding program. Table 28 indicates the calculation of depreciation, maintenance and labour costs for the fed steers.

Table 28 - Depreciation, opportunity, maintenance and labour costs for the molasses production feeding scenario

Item	**% allocation to enterprise**	**Current value**	**Life in years**	**Annual value**	**Cost per head fed**
Depreciation and capital expense					
Feeders and troughs	0.20	$5,000	15	$67	-
Mixer	0.20	$5,000	15	$67	-
Total		$10,000		$133	-
Depreciation costs per head fed	-	-	-	$4.17	-
Opportunity cost of capital	-	-	-	5.00%	$3.13
Depreciation and capital opportunity costs per head fed	-	-	-	-	$7.29
Repairs and maintenance	-	-	-	$500	$15.63
Cost of labour (includes unpaid labour)	-	-	-	$500	$15.63

3.4.3 Results and discussion

Table 29 shows the calculation of the gross margin for the scenario of feeding the tail of the steer cohort a molasses production mix for 90 days from mid-July at 425 kg starting liveweight. As evident from the negative gross margin of -$160/head, the extra costs of feeding were greater than the extra benefits. If the feeding exercise were undertaken on a regular basis an allowance for the reduced time (3-6 months) that the steers would be retained on the property would need to be made by slightly increasing the overall size of the herd to maintain the same grazing pressure. The slight change expected in additional breeders mated would not offset the funds lost in the feeding exercise.

Note that cattle were valued going into the feeding operation at their long term market value less selling costs. This accurately reflects the opportunity cost of the steers to the molasses feeding exercise. The results are sensitive to the difference between the value ($/kg) of the steer at the commencement of the feeding exercise and the sale price of the steers at the conclusion of feeding as indicated in Table 30. About 40 c/kg liveweight more than the expected sale price would be required at the point of sale for the feeding exercise to be profitable. These results for feeding a molasses production mix to the steer tail in the Northern Downs are consistent with results for the Northern Gulf constructed property (Bowen *et al.* 2019a) where the gross margin per animal fed was -$87 and, similarly, ca. 40 c/kg liveweight more than the expected sale price of steers was required at the point of sale for the feeding exercise to be profitable.

Table 29 – Calculation of gross margin for feeding the tail of the steer cohort a molasses production mix to achieve target weights earlier

Parameter	Value
Feeding and stock costs	
Current weight in the paddock (kg)	425
Weight loss to saleyards (%)	5.0
Steer weight at saleyards (kg)	403.75
Sale price at yards ($/kg live)	$2.40
Gross sale price ($/head)	$969
Commission and insurance on sales (%)	3.5
Transaction levy, yard dues etc. ($/head)	$15.00
Transport cost ($/head)	$43.33
Steer value on property net of selling expenses	$877.00
Selling cost ($/kg)	$0.23
Average value of fed animals (c/kg on to feed)	$2.06
Average value into feed yard ($/head)	$876.76
Total number of livestock to be fed	32
Total opening value of livestock to be fed	$28,056
Expected daily gain (kg/d)	0.70
Number of days fed	90
Expected exit liveweight (kg)	488
Weight loss to saleyards	5.0%
Steer sale weight at saleyards	464
Feed consumption (% of liveweight consumed as dry matter)	1.2
% dry matter in feed	76
Supplement intake (kg/head.day, 'as-fed')	7.21
Total feed consumption (kg/head, 'as-fed')	649
Total feed required (t)	20.76
Total cost of feed 'as fed' ($/t including mixing costs and transport to property)	$363.01
Cost of feed per head 'as fed' ($/head)	$235.49
Other costs ($/head)	
Freight out	$54.17
Labour	$15.63
Interest on livestock capital (at 5%)	$10.81
Interest on feed (at 5%)	$2.90
Commission	$38.94
Transaction levy and yard fees	$15.00
Depreciation and opportunity cost of capital	$7.29
Repairs and maintenance	$15.63
Mortality	0%
Total feed and other costs ($/head)	*$395.86*
Income from sales	
Sale price at yards ($/kg live)	$2.40
Gross sale price ($/head)	$1,113
Gross margin per animal fed	***-$160***
Surplus or deficit per annum	-$5,119
Breakeven sale price ($/kg liveweight)	$2.75
Breakeven purchase price ($/kg liveweight)	$1.82

Table 30 – Sensitivity analysis ($) of the margin per animal fed a molasses mix to price change based on long-term market value of steers

Gross margin achieved in this scenario highlighted grey

Expected value of steers at saleyards prior to feeding ($/kg liveweight)	**Expected value on to feed ($/kg liveweight)**	**Expected sale price of fed steers at the saleyards ($/kg liveweight)**						
		$1.80	**$2.00**	**$2.20**	**$2.40**	**$2.60**	**$2.80**	**$3.00**
$1.80	**$1.46**	-$170	-$81	$9	$98	$188	$277	$367
$2.00	**$1.66**	-$256	-$167	-$77	$12	$102	$191	$281
$2.20	**$1.86**	-$342	-$253	-$163	-$74	$16	$105	$195
$2.40	**$2.06**	-$428	-$339	-$249	-$160	-$70	$19	$108
$2.60	**$2.26**	-$514	-$425	-$335	-$246	-$157	-$67	$22
$2.80	**$2.46**	-$600	-$511	-$422	-$332	-$243	-$153	-$64
$3.00	**$2.66**	-$687	-$597	-$508	-$418	-$329	-$239	-$150

Table 31 indicates the expected returns when current steer prices are applied in the model. Valuing the steers at $2.80 at the sale yards prior to sale and at $2.90/kg after the feeding exercise reduces the loss per head but is still unprofitable. The producer would still lose more than $3,000/pen of 32 steers fed. This example demonstrates that higher input and output prices for steers does not make molasses production feeding profitable. It is still necessary to add more than 40 c/kg to the input (sale yard) price of steers when they are sold to make a profit.

Table 31 – Sensitivity analysis ($) of the margin per animal fed a molasses mix to price change based on current steer prices

Gross margin achieved in this scenario highlighted grey

Expected value of steers at saleyards prior to feeding ($/kg liveweight)	**Expected value on to feed ($/kg liveweight)**	**Expected sale price of fed steers at the saleyards ($/kg liveweight)**						
		$2.30	**$2.50**	**$2.70**	**$2.90**	**$3.10**	**$3.30**	**$3.50**
$2.20	**$1.83**	-$104	-$15	$75	$164	$254	$343	$433
$2.40	**$2.03**	-$190	-$101	-$11	$78	$168	$257	$346
$2.60	**$2.23**	-$276	-$187	-$97	-$8	$81	$171	$260
$2.80	**$2.43**	-$362	-$273	-$184	-$94	-$5	$85	$174
$3.00	**$2.63**	-$449	-$359	-$270	-$180	-$91	-$1	$88
$3.20	**$2.83**	-$535	-$445	-$356	-$266	-$177	-$87	$2
$3.40	**$3.03**	-$621	-$531	-$442	-$352	-$263	-$173	-$84

A molasses feeding exercise may be useful after a below average wet season if a large proportion of steers are lighter than usual and would suffer a substantial price penalty if sold at the usual time but at lighter weights. The spreadsheet compiled for this exercise can be used to judge the profitability of such a short-term feeding exercise. However, the use of production rations as a drought management strategy may lead to unwanted pressure being placed on pasture resources and land condition.

3.5 First mating heifers as yearlings

3.5.1 Introduction

Yearling mating (usually between 13-17 months) may be a practical and desirable routine management option where heifer growth is sound. Generally, about 80% of *B. indicus* and *B. indicus* crossbred heifers weighing 275 kg will conceive (Doogan *et al*.1991). However, many heifers reach first oestrus (puberty) at well below 200 kg; equally, many have not reached first oestrus at 400 kg. Research in northern Australia (Fordyce *et al*. 1996) on first evidence of oestrus in Brahman crossbred heifers found that average weight and age at first oestrus in un-supplemented heifers was 285 kg at 20.5 months. The first oestrus variation was high with standard deviations of 6.6 months and 71 kg liveweight, respectively. First oestrus was reached by 67% of animals within the 225-325 kg liveweight range and 15-27 months of age.

In studies of mated yearlings (about 14 months of age at joining) pregnancy rates ranged from 25-63% in Brahman (Fordyce 1996) and 33% in Brahman crossbred (Doogan *et al*. 1991) heifers. However, annual mortalities of yearling mated heifers increased to 4.5% compared to an annual average of 2% mortality in heifers mated as 2 year-old (Holroyd and Fordyce 2019). About 33% of these mortalities were calving related (Fordyce *et al*. 1995; Jayawardhana 1998). The pregnancy rate of these yearling-mated heifers, as lactating first calf cows (colloquially called 'rebreed rate'), was variable and seasonally and nutritionally dependent but ranged from 46-85%.

Schatz (2010) also identified weight as the most important factor affecting the onset of puberty in heifers in northern Australia. Although there is an interaction with age, heifers have to be a critical weight before reaching puberty. This critical weight varies both between and within breeds as shown in Table 32.

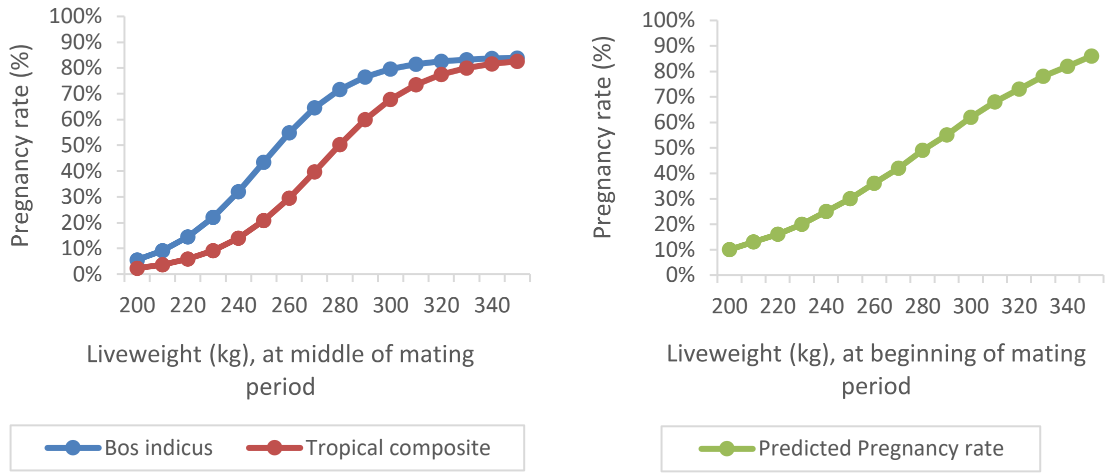
Table 32 - Weights at which purebred and crossbred heifers show oestrus (Schatz 2010)

Cattle breed	**Percentage in oestrus**		
	50%	**70%**	**90%**
	Body weight (kg)		
Angus	250	273	295
Brahman	307	330	341
Brangus	273	295	318
Charolais	318	341	352
Hereford	273	295	318
Santa Gertrudis	307	330	341
Limousin	295	318	341
Simmental	284	307	341

Figure 11 shows the predicted pregnancy rates for heifers experiencing a 12-week mating period. Measures of the performance of first calf heifers made at the Douglas Daly Research Station in the Northern Territory (NT) by Schatz (2010) show that re-conception rates in first calf heifers were quite high by NT standards (overall re-conception rate 67%). This is in comparison to Schatz and Hearnden (2008) who only found first calf heifer re-conception rates in excess of 30% on 2 out of 12 properties (i.e. 17%) when performance recording on NT commercial properties.

Figure 11 - (a) Effects of breed on pregnancy rate vs. weights, for heifers under a 12-week mating period (from Mayer et al. 2012) and (b) Effect of pre joining weight on pregnancy rate in maiden heifers (joined for the first time as yearlings at Douglas Daly Research Station, Northern Territory; from Schatz 2010)

(a) (b)



Schatz (2010) also found that pre-calving nutrition treatment did not have a significant effect on re-conception rates at Douglas Daly Research Station. Overall 68% of heifers receiving a high plane of nutrition, and 65% of control heifers, reconceived. This is somewhat surprising since it is generally accepted that pre-calving weight/body condition affects re-conception rates in first calf heifers (Wettemann *et al*. 1986; Short *et al*. 1990). The lack of relationship in the study of Schatz (2010) was due to the quality of the nutrition (improved and fertilised pastures) which allowed the heifers to maintain sufficient weight and condition through the period while they were lactating (and being joined for the second time) so that most were able to reconceive.

Schatz and Hearnden (2008) analysed data collected on NT commercial properties and found that there was a very strong relationship (P<0.0001) between the average weight of lactating first calf heifers at weaning and their re-conception rate. This data was used in Schatz (2010) to calculate re-conception rates for of heifers with different average weights at weaning (Table 33). The Schatz and Hearnden (2008) data showed that there was no consistent relationship between pre-calving weight and weight at weaning. While most heifers lost weight during this time (the average weight change of heifers from all properties in the study was -40 kg), the amount of weight that they lost varied from property to property (average weight change ranged -88 to +11 kg).

Table 33 - Predicted re-conception rates for first calf heifers on Northern Territory cattle properties from different average weights at the time when their calves are weaned (WR1); (Schatz 2010)

The equivalent approximate pre-calving weights (PC Wt) are shown for scenarios when heifers lose 20, 40, or 60 kg from pre-calving weight (PC) to weaning round 1 (WR1)

WR1 Wt (kg)	Re-conception rate	PC Wt if lose 20 kg from PC - WR1 (kg)	PC Wt if lose 40 kg from PC - WR1 (kg)	PC Wt if lose 60 kg from PC – WR1 (kg)
250	**1%**	270	290	310
260	**2%**	280	300	320
270	**3%**	290	310	330
280	**3%**	300	320	340
290	**5%**	310	330	350
300	**6%**	320	340	360
310	**8%**	330	350	370
320	**11%**	340	360	380
330	**14%**	350	370	390
340	**18%**	360	380	400
350	**23%**	370	390	410
360	**29%**	380	400	420
370	**36%**	390	410	430
380	**43%**	400	420	440
390	**50%**	410	430	450
400	**58%**	420	440	460
410	**65%**	430	450	470
420	**72%**	440	460	480
430	**77%**	450	470	490
440	**82%**	460	480	500
450	**86%**	470	490	510
460	**90%**	480	500	520
470	**92%**	490	510	530
480	**94%**	500	520	540
490	**96%**	510	530	550
500	**97%**	520	540	560

3.5.2 Methods

In this scenario, the extra returns from transitioning the optimised base herd to yearling mating, was examined. The growth model for the Northern Downs region base herd identified that yearling heifers at mating were likely to average 200 kg liveweight and be 240 kg at mid-mating, suggesting an average 35% conception rate. First calf heifers are likely to average about 380 kg liveweight at weaning (heifers who have a calf in December, put on half the expected weight gain as per Schatz (2010)) suggesting a 43% re-conception rate. In this yearling mating scenario, yearling mated heifers that did not conceive were retained and mated in the following mating period with an expected conception rate of 80% (Figure 12). The reproduction parameters and mortality rates for the herd with yearling mating are shown in Table 34.

Figure 12 - Calculation of heifer conception rates when yearling mating is practiced and no pregnancy-tested empty (PTE) yearling heifers are culled

PTIC, pregnancy-tested in-calf

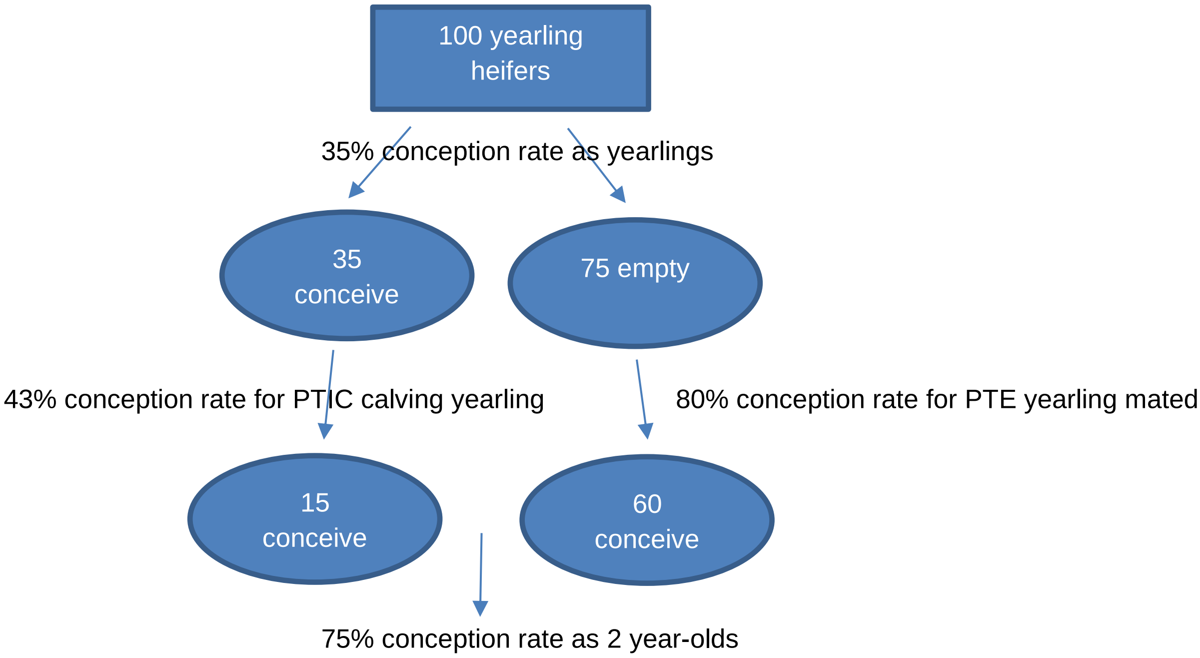


Table 34 - Reproduction parameters and mortality rates for the herd with yearling mating

Initial cattle age **Final cattle age**	**Weaners** **1**	**1** **2**	**2** **3**	**3** **4**	**4** **8**	**8** **11**
Expected conception rate for age group (%)	n/a	35	75	55	75	76
Expected calf loss from conception to weaning (%)	n/a	14.9	10.0	7.2	7.2	9.3
Proportion of empties (PTE) sold (%)	n/a	0	100	100	100	100
Female death rate (%)	1.5	5[#]	4	3	3	4
Male death rate (%)	1.5	1.5	1.5	1.5	1.5	n/a

- mortality risk in yearling heifers is increased from 1.5% to 5% to account for the increased pressure placed on heifers mated as yearlings

Mating the yearling heifers changed the herd structure on the base property. Table 35 shows the change in the herd structure and herd performance if the yearling mating exercise were to be continued. To balance the herd model, and maintain constant grazing pressure, once yearling mated was implemented about 2.4% of 2 year-old heifers were culled prior to mating. All heifers and cows 2-3 years plus in age were culled on pregnancy status and cows were last mated at 9-10 years old which was the new optimum culling age. Compared to the base herd, the yearling-mating herd had a lower weaning rate from cows mated, a greater number of calves weaned, less (no) yearling heifers sold, a decreased age of last mating (by 1 year) and a greater average female sale price per head.

Table 35 – Herd performance parameters for the base herd and the herd with yearling mating (both optimised)

Key data highlighted grey

Parameter	Base herd	Yearling mating
Total adult equivalents (AE)	2,000	2,000
Total cattle carried	2,116	2,147
Weaner heifers retained	336	362
Total breeders mated	1,035	1,314
Total breeders mated and kept	755	1026
Total calves weaned	673	725
Weaners/total cows mated	64.97%	55.13%
Weaners/cows mated and kept	89.07%	70.64%
Overall breeder deaths	3.43%	3.97%
Female sales/total sales	47.94%	47.35%
Total cows and heifers sold	300	316
Maximum cow culling age	11	10
Heifer joining age	2	1
Weaner heifer sale and spay	0.00%	0.00%
One year-old heifer sales	1.46%	2.43%
Two year-old heifer sales	20.00%	25.00%
Total steers and bullocks sold	326	351
Maximum bullock turnoff age	2	2

3.5.3 Results and discussion

Table 36 indicates the extra returns generated from transitioning the optimised base herd to yearling mating. Although the yearling-mated herd required more bulls, the adjustment to breeder numbers during the changeover covered most of that extra capital cost, resulting in an improvement in annual profit of ca. $8,700. It is important to note that, although the property with yearling mating achieved a 10% lower weaning rate on average, it was more profitable than the base situation. However, the risks associated with yearling mating in a highly variable climate should not be underestimated. If yearling mating was implemented, the property would have, on average, about 120 lactating, yearling mated heifers every year that would be at significant mortality risk in the event of a delayed or failed wet season scenario which could occur in ca. 8 out of 30 years (J. Rolfe pers. comm.). Smith *et al.* (2013) identified losses of up to 18% occurring in young, wet breeders when seasonal conditions seriously deteriorated, double that of heifers from the same group who were not wet (lactating) over the same period. Although the herd model has increased mortality rates for yearling mated heifers, it is unlikely that all of the risks associated with yearling mating are fully accounted for in our analysis. The increased risk of calf loss and mortality in first and second calf heifers would suggest that increasing them as a proportion of the overall breeding herd would require exceptional levels of herd management and timeliness. Failure to be very responsive in management would occasionally lead to serious crashes in production that would take some time to overcome.

A further consideration is that the conception rates applied in this yearling mating scenario rely on the assumed average liveweight gain of 133 kg/head for heifers. A lower estimate of annual liveweight gain of heifers in this environment would likely make the yearling mating scenario uneconomic. Previous analyses conducted for beef enterprises across northern Australia indicate that implementing a practice of mating yearling heifers in regions with low and variable levels of nutrition is unlikely to be economically positive (Chudleigh *et al.* 2016).

Table 36 - Returns for transition to yearling mating

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5%
NPV	$133,300
Annualised NPV	$8,700
Peak deficit (with interest)	-$23,900
Year of peak deficit	10
Payback period (years)	13
IRR	not calculable

3.6 Supplementing first-calf, yearling heifers to improve re-conception rates

3.6.1 Introduction

Energy and protein supplements for first-calf heifers are often recommended as best management practice to increase re-conception rates (Dixon 1998; DAF 2018b). Recent research by Schatz (2010) investigated whether pre-partum supplementation during the dry season with a suitable supplement could reliably increase re-conception rates in first-lactation heifers in the Victoria River District (VRD) of the NT. Schatz (2010) concluded that feeding pre-partum protein supplements for a period of at least 100 days until green grass is available at the start of the wet season is a reliable method of changing re-conception rates in first-lactation heifers in the VRD. The trial groups achieved a 42% improvement in re-conception rates with the predicted pregnancy rate changing by between 4-4.6% (average 4.4%), for each 10 kg change in the pre-calving weight corrected for stage of pregnancy, for heifers with pre-calving body weights between about 380 and 460 kg.

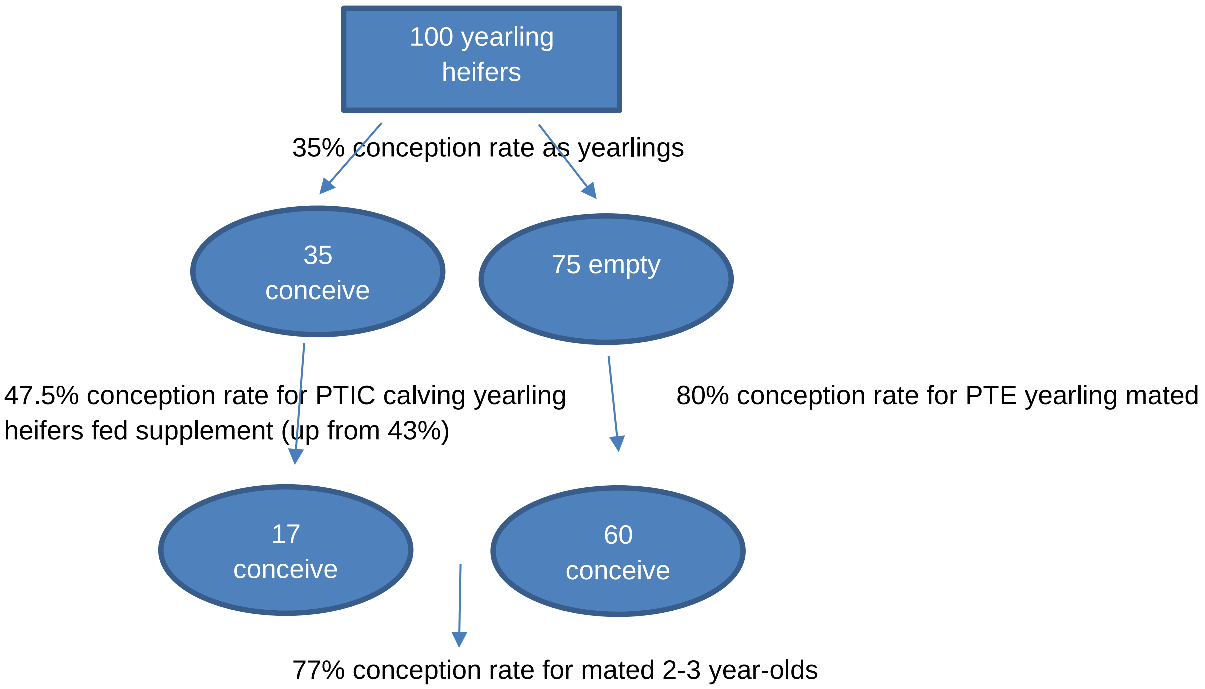
3.6.2 Methods

In this strategy, a change in the re-conception rate of first-calf, lactating yearling heifers was sought by improving their bodyweight prior to calving with an M8U supplement (molasses with 8% urea by weight). For this scenario, the base for comparison was a herd with heifers first mated as yearlings but with no supplementation to improve re-conception rates.

The parameters for this supplementation scenario were based on a study undertaken by Schatz (2010). That study investigated whether pre-partum supplementation during the dry season with a high-protein supplement could reliably increase re-conception rates in first-lactation heifers at the Kidman Springs Research Station of the NT. The available nutrition and climate of the Northern Downs and Kidman Springs are sufficiently similar for the NT trial results to be considered relevant. Although the trial groups averaged a 42% improvement in conception rates, analysis of the trial data identified that the predicted pregnancy rate will change by between 3% and 4.6% for each 10 kg change in the pre-calving weight (corrected for stage of pregnancy) for heifers with pre-calving body weights within 340-460 kg.

The growth path for the Northern Downs region base herd identified that first calf yearling heifers were likely to average about 324 kg liveweight just prior to calving. Feeding the heifers with an M8U mix ($280/t landed in Julia Creek) for 100 days prior to calving was expected to allow the heifers to gain an additional 15 kg of liveweight as long as the pasture being grazed had at least 6 MJ ME/kg DM available. The additional 15 kg of bodyweight was expected to improve the conception rate by 4.5% in the supplemented, pregnancy-tested, in-calf (PTIC) yearling mated heifer group (Schatz 2010). The new conception rate was applied to the Northern Downs herd with yearling mating model to identify the investment returns that may be gained by feeding first lactation yearling heifers with a suitable protein supplement (Figure 13).

Figure 13 - Calculation of overall conception rate for heifer classes when pregnancy-tested in-calf (PTIC) yearling heifers are fed



Following supplementation, the adjustment to the first-calf, yearling-mated heifer conception rate was made and surplus heifers created by the change in reproduction efficiency were sold as 2-3 year-olds to maintain the same grazing pressure and culling strategy. The conception rates for heifers and age groups older than the 2-3 year age group were maintained at the same level as the un-supplemented base herd. The one-off feeding of the M8U supplement to one group of heifers was considered unlikely to change the overall average sale weight of culls cows from the herd or the grazing pressure applied by the fed group so the sale weights and paddock weights were maintained.

As a result of supplementation, it was assumed that the overall conception rate for 2-3 year-old heifers increased from 75% to 77% and the weaning rate (from cows kept) for the herd changed from 55.13% to 55.29%. The breeder herd with the heifer feeding strategy produced the same number of weaners/annum on average from 10 fewer cows being mated (Table 37).

Table 37 - Cows mated and weaners produced with pregnancy tested in-calf (PTIC) yearling heifer feeding

Key data highlighted grey

Parameter	**Herd where heifers are first mated at 2 years of age**	**Yearling mating (Base for comparison with heifer feeding scenario)**	**PTIC yearling heifer feeding**
Total adult equivalents (AE)	2,000	2,000	2,000
Total cattle carried	2,116	2,147	2,149
Weaner heifers retained	336	362	362
Total breeders mated	1,035	1,314	1,039
Total breeders mated and kept	755	1,026	1,030
Total calves weaned	673	725	724
Weaners/total cows mated	64.97%	55.13%	55.29%
Weaners/cows mated and kept	89.07%	70.64%	70.24%
Overall breeder deaths	3.43%	3.97%	3.98%
Female sales/total sales	47.94%	47.35%	47.33%
Total cows and heifers sold	300	316	315
Maximum cow culling age	11	10	10
Heifer joining age	2	1	1
Weaner heifer sale and spay	0.00%	0.00%	0.00%
One year-old heifer sales	1.46%	2.43%	0.00%
Two year-old heifer sales	20.00%	25.00%	28.36%
Total steers and bullocks sold	326	351	351
Maximum bullock turnoff age	2	2	2

The calculation of the expected feeding cost of the M8U supplement is shown in Table 38. One-off capital expenditure of $5,000 was required for troughs and feeding out equipment. Approximately 35% of the yearling mated heifers were fed the supplement as PTIC heifers. In this case, the comparison was between a herd with yearling mated heifers and the same herd adjusted to show the impact of the feeding exercise on reproduction efficiency, herd structure and feeding costs over time.

Table 38 – Calculation of annual M8U feeding costs for pregnancy-tested, in-calf (PTIC), 1-2 year age group heifers

Parameter	Value
Number of PTIC heifers to be fed	122
Average body weight (kg)	330
Food consumed (0.4% liveweight; kg/head.day)	1.32
Number of days to be fed	100
Total intake of supplement (kg/head.day)	132
Cost of supplement ($/t landed)	$280
Total supplement fed (t)	16
Total cost of supplement ($)	$4,509
Cost of feeding out (twice/week)	28.57
Wages and fuel for 1 feeding out	$100
Total cost of feeding out the supplement	$2,857
Total cost of the supplement and the feeding out	$7,366
Cost per head fed per annum	$60.38

3.6.3 Results and discussion

Table 39 shows the predicted investment returns for feeding M8U supplement to first-calf, lactating and yearling-mated heifers to achieve an improved re-conception. This strategy reduced the profit of the property by ca. $11,100/annum compared to a property with yearling mating but no supplementation. These results are in accord with those for both the Northern Gulf region (Bowen *et al.* 2019a) and the central Queensland region (Bowen and Chudleigh 2018b) where the scenario was to improve re-conception rates of first-calf heifers mated as 2 year-olds. In the Northern Downs, supplementation of first-calf, yearling-mated heifers improved re-conception rates by 4.5% (43 to 47.5%). The re-conception rate of the un-supplemented first calf heifers was improved in the Northern Gulf region by a greater amount (6% from a base of 45%) and in central Queensland by a lesser amount (2% from a base of 78%).

Table 39 - Returns for investment in M8U supplement for first-calf, yearling heifers to improve re-conception rates

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5%
NPV	-$170,400
Annualised NPV	-$11,100
Peak deficit (with interest)	-$479,500
Year of peak deficit	never
Payback period (years)	never
IRR	not calculable

3.7 Better genetics for breeder fertility in a herd with yearling mating

3.7.1 Introduction

Research has identified that improvement in herd weaning rates are possible by applying selection for reproduction efficiency. Examples of relevant research results include:

- Johnston *et al.* (2013) identified that opportunities exist, particularly in Brahman cattle, to improve weaning rates though genetic selection.
- Burns *et al.* (2014) estimated that an EBV for sperm motility in Brahman cattle may lift lifetime weaning percentage by 6% points in 10 years.

3.7.2 Methods

The benefits expected to arise from converting the base female herd with yearling mating to a breeding herd with different genes for reproduction that provide a 6% point improvement in breeder weaning rates, as per Burns *et al.* (2014), were tested. A herd with yearling mating was used as the base for comparison for this strategy as such a herd will result in a faster improvement in weaning rate than 2 year-old mating. This strategy was tested using two methods of implementation. One approach (Scenario 1) changed over the breeding bull herd in the first year and incurred a capital cost and the second approach (Scenario 2) replaced the breeding bulls as they came due for replacement and incurred no additional capital costs. Both approaches to implementing the change paid no more per head for the bulls with the different genes for fertility.

In Scenario 1 it was assumed that the property manager converted all of the current breeding bull herd to one with different genes in the first year of the analysis with the first group of genetically different calves born towards the end of the second year. The calendar year was used in the analysis which resulted in calves being born around November of the first year from the mating prior to the changeover of the bulls. On this basis it was Year 4 before yearling heifers with genes capable of providing a 6% point improvement in conception rate were first mated and calved. Heifer culling and mating strategies were maintained as the genes for reproduction efficiency spread through the breeder herd. This meant that all of the heifers were still mated as yearlings and retained, surplus 2-3 year-old heifers were culled before mating and remaining 2-3 year-old replacement heifers were culled on PTE status (i.e. not in-calf) after mating. Mature cows were culled on the basis of pregnancy status and their age.

The cost of replacement herd bulls was set at the same price used in the base herd, i.e. $3,500. The net cost of the changeover of all of the herd bulls at the beginning of the investment period was $68,250 (39 x $3,500 for the new bulls less 39 x $1,750 for the old ones). A total of 50% of the existing herd bulls were sold on to industry while 50% went to the abattoirs.

No other herd performance parameters were changed. The herd structure was rebalanced to maintain grazing pressure as the genes for reproduction efficiency flowed through the breeding herd. The age for final culling for mature breeders was maintained at the same age as the base herd with yearling mating. Table 40 shows the change in weaning rate and other factors as the genes flowed through the breeding herd and performance increased. The herd modelling indicated that it was likely to take at least 8 years for the overall herd weaning rate to improve by 5.47% points if the entire bull herd was replaced in the first year. The increase in weaning rate stabilised at 5.47% points rather than 6% points due to the numbers in the first-calf heifer class increasing as a proportion of the herd.

The cow culling strategy of the base herd was maintained to allow identification of the net benefits of the change in weaning rates.

Table 40 - Modelled steps in genetic change of weaning rate with first year bull replacement, at same cost, in a yearling mated herd

The herd weaning rate is shaded grey

Parameter	Base herd with yearling mating	Year 4	Year 6	Year 8	Year 10	Year 12
Total adult equivalents (AE)	2,000	2,000	2,000	2,000	2,000	2,000
Total cattle carried	2,147	2,149	2,141	2,134	2,131	2,130
Weaner heifers retained	362	367	369	369	370	370
Total breeders mated	1,314	1,300	1,265	1,240	1,226	1,220
Total breeders mated and kept	1,026	1,014	1,003	995	991	990
Total calves weaned	725	734	737	739	739	739
Weaners/total cows mated	55.13%	56.48%	58.26%	59.56%	60.28%	60.60%
Overall breeder deaths	3.97%	3.97%	3.93%	3.90%	3.89%	3.89%
Female sales/total sales	47.35%	47.43%	47.50%	47.56%	47.58%	47.58%
Total cows and heifers sold	316	321	324	325	325	326
Maximum cow culling age	10	10	10	10	10	10
Heifer joining age	1	1	1	1	1	1
One year-old heifer sales	2.43%	4.77%	11.61%	16.03%	18.09%	18.66%
Two year-old heifer sales	25.00%	25.00%	19.00%	19.00%	19.00%	19.00%
Total steers and bullocks sold	351	356	358	358	359	359
Maximum bullock turnoff age	2	2	2	2	2	2

Scenario 2 involved introduction of the different genes for fertility at a slower rate and without the additional capital costs as incurred by the Scenario 1. In Scenario 2 replacement bulls (with the different genes for fertility) were purchased at the same cost as the previous herd bulls but as the herd bulls became due for replacement. That is, herd bulls were not all replaced in Year 1 of the analysis and the smaller number of new bulls were considered likely to have impact on the first calving, not the second calving as applied in the first scenario looking at genetic improvement of fertility. It was assumed that there were no additional costs in herd management. The heifers produced by the new bulls were grouped with the base herd heifers of the same age and all were subject to the same selection criteria as they moved through the age cohorts of the breeding herd. The constraint that no additional costs should be incurred prevented the identification of the genetically different heifers so that females with and without the different genes had the same chance of being culled. The new bulls were allocated to mature cow groups with the highest conception rates so that proportionally more heifers with the genes for fertility were likely to be mated in any age cohort as the different genes flowed through the herd. We acknowledge that this allocation of bulls would be challenging in reality. However, this strategy modelled the fastest possible rate of spread of the improved genes throughout the herd, thereby giving the most positive possible economic outcome for this strategy.

Table 41 shows the incremental change in conception rates over the first 5 matings as the new bulls replaced the current bull herd. All heifers had the different genes from the 6th mating and it was Year 12 before the entire breeder herd was converted.

Table 41 - Modelled steps in genetic change of conception rate with bulls replaced over time in a yearling mated herd

Herd parameter	Mating				
	1st	**2nd**	**3rd**	**4th**	**5th**
Total herd bulls	39	39	39	39	39
Bulls with different genes	8	16	23	31	39
Mature cows mated to different bulls	260	520	780	1,040	
Number that conceive	195	390	517	712	
Number that wean a calf	181	362	480	661	
Heifer weaners produced	90	181	240	330	
Yearling heifers	89	178	236	325	
Two year heifers pre culling	89	178	236	325	
Heifers with different genes mated	87	174	231	318	
Total heifers mated	348	348	348	348	
Percentage of heifers with different genes	25.0%	50.0%	66.2%	91.2%	100%
Improvement in conception rate of mated heifers	1.5%	3.0%	4.0%	5.5%	6.0%
Improvement in conception rate of 3-4 year heifers		1.5%	3.0%	4.0%	5.5%
Improvement in conception rate of 4-5 year cows			1.5%	3.0%	4.0%
Improvement in conception rate of 5-6 year cows				1.5%	3.0%
Improvement in conception rate of 6-7 year cows					1.5%
Year of impact	Year 3	Year 4	Year 5	Year 6	Year 7

Table 42 shows the change in herd structure over the 12 years taken to fully implement the strategy.

Table 42 - Modelled steps in genetic change of weaning rate and herd structure with bulls replaced over time, and at the same cost, in a yearling mated herd

The herd weaning rate is shaded grey

Parameter	Base herd with yearling mating	Year 3	Year 5	Year 7	Year 9	Year 11	Year 12
Total adult equivalents (AE)	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Total cattle carried	2,147	2,147	2,144	2,135	2,129	2,126	2,125
Weaner heifers retained	362	363	366	369	370	370	370
Total breeders mated	1,314	1,311	1,284	1,244	1,223	1,209	1,206
Total breeders mated and kept	1026	1023	1011	996	989	984	984
Total calves weaned	725	727	733	738	740	740	740
Weaners/total cows mated	55.13%	55.47%	57.06%	59.34%	60.49%	61.23%	61.40%
Weaners/cows mated and kept	70.64%	71.07%	72.46%	74.14%	74.82%	75.20%	75.27%
Overall breeder deaths	3.97%	3.97%	3.95%	3.90%	3.88%	3.87%	3.86%
Female sales/total sales	47.35%	47.37%	47.45%	47.55%	47.60%	47.62%	47.63%
Total cows and heifers sold	316	317	321	325	326	327	327
Maximum cow culling age	10	10	10	10	10	10	10
Heifer joining age	1	1	1	1	1	1	1
Weaner heifer sale and spay	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
One year-old heifer sales	2.43%	3.03%	8.04%	15.37%	19.26%	21.42%	21.83%
Two year-old heifer sales	25%	25%	22%	19.55%	19%	19%	19%
Total steers and bullocks sold	351	353	355	358	359	359	359
Maximum bullock turnoff age	2	2	2	2	2	2	2

3.7.3 Results and discussion

The beef property was no better off with the investment in better genetics for breeder fertility, when changeover costs were incurred to replace all bulls in Year 1 to improve the average herd weaning rate by 5.47% (Table 43). Immediate change-over of bulls reduced the property profit by ca. $1,800/annum. The return on extra capital (1%) was not inviting for what could be considered to be a fairly risky investment with uncertain outcomes. The alternative to replacing the bull herd in Year 1 was to follow the normal replacement strategy but purchase bulls with the potential to improve breeder fertility as predicted by Burns *et al*. (2014). This strategy resulted an improvement to property profit of ca. $1,800/annum (Table 43).

Table 43 - Returns for investing in genetically superior bulls to improve breeder fertility in a yearling mated herd

All terms defined in the Glossary of terms and abbreviations

Factor	Immediate bull changeover, same cost	Gradual bull changeover, same cost
Period of analysis (years)	30	30
Discount rate for NPV	5%	5%
NPV	-$27,100	$28,200
Annualised NPV	-$1,800	$1,800
Peak deficit (with interest)	-$136,600	$0
Year of peak deficit	6	6
Payback period (years)	never	7
IRR	1%	28%

The results for investment in genetic improvement of weaning rate in the Northern Downs are similar to the results for the same genetic improvement applied in a representative beef herd in central Queensland where returns were also slightly reduced or changed minimally as a result of implementing these alternative strategies (Bowen and Chudleigh 2018b; Chudleigh *et al.* 2019a). However, the results were less than for the same genetic improvement in the Northern Gulf region: $4,100 and $6,800 extra profit/annum for immediate and gradual bull changeover, respectively (Bowen *et al*. 2019a). The difference in results between the two more productive regions (central Queensland and Northern Downs) and the Northern Gulf region is largely due to the effect of diminishing returns for change in weaning rate for the central Queensland and Northern Downs regional herds which had an average base weaning rate of 77% and 65% respectively from cows mated (as per CashCow data of McGowan *et al.* (2014)) cf. 59% in the Northern Gulf. This effect of diminishing returns is illustrated by comparing the percentage change in herd gross margins per AE after interest resulting from implementing the genetic improvement strategy. The increase in herd gross margin with immediate bull changeover for the Northern Gulf property was ca. $10 per AE after interest (8.1% improvement) between Year 1 and Year 12 as a result of the 5.51% point increase in herd weaning rates. The corresponding increase in herd gross margin for the Northern Downs region property was ca. $3 per AE after interest (1.4% improvement) resulting from a 5.47% point improvement in weaning rates over 12 years.

Beef producers have to be aware that the time taken to change the reproduction efficiency of the herd through selecting only replacement bulls with the characteristics described by Burns *et al.* (2014) would be decades and any reduction in other herd performance parameters due to the introduction of the genes for changed reproduction efficiency would quickly negate any potential for economic gains.

3.8 Objectively selected home-bred bulls

3.8.1 Introduction

Replacement bulls are a substantial cost to the property. If home-bred bulls, produced from a group of breeders with sound performance, are objectively selected, tested for soundness and used in the breeding herd, this could substantially reduce the cost of bull replacement. This strategy would rely on the selected bulls at least maintaining the performance parameters of the total herd over time.

3.8.2 Methods

In this strategy, the potential economic impact of selecting breeding bulls from the male weaners, rather than purchasing replacement bulls, was tested. The strategy involved the objective selection of home-bred bulls so as to maintain the starting performance parameters of the total herd over time. The comparison was with the base herd that had 2 year-old heifer mating.

The opening complement of herd bulls required for the breeding herd, when stabilised at 2,000 AE, was about 31 bulls (bull to cow ratio of 3%). In the base herd, ca. six replacement bulls entered the herd annually (ca. 20% of bull herd) as 2 year-olds, purchased for an average landed cost of $3,500. Herd bulls were kept for 5 years with the annual mortality rate expected to average 5%. The percentage of bulls used in the breeding herd was expected to continue at 3% when the change to home-bred bulls was made. Table 44 shows the structure and replacement strategy for the breeding bull herd for the base property.

Table 44 – Bull replacement strategy and cost for the base herd using purchased bulls

Parameter	Value
Number of bulls required	31
Cost of bulls purchased annually (6 bulls costing $3,500 each)	$21,000
Value of bulls sold annually (5 bulls at $1,015 each)	$5,075
Average value per head of bulls on hand	$2,435
Net bull replacement cost (total)	$17,010
Net bull replacement cost per calf weaned	$25.29

The home-bred bull scenario involved identifying a group of male weaners at the first round weaning that had been produced by cows with sound reproductive performance. The weaner bulls were kept to yearling age when 50% were sold after being culled on objective measures such as weight gain, tick score and scrotal size. Cull yearling bulls were sold at the same average price for steers of the same age. The final group of selected bulls entered the breeding bull herd after testing for soundness. Culled herd bulls of a mature age sold to the abattoirs for the same average value as for the base herd using purchased bulls. The first group of weaner bulls was retained in the 1st year of the analysis and entered the bull herd in the 3rd year.

This scenario relied upon the maintenance of accurate records for the reproduction performance of heifers over their first two matings so that young cows with better reproduction performance could be identified, segregated and their progeny identified. These young females were used to maintain a group of cows to produce the calves from which the weaner bulls were selected. It was assumed that 40 cows would be kept as a separate breeder group for the purpose of producing home-bred bulls. Any non-pregnant females in the separate breed group were replaced with cows that had produced a viable weaner at their 1st mating and were then PTIC at first round weaning after their second mating.

The additional costs expected to be incurred by the bull selection process were $100 per weaner bull retained ($1,300/annum). These costs included costs of additional record keeping, bull testing and some additional labour. A total of $10,000 worth of additional fencing and water infrastructure was required to maintain the weaner and yearling bulls separate until they entered the bull herd. Additional expenses incurred in maintaining the records for the heifers and the segregated breeders were expected to be about $50 per cow retained in the segregated herd ($2,000/annum).

3.8.3 Results and discussion

The investment in conversion to home-bred bulls rather than purchased bulls was paid back by the end of Year 3 of the analysis, with an extra profit of ca. $10,000/annum, on average, over the life of the investment (Table 45). The return on the extra funds invested was 53% per annum. Similar, positive returns for investing in production of home-bred bulls was determined for a constructed property in the Northern Gulf region of Queensland (Bowen *et al.* 2019a) where the IRR was 59% (cf. 53% here). The key assumptions were that the bull to cow mating ratio could be maintained and that no aspect of herd performance (reproduction or growth) would be impacted by the change. The positive returns for this scenario, comparative to others examined for the Northern Downs property, indicate that a strategy of investing in producing home-bred bulls is worthy of further consideration. Doubling the cost of recording the performance of the retained breeder herd (from $50/head.annum to $100/head.annum) reduced the return on extra capital invested to 39% and the annualised NPV from $10,000 to $8,000/annum.

Table 45 - Returns for investing in production of home-bred bulls compared to the base herd
All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5%
NPV	$153,600
Annualised NPV	$10,000
Peak deficit (with interest)	-$17,300
Year of peak deficit	2
Payback period (years)	3
IRR	53%

3.9 Investing to reduce foetal/calf loss

3.9.1 Introduction

The CashCow project (McGowan *et al.* 2014) identified median values of 14.9% foetal/calf loss in heifers, 4.7% in first lactation cows and an overall rate of 10% for the CashCow Northern Downs region, which is applicable to the Northern Downs region study area applied in this analysis (Table 46). These losses occurred sometime between conception (pregnancy testing) and weaning. Calf losses were identified in the CashCow project if a heifer or cow was diagnosed as pregnant in one year and was recorded as dry (non-lactating) at an observation at least one month after the expected calving month the following year. This measure of foetal/calf loss, as it was derived in the CashCow project, excludes cow mortality and associated calf losses during the same period.

Table 46 - Median reproduction performance for the Northern Downs region (McGowan et al. 2014)

Reproduction performance indicator	Heifers	First lactation cows	2nd lactation cows	Mature	Aged	Overall
P4M*		45	62	67	71	66
Annual pregnancy**	87	75		82	83	80
Foetal/calf loss	14.9	4.7		7.2	9.3	10
Contributed a weaner^	77	68		71	70	72
Pregnant missing#		6.7		7	6.5	6.6

*P4M – Percentage of lactating cows that became pregnant within four months of calving

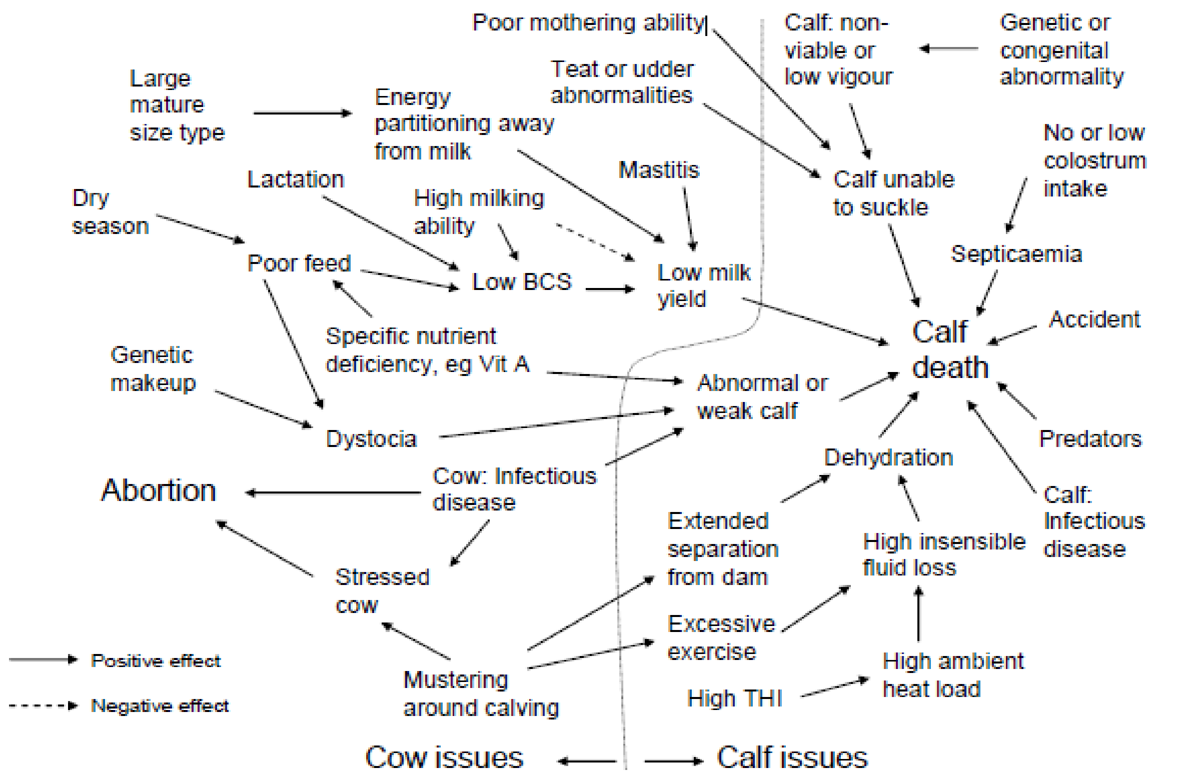
** Percentage of cows in a management group (mob) that became pregnant within a one-year period. For continuously mated herds, this included cows that became pregnant between September 1 of the previous year and August 31 of the current year

^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.

#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.

The CashCow project developed a possible causal pathway for calf loss (Figure 14). Each property manager would need to work their way through the factors likely to be affect calf/foetal loss in their herd based on the modelling of the CashCow project and the causal pathways identified in Figure 14 if a relatively high value for loss in any age class of females was identified. From there an analysis based on the identified cause and effect pathway could proceed.

Figure 14 - Possible causal pathway for foetal and calf loss in northern Australia (McGowan et al. 2014)



3.9.2 Methods

In this strategy an investment to reduce foetal/calf loss in all breeders was investigated. The comparison was with the base herd with 2 year-old heifer mating. The median values identified in the CashCow project for the Northern Downs region (McGowan *et al.* 2014) were maintained at the median level of loss estimated in the CashCow project. Table 47 indicates the values for calf loss and conception rate applied in the without-change (base) herd model in the analysis.

Table 47 - Expected rates of conception and calf loss applied in the herd model with 2 year-old mating

Cattle age start year **Cattle age end year**	**1** **2**	**2** **3**	**3** **4**	**4** **8**	**8** **11**
Expected conception rate for age group	0%	80.0%	55.0%	75.0%	76.0%
Expected calf loss from conception to weaning	0%	14.9%	4.7%	7.2%	9.3%

The wide range of possible agents and combinations of agents identified by the CashCow project, together with a lack of other research data indicating a 'typical' cause and effect relationship for our beef property limits the identification of appropriate strategies to reduce foetal/calf loss. The question was rephrased to look at what level expenditure could be incurred on a per head per annum basis to resolve a foetal/calf loss problem. The first question was:

1) If $5, $7.50 or $10 was spent per head across the entire breeder herd including weaner heifers, and foetal/calf loss reduced by 50%, what would be the return on the funds spent?

As the CashCow project (McGowan *et al.* 2014) also identified that additional capital costs (such as effective fencing, good paddock design, appropriate segregation, training of cattle, and selection for temperament) could be required to address the problem of foetal/calf loss, a second question was assessed:

2) What amount of capital could be spent (upfront) to reduce calf mortality by 50% across all breeders on this property?

The data from the new steady-state herd model with 50% lower rates of calf loss across all breeders and weaner females were then imported as the new herd culling target for the investment herd model with 2 year-old mating and the additional treatment costs inserted from the 1st year. Where the examples considered additional capital expenditure, the capital costs were added to the capital purchases section of the first year of the investment model. This reflected the expectation that a 1-year (minimum) lag between expenditure and receipt of benefits would be expected for any strategy aimed at improving foetal/calf loss. The treatment cost allocated included the cost of any treatment plus any additional labour required to undertake the treatment. The effective economic life of additional capital invested was taken to be 30 years with no residual value. The 2 year-old mating herd model (without change; base herd) and the 'with change' 2 year-old mating models were compared to identify the additional returns achieved.

3.9.3 Results and discussion

Table 48 presents the results of the investment analysis to achieve a 50% reduction in calf loss across all breeding females at cost levels of $5, $7.50 and $10 per retained female treated per annum or upfront capital expenditure of $50,000, $75,000 and $100,000. The analysis indicates that no more than $7.50/head.annum across the entire breeding herd including weaner heifers should be spent on reducing foetal/calf loss by 50% if a return on the funds invested was being sought. For this size of herd and property, expenditure of up to $100,000 as upfront capital expenditure with no additional ongoing expenses appears worth further consideration on the basis that foetal/calf loss is reduced by at least 50% across the entire breeding herd. The maximum amount of capital that can be invested upfront to resolve a calf loss issue is directly related to the size and current productivity of the herd together with the level of change in productivity achieved. On the other hand, the size of the herd would not impact the benefits arising from applying per head treatment costs as only the current level of herd productivity and the change in herd productivity would impact benefits.

It is very important to recognise that the likely benefit of any combination of upfront capital and expenditure on additional livestock treatments should not be inferred from this analysis. Additionally, it should be recognised that at present strategies that can achieve a 50% reduction in calf loss have not been identified and demonstrated. However, as current research activities are being conducted in this area of reducing foetal/calf loss it was deemed pertinent to consider the amount of money that could be invested in reducing foetal/calf loss for an individual beef property if a return on funds invested was being sought.

These results for the Northern Downs region are in accord with those for both less productive (Northern Gulf; Bowen *et al.* 2019a) and more productive (central Queensland; Bowen and Chudleigh 2018b) regions of Queensland. In the Northern Gulf region, the same conclusion was reached that no more than $7.50/head.annum across all breeding females could be spent on reducing foetal calf loss by 50%. Also, that up to $100,000 as upfront capital expenditure could be spent to achieve the same biological response. In the central Queensland region where median breeder reproductive performance was higher, no more than $5/head.annum could be spent on heifers and first lactation cows to achieve the same 50% reduction in calf loss in those groups, only. Additionally, a lesser amount of $20,000 as upfront capital could be spent to achieve the same biological response.

Table 48 - Returns for investing to achieve a 50% reduction in calf loss across all breeding females

All terms defined in the Glossary of terms and abbreviations

Factor	Investment type					
	$5/head. annum	$7.50/head. annum	$10/head. annum	$50,000 capital	$75,000 capital	$100,000 capital
Period of analysis (years)	30	30	30	30	30	30
Discount rate for NPV	5%	5%	5%	5%	5%	5%
NPV	$74,100	$20,200	-$33,200	$134,300	$110,500	$86,700
Annualised NPV	$4,800	$1,300	-$2,200	$8,700	$7,200	$5,600
Peak deficit (with interest)	-$7,100	-$10,600	-$96,200	-$50,000	-$75,000	-$100,000
Year of peak deficit	1	1	never	1	1	1
Payback period (years)	1	4	never	7	7	13
IRR	102%	25%	not calculable	26%	17%	12%

3.10 Converting from breeding to steer turnover

3.10.1 Introduction

A number of properties in the Northern Downs region 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 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 and relative steer purchase and sale prices can be determined from the price analysis. The modelling of a steer growing activity will allow consideration of the question:

- Is it more profitable to run the property solely as a steer growing operation, or as a breeding operation turning off only home-bred steers at the same age and weight?

The main difference between the two activities is that the steer growing (turnover) 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 base herd with 2 year-old mating (Section 2.3).

3.10.2 Methods

In this scenario, the effect on profitability from converting from a breeding to a steer turnover operation was assessed. The herd model was restructured to purchase weaner steers at the average weaner weight of the home-bred steers. They were then held the same amount of time and sold for the same weight and value as identified for the steers sold in the base herd model with 2 year-old mating. The purchase price of the weaner steers was based on the value applied to calculate the on-farm value of the weaner steers ($1.92 on-farm, Julia Creek) except in this model the steers were purchased and then transported to a point equivalent to the distance to Julia Creek from Townsville (Table 49). It is recognised that steers may be purchased across a number of regions but the cost to the enterprise was decided by working back from the previously calculated on-farm price as well as the cost of the cost of transport to the property, settling the cattle on the property, and the cost of finding the steers. All other husbandry, selling costs, selling prices and sale weights for steers were maintained at the same value as the steers produced by the breeder herd with 2 year-old heifer mating. The annual mortality rate in purchased steers was doubled compared to that experienced by the steers produced by base breeder herd (1.5% increased to 3%/annum) based on anecdotal evidence.

Table 49 – Landed cost of purchased, turnover steers

Purchases are on a liveweight basis

Parameter	Value
Travel costs	$1,554
Number purchased	1,554
Travel cost/head	$1.00
Transport cost/head	$27.44
Induction cost/head	$5.00
Average purchase liveweight (kg)	181
Buying cost/kg	$0.18
Nominal purchase price/kg at the yards	$2.23
Landed purchase cost/kg	$2.41
Cost per head on farm	*$436.07*

Removing the breeding herd and replacing them with steers changes the livestock schedule. Table 50 indicates the typical livestock schedule for the steer growing operation.

Table 50 – Livestock schedule for the steer turnover operation

Description	Opening number	Number purchased	Number sold	Closing number
Weaner steers	-	1,554	0	1,507
1 year-old steers	1,507	0	0	1,462
2 year-old steers	1,462	0	1,462	0

3.10.3 Results and discussion

Table 51 compares the livestock trading schedule for the property operated as a steer turnover operation with the property operated as a breeding and growing operation with 2 year-old heifer mating. Table 52 compares the resulting livestock gross margins for a steer turnover vs. breeding operation.

Table 51 - Livestock trading schedule for steer turnover and breeding operations

Parameter	**Steer turnover**		**Breeder herd**	
	Number	**Value**	**Number**	**Value**
Opening stock	2,969	$2,209,699	2,741	$1,633,913
Purchases	1,554	$679,207	6	$21,000
Births	0	$0	673	$0
Transfers in	0	$0	0	$0
Number unaccounted for	0	$0	0	$0
Total	*4,523*	*$2,888,906*	*3,420*	*$1,654,913*
Net Sales	1,462	$1,261,238	632	$496,541
Deaths	92	$0	67	$0
Rations	0	$0	0	$0
Transfers out	0	$0	0	$0
Closing Stock	2,969	$2,209,699	2741	$1,633,913
Total	*4,523*	*$3,470,937*	*3440*	*$2,130,454*
Trading profit or loss		*$582,031*		*$475,541*

Table 52 - Livestock gross margin for steer turnover and breeding operations

Parameter	**Steer turnover**	**Breeder herd**
Trading profit or loss	$582,031	$475,541
Other livestock income	$0	$0
Sales livestock produce	$0	$0
Agistment	$0	$0
Gross Income	$582,031	$475,541
Variable expenses	$44,335	$38,787
Gross margin (before interest)	*$537,697*	*$436,754*

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 turnover and the breeding operation equivalent) is about $2.70/kg at the yards. This is 20% more than the long term average price applied in calculating the steer purchase price in the steer turnover operation. This means that steer purchase prices could increase by up to 20% above their long term average, with sale prices for steers maintaining the same average price point, before the steer growing and the breeding operation produce about the same herd gross margin.

Table 53 shows the stock movement during the first 12 months of the transition from a breeding operation to a steer turnover operation. Most of the activity is expected to be undertaken mid calendar year. The transition from a breeder herd to a steer turnover operation was completed over the first 12 months and this required the entire female component of the existing herd be sold over a short period of time. The existing steers were retained and added to the purchased steers to achieve full carrying capacity of the property.

Table 53 - Livestock schedule for the year of transition from breeding to turnover steers

Start of year Description	Start year	Purchase	Sell	Closing numbers
New calves	n/a	0	0	0
Heifer weaners	337	0	337	0
Heifers 1 year	331	0	331	0
Heifers 2 years	321	0	321	0
Cows 3 years	247	0	247	0
Cows 4 years	143	0	143	0
Cows 5 years	104	0	104	0
Cows 6 years	76	0	76	0
Cows 7 years	55	0	55	0
Cows 8 years	40		40	
Cows 9 years	29		29	
Cows 10 years	21		21	
Cows 11 years	15		15	
Steer weaners	336	1,200	0	1,490
Steers 1 year-old	331		0	321
Steers 2 years	326	0	326	0
Herd bulls	29	2	23	
Total cattle	*2,741*	*1,202*	*2,068*	*1,819*
Total adults	*2,068*	*0*	*1,731*	*1,819*

Table 54 indicates the extra returns generated by transitioning from the breeder herd to the steer turnover operation where the price basis relevant to the past decade was maintained: ca. $62,500 extra profit/annum. However, additional capital was required to establish the steer turnover operation and almost a decade was required to break-even with the current investment in the breeding operation. In addition to the relatively substantial improvement in profitability from implementing this strategy, there are less tangible benefits associated with transitioning from a breeder operation to steer turnover. Most importantly, a steer turnover operation lends itself to more timely destocking during dry periods. The highly variable annual rainfall and subsequent pasture growth in this region necessitates periodic destocking of properties, estimated to occur in ca. 8 out of 30 years (J. Rolfe pers. comm.). Generally there is a more flexible approach associated with a steer growing operation enabling managers to sell-down cattle more readily in response to poor seasons. Conversely it is problematic for those managing a breeder operation 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 in northern Queensland strongly suggest that the stress and emotional price tag of running excessive 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 (J. Rolfe pers. comm.). However, it is impossible to prescribe what a suitable balance might be between a breeding component and a steer growing/trading 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 54 - Returns for converting from a breeding to a steer turnover operation at long term prices

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5%
NPV	$961,500
Annualised NPV	$62,500
Peak deficit (with interest)	-$576,700
Year of peak deficit	2
Payback period (years)	9
IRR	18%

3.11 Purchasing a breeder property in the Northern Gulf region of Queensland

3.11.1 Introduction

Some beef producers in north Queensland have a breeder property located in the forest country and a another property located on the Northern Downs that takes weaner steers from the breeding herd to grow them out on Mitchell grass pastures. This system of beef production has developed over time and is thought to be in response to a number of key factors, (not necessarily in order of importance):

- the price risk associated with purchasing weaner steers for a steer growing operation;
- the perception that a regular supply of steers of a known quality will be available from the breeder property;
- a desire of some families located in the region to build a beef production system of sufficient size to maintain employment for family members who wish to work in the beef industry;
- the perception that having breeding and steer growing systems located in different regions will reduce production risks, particularly those associated with the production variability of the Northern Downs region of north Queensland;
- the better steer growth rates often available from the Mitchell grass pastures of the Northern Downs compared to the native pastures of the forest country, especially during years with more favourable rainfall patterns; and
- the history of better access to southern Queensland markets and production systems by properties located on the Northern Downs. Cattle from the Northern Downs have commonly been sold into the south and east of Queensland, however, the development of live export markets out of northern Australia is changing this.

Previous analysis indicated that purchasing and growing steers on the constructed Northern Downs property was more profitable than a breeding enterprise (Section 3.10). However, analysis for a constructed Northern Gulf region property (Bowen *et al.* 2019a) showed that sale of weaners was less profitable than targeting sale of export steers. Therefore, managing the two properties separately, individually optimised for profitability, may be the best strategy. It is possible that property investment decisions are being made on the perception that the high cattle prices prevailing in the northern beef industry over recent times will continue for some time so the effect of cattle prices on the outcome of the investment should be considered in an analysis of this strategy.

3.11.2 Methods

In this strategy, the owner of the constructed Northern Downs property decides to buy a breeder property in the Northern Gulf region of Queensland. Three scenarios were examined to consider alternative options for managing the two properties:

1) Running the Northern Gulf property as a 'calf factory', transferring weaner steers from that block to the Northern Downs property.

2) Running the properties separately by continuing the Northern Gulf property as a separate entity where no cattle were transferred to the Downs property.

3) Running the properties separately, as for Scenario 2. However, rather than using long-term cattle prices, the higher average cattle prices achieved over the past 5 years were maintained (in real terms) over the 30-year investment period.

Table 55 Indicates the prices applied as representing the on-farm prices averaged over the last 11 and 5 years at Julia Creek. The equivalent price at the chosen indicator market, for the same period of years, is also shown.

Table 55 – Net sale prices applied based on last 11 years and last 5 years of price data

Category	**Paddock weight (kg)**	**Net price on- farm Julia Creek last 11 years**	**Equivalent 11-year average market price**	**Net price on-farm Julia Creek last 5 years**	**Equivalent 11-year average market price**
Weaner steers	181	$1.92	$2.47, Roma	$2.46	$3.07, Roma
Heifers 1-2 years	328	$1.60	$2.03, Roma	$2.05	$2.52, Roma
Heifers 2-3 years	472	$1.39	$1.58, Townsville	$1.75	$1.96, Townsville
Cows 3 years onwards	500	$1.45	$1.64, Townsville	$1.80	$2.01, Townsville
Steers 1-2 years	344	$1.89	$2.35, Roma	$2.41	$2.92, Roma
Steers 2-3 years	495	$1.82	$2.22, Roma	$2.31	$2.75, Roma
Bullocks 3 years	646	$1.77	$1.98, Townsville	-	-
Bulls all ages	750	$1.45	$1.64, Townsville	$1.80	$2.01, Townsville

The Northern Downs property was modelled as a breeder property with 2 year-old heifer mating, and turning off 31-month old steers. The Northern Gulf property was modelled as the constructed, base property applied in the Northern Gulf analysis as part of this same project (Bowen *et al.* 2019a). The Northern Gulf property purchased in this strategy was the property after implementing 10 years of land condition restoration and effective wet season P supplementation for cattle. Therefore, the Northern Gulf property purchased had 30,000 ha of native pastures on representative land types and carried ca. 1,500 adult equivalents (AE). The management features of the self-replacing Brahman breeding herd included continuous mating and adequate wet season P supplementation. At this level of management and inputs, the average mortality rate was expected to be 2.5% and the average weaning rate from all cows mated ca. 57%. The average annual post-weaning weight gain for steers was expected to be ca. 113 kg/head. The steers produced by the base herd were sold to the live export market in two groups, either at 29 months old and 418 kg (the lead) or 41 months old and 414 kg (the tail).

In Scenario 1, the Northern Gulf property was purchased, walk-in-walk-out (WIWO), and all weaner steers transferred to the Northern Downs property. The Northern Gulf property then built up breeder numbers to compensate for the transfer of the steers to the Northern Downs property, i.e. the Northern Gulf property became a weaner production operation. The Northern Downs property also reduced breeder numbers to accommodate the weaner steers taken from the Northern Gulf property. The Northern Downs property then held the Northern Gulf weaners through to feed-on weights together with the steers produced by the residual breeders left on the Northern Downs property after the transition. The combined properties had to repay the debt which was incurred by the WIWO purchase of the Northern Gulf property.

In Scenario 2, the Northern Gulf property was purchased, WIWO, and it was continued as an export steer production operation. The Northern Downs property was also maintained as a breeding and steer growing operation. There was no transfer of cattle between the properties and the combined properties had to repay the debt of the Northern Gulf property purchase.

Total debt incurred covered land, plant and cattle for the Northern Gulf property and was the same amount in each of the three scenarios: $5,407,194.

3.11.3 Results and discussion

Table 56 indicates the change in herd structure for the purchased Northern Gulf property when weaner steers were produced for transfer to the Northern Downs property in Scenario 1. The steady-state gross margin calculation for the property indicated that the underlying average net profit of the Northern Gulf property was reduced by about $64,000/annum by the change from export steer production to weaner steer production. When run as a ‘calf factory’, the Northern Gulf property transferred ca. 288 weaner steers per annum to the Northern Downs property.

Table 56 – Scenario 1: Herd structure for the purchased Northern Gulf property when producing either export steers for sale or weaner steers for transfer to the Northern Downs property

Parameter	Export steers	Weaner steers
Total adult equivalents (AE)	1,500	1,500
Total cattle carried	1,739	1,539
Weaner heifers retained	233	288
Total breeders mated	805	997
Total breeders mated and kept	751	931
Total calves weaned	465	576
Weaners/total cows mated	57.76%	57.76%
Weaners/cows mated and kept	61.91%	61.91%
Overall breeder deaths	2.50%	2.50%
Female sales/total sales	47.89%	46.52%
Total cows and heifers sold	202	251
Maximum cow culling age	11	11
Heifer joining age	2	2
Two year-old heifer sales	60.55%	60.55%
Total steers and bullocks sold	220	288
Maximum bullock turnoff age	3	0
Average female price	$669.40	$669.40
Average steer and/or bullock price	$834.79	$306.13
Capital value of herd	$990,254	$940,865
Imputed interest on herd value	$49,513	$47,043
Net cattle sales	$319,118	$255,924
Direct costs excluding bulls	$63,107	$60,378
Bull replacement	$26,301	$32,586
Gross margin for herd	$229,710	$162,960
Gross margin less interest	*$180,197*	*$115,917*

Table 57 shows the herd structure for the Northern Downs property with the transfer of weaner steers from the Northern Gulf property after the transition period during which the herd structures on both properties are adjusted to the new herd targets.

Table 57 – Scenario 1: Herd structure for the Northern Downs property with and without the Northern Gulf property purchase and transfer of weaner steers from the Northern Gulf

Breeder herd components	Without Northern Gulf property	With Northern Gulf property and transfer of weaner steers
Total cows and heifers mated	1,035	849
Calves weaned	673	550
Weaner steers	336	275+287

Table 58 indicates the extra returns generated by the purchase of the Northern Gulf property and either 1) converting it to a weaner production block (a calf factory), 2) running it separately as an expert steer production system, or 3) running it separately but assuming the higher average cattle prices of the last 5 years will be maintained (in real terms) over the next 30 years. The large negative results indicate that, regardless of whether it is run in combination with the Northern Downs property or separately, purchasing a breeder property in the Northern Gulf is problematic due to the inherent low productivity and profitability, and the high capital cost of this venture. Maintaining the average cattle prices achieved over the last 5 years for the 30-year period of the investment, for both the Northern Gulf and the Northern Downs properties, did not make the investment any more inviting. In the latter scenario (Scenario 3) the return on assets for the individual Northern Gulf property was still < 1%, even with the assumption of higher cattle prices. Hence, reducing equity below 60% to purchase the Northern Gulf property was problematic for all scenarios. Equity did not increase above 50% over the 30-year period.

Although all three investment scenarios produced negative returns, purchasing a breeder block in the Northern Gulf region and turning it into a 'calf factory' for a Northern Downs property was substantially less profitable than purchasing the Northern Gulf property and running it with the optimal production system, i.e. producing export steers. The analysis did not incorporate potential growth in capital value in real terms but that is unlikely to offset the negative returns.

Table 58 - Returns for investment in a Northern Gulf (NG) property

All terms defined in the Glossary of terms and abbreviations

Factor	Scenario 1 Run NG property as a calf factory	Scenario 2 Run NG property separately as a breeding and growing operation	Scenario 3 Run NG property separately; last 5 years of cattle prices maintained
Period of analysis (years)	30	30	30
Discount rate for NPV	5%	5%	5%
NPV	-$4,238,800	-$3,911,200	-$3,381,200
Annualised NPV	-$275,700	-$254,400	-$220,000
Peak deficit (with interest)	-$14,658,000	-$13,716,600	-$12,491,100
Year of peak deficit	never	never	never
Payback period (years)	never	never	never
IRR	-0.40%	-0.06%	0.61%

3.12 Purchasing a steer growing and finishing property in the Dawson Callide area of central Queensland

3.12.1 Introduction

Bowen and Chudleigh (2017, 2018a,b,c) and Bowen *et al.* (2018) found the productive Brigalow land types of the Fitzroy NRM region of central Queensland to result in high annual steer weight gains. Buffel grass (*Cenchrus ciliaris*) pastures in good condition can achieve ca. 180 kg/head.annum and well-established and managed leucaena grass pastures can achieve ca. 255 kg/head.annum at higher stocking rates than buffel pastures. Given that purchasing a low-productivity, Northern Gulf breeder property was found to be a poor investment in the previous section (Section 3.11) the purchase of a developed Brigalow property in the Dawson Callide area of central Queensland could be considered as an alternative to run the majority of the steers produced by the Northern Downs property, from weaning to sale.

3.12.2 Methods

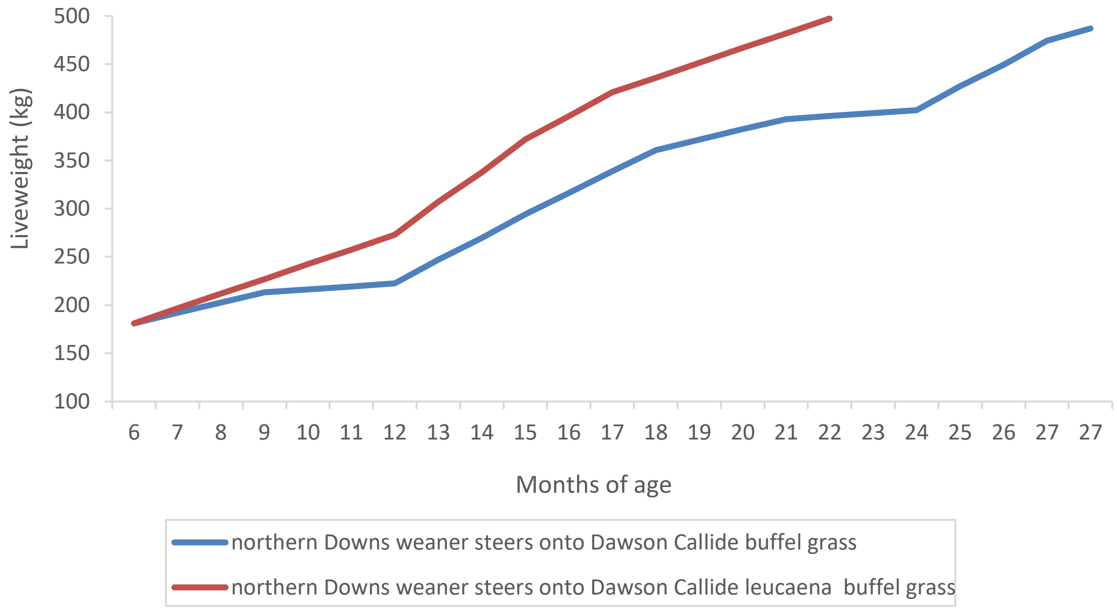
In this strategy, the owner of the constructed Northern Downs property decides to buy a breeder property in the Dawson Callide region of central Queensland. The Dawson Callide property purchased was of a sufficient size to run the majority of the steers produced by the Northern Downs property, from weaning to sale at feed-on weights. Two scenarios were examined:

1) Running the Northern Downs property as a 'calf factory', transferring weaner steers from that block to the Callide Dawson property which was purely a steer growing enterprise.
2) Running the properties as for Scenario 1, however, rather than using long-term cattle prices, the higher average cattle prices achieved over the past 5 years were maintained (in real terms) over the 30-year investment period.

Table 55 shows the prices applied to the Northern Downs property for each sale price scenario. The steer sale prices for the Dawson Callide property were increased from $1.92 to $2.46/kg liveweight for transfer prices, and from $1.89 to $2.75/kg liveweight for sale prices, to indicate the change in the average steer price for the last 11 years compared to the last 5 years.

The recent sale of a suitable property in the Dawson Callide region indicates that 900 ha of mixed leucaena-grass and buffel grass pastures can be purchased in the Dawson Callide region for about $3.5 million, bare. The current market price of a suitable property was used in this analysis as it reflects the current opportunity cost of the land and the amount of capital that would have to be invested to take ownership of the asset at this time. In this example, the property was assumed to have 400 ha of established leucaena and 520 ha of buffel pastures. Growth paths and stocking rates from Bowen and Chudleigh (2017, 2018a,b,c) were applied to the weaner steers transferred to the Dawson Callide property (Figure 15). The weaner steers were transferred from the Northern Downs property and sold at feed-on weights off both buffel grass and leucaena-grass pastures with sufficient steers transferred to fully stock the Dawson Callide property. Steers remained on the leucaena-grass pastures from weaning to sale at feed-on weights as this has been identified as the most profitable way to utilise leucaena-grass pastures Bowen and Chudleigh (2017, 2018c).

Figure 15 - Expected growth paths for Northern Downs steers transferred to the Dawson Callide as weaners and grazing either buffel grass pastures or leucaena-buffel grass pastures



3.12.3 Results and discussion

Table 59 indicates the average number of weaner steers transferred to each pasture type on the Dawson Callide property.

Table 59 – Steer livestock schedule for Dawson Callide property

Description	**Opening number**	**Number transferred**	**Number sold**	**Closing number**
Steers on buffel - weaners to 12 months old	-	138	0	137
Steers on buffel - 1 to 2 years old	137	0	0	136
Steers on buffel - 2 to 3 years old	136	0	136	0
Steers on leucaena-grass – weaners to 12 months old	-	291	0	288
Steers on leucaena-grass – 1 to 2 years old	288	0	288	0
Total	-	*429*	*424*	-

Approximately 429 weaner steers were transferred to the Dawson Callide property from the Northern Downs property each year. The majority of the weaner steers transferred to the Dawson Callide (291) grazed leucaena-grass pastures until they were sold at feed-on weight (456 kg). The remainder of the transferred steers (138) grazed buffel grass until they were also sold at feed-on weights (487 kg), but at an older age compared to the steers that grazed leucaena.

The breeder herd was increased on the Northern Downs property due to the change to turning off weaner steers. Additional weaners were purchased in the transition phase to fully stock the Callide Dawson property as soon as possible and hence optimise production from the investment. Costs were contained on the Dawson Callide property through the costs of mustering and property labour being offset by a reduced wage combined with free rental of the house. Table 60 indicates the herd structure of the Northern Downs property before and after the Callide Dawson property is purchased.

Table 60 – Herd composition for the Northern Downs property with and without the Dawson Callide property purchase

Breeder herd components	Without Dawson Callide property	With Dawson Callide property
Total cows and heifers mated	1,035	1,319
Calves weaned	755	962
Weaner steers	336	429

Table 61 indicates the extra returns generated by investing in the developed Brigalow block in the Dawson Callide region of central Queensland. Although the Dawson Callide block is highly productive, the high capital cost relative to the net profit of the combined properties makes the investment uninviting. Maintaining the average prices of the last 5 years, over the 30-year period of the investment, for both the Callide Dawson and the Northern Downs properties does not make the investment much more inviting.

Table 61 - Returns for investment in a Dawson Callide property used for growing out weaner steers produced on the Northern Downs property to feed-on weights
All terms defined in the Glossary of terms and abbreviations

Factor	Scenario 1 Long-term cattle prices used over 30 years	Scenario 2 Last 5 years of cattle prices maintained
Period of analysis (years)	30	30
Discount rate for NPV	5%	5%
NPV	-$1,813,000	-$436,700
Annualised NPV	-$117,900	-$28,400
Peak deficit (with interest)	-$7,403,400	-$4,375,400
Year of peak deficit	never	20
Payback period (years)	never	never
IRR	1.40%	4.06%

3.13 Optimising the age of transfer of steers from a Northern Gulf property to a Northern Downs property

3.13.1 Introduction

Extensive beef businesses in northern Australia commonly include breeding and growing operations run separately on different properties. Where properties with dissimilar production capabilities are owned, it is typical for the property with the least productive country to run the breeding herd and the property with the higher potential for growth rates to run all the growing cattle in addition to a breeder herd. Evidence exists for the Northern Downs region (Section 3.11) and for other regions of northern Australia (Bowen and Chudleigh 2018b; Bowen *et al.* 2019a; Chudleigh *et al.* 2019b) that a focus on maintaining a breeding herd to produce weaner steers is the least profitable beef enterprise in northern Australia. Furthermore, these previous analyses indicate that retaining steers on the breeding property to an older age of sale would optimise drought resilience in addition to the profitability of the property. These previous analyses suggest that the usual industry practice of transferring steers from the breeding property to the growing property at weaning would result in the breeding property being either unviable, or barely viable, when looked at in isolation.

3.13.2 Methods

The questions we considered in this scenario were:

- Would it be more profitable to treat dissimilar properties held by one owner as separate entities and have no regular, planned transfer of steers?
- Or, is it more profitable to specialise those properties in their various roles of breeding and growing and transfer all steers from the breeding to the growing property?
- Also, if the operations of the two properties are integrated, at what age should steers be transferred to optimise the total profit?

To provide insight into these questions, we applied herd modelling and economic analysis to identify the total profit likely to be generated by the properties firstly operating as separate entities and, secondly, operating as integrated entities transferring steers at 6 (weaning), 18 or 30 months old. This scenario is a variation on the analysis of Section 3.11 where the owner of the Northern Downs property purchased a Northern Gulf property and considered a similar set of questions. The major difference in this scenario is that the capital costs of purchasing the Northern Gulf property are not incurred as it was assumed to be already owned. Hence the analysis starts with the assumption of no debt for the combined properties. Debt was incurred, as required, for implementation of the various options.

Two properties that have been modelled as part of this series of DCAP project activities were used as representative of a breeding property and a growing property that are held by one owner. They were the constructed properties developed for the Northern Downs regional analysis (this report) and the Northern Gulf regional analysis (Bowen *et al.* 2019a), respectively. The comparison of the various options was to a base situation where both the Northern Gulf and the Northern Downs properties were run separately as independent breeding and growing entities. That is, the base situation for both properties was a breeding and growing operation with the age of steer turn-off identified previously as most representative for that property (31 months for the Northern Downs and sale in two cohorts at 29 and 41 months for the Northern Gulf property).

The typical process for beef producers who already own properties located in each region is to breed cattle on the Northern Gulf property, and to breed and grow cattle on the Mitchell grass downs (Northern Downs) property. The alternative of growing in the forest and breeding on the Northern Downs was not tested here. These representative properties are entirely constructed and may or may not represent the circumstances of beef producers who operate separate production systems across the two regions under single ownership. The data applied in this analysis would need to be modified to suit the herd productivity, growth paths, costs and prices faced by any actual beef producer to most accurately answer the questions posed here for their specific operation.

3.13.2.1 The Northern Gulf property

The Northern Gulf property was modelled as the constructed, base property applied in the Northern Gulf analysis as part of this same project (Bowen *et al.* 2019a). The Northern Gulf property had benefited from 10 years of land condition restoration and effective wet season P supplementation for cattle. Therefore, the Northern Gulf property was 30,000 ha of native pastures on representative land types as described in Shaw *et al*. (2007) and carried ca. 1,500 AE. The self-replacing Brahman (>75% *B. indicus*) breeding herd grazed less productive land types such as Goldfields (red duplex), Georgetown granite, Range soil, Sand ridge and Sandy forest which were considered ‘Deficient’ in P on average (4-5 ppm bicarbonate extracted P (Colwell 1963) in the top 100 mm soil).

The management features of the self-replacing Brahman breeding herd included continuous mating and adequate wet season P supplementation. Replacement heifers were separated from the breeding herd until they were first mated at about 2 years of age. Bulls were left with the breeding herd year-round (continuous mating) with two main musters undertaken to wean calves and identify cull cows. Data used to describe the reproduction efficiency of the breeder herd reflected the expected conception rates of breeders and the typical loss of calves between conception and weaning experienced by breeders grazing pastures in this region and receiving the adequate P supplementation program of the herd (Table 62). Mortality rates reflected the adequate wet season provision of P supplements, the breeding herd segregation system applied and a high level of timely stock management. At this level of management and inputs, the average mortality rate was expected to be 2.5% and the average weaning rate from all cows mated ca. 57%. The average annual post-weaning weight gain for steers was expected to be ca. 113 kg/head. The steers produced by the base herd were sold to the live export market in two groups, either at 29 months old and 418 kg (the lead) or 41 months old and 414 kg (the tail). Full details of the constructed property can be found in Bowen *et al* (2019a).

Table 62 - Reproduction parameters and mortality rates for the breeder herd on the Northern Gulf property receiving adequate wet season P supplementation

Initial cattle age **Final cattle age**	**Weaners** **1**	**1** **2**	**2** **3**	**3** **4**	**4** **8**	**8** **11**
Expected conception rate for age group (%)	n/a	0	78	45	70	65
Expected calf loss from conception to weaning (%)	n/a	0	16.4	9.5	11.8	13.7
Proportion of empties (PTE) sold (%)	n/a	0	100	10	10	10
Female death rate (%)	2.5	2.5	2.5	2.5	2.5	2.5
Male death rate (%)	2.5	2.5	2.5	2.5	2.5	n/a

Table 63 shows the base herd structure for sale of live export steers from the Northern Gulf breeding property in two cohorts at 29 and 41 months of age.

Table 63 - Herd structure for a 1,500 AE herd on the Northern Gulf property turning off live export steers in two cohorts at 29 and 41 months of age

Parameter	**Number held**	**Number sold**
Weaners 5 months	465	0
Heifers 1 year but less than 2	227	0
Heifers 2 years but less than 3	106	115
Cows 3 years plus	645	87
Steers 1 year but less than 2	227	0
Steers 2 years but less than 3	38	183
Bullocks 3 years but less than 4	0	37
Bulls all ages	32	5
Total	*1,739*	*427*

3.13.2.2 The Northern Downs property

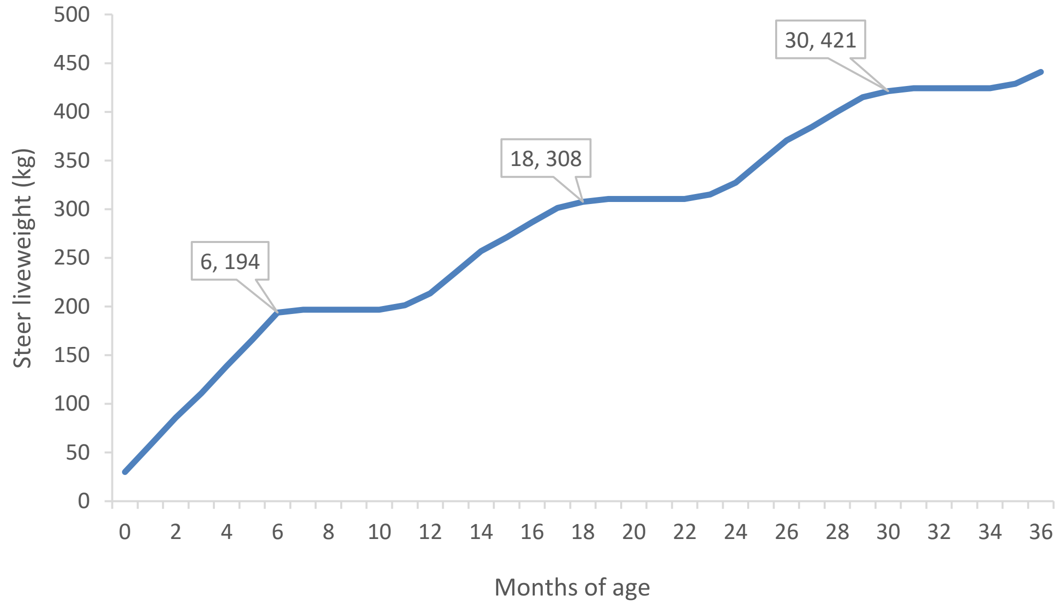
The Northern Downs property was the constructed, base property developed in this report, i.e. a total area of 16,000 ha of Mitchell grass and associated native pastures growing on primarily Open Downs and Ashy downs land types (State of Queensland 2019) with a long-term, average carrying capacity of ca. 2,000 AE. The assumption was that at the long-term, average stocking rate of 8 ha/AE, the property would maintain land condition and carrying capacity. The self-replacing *B. indicus* crossbred breeding herd (ca. 50% *B. indicus*) primarily grazed Open downs and Ashy downs land types which were considered adequate in P on average (>8 ppm bicarbonate extracted P (Colwell 1963) in the top 100 mm soil). The base Northern Downs property for this analysis was run as a breeding and steer growing property with 2 year-old heifer mating, and turning off 31 month-old steers.

3.13.2.3 Steer transfer weights

The various weights for the transfer of steers from the Northern Gulf property to the Northern Downs property were identified from the steer growth path for the Northern Gulf property. The expected annual growth of steers grazing native grass pastures on the Northern Gulf property was about 113 kg/head.annum. This is based on an effective wet season P supplementation regime and sustainable land management (Bowen *et al.* 2019a). Figure 16 indicates the points on the steer growth path applied as the expected alternative ages and weights for the transfer of steers between the properties. The values shown in the boxes are the age in months and the paddock weight of the steers to be transferred.

Figure 16 - Steer growth on the Northern Gulf property with adequate wet season P supplements

Boxes give steer age (months) and liveweight (kg) at the three selected ages of transfer from the Northern Gulf property to the Northern Downs property



3.13.2.4 Operating the Northern Gulf property to produce steers at different ages

Table 64 shows the change in herd structure and sales of the Northern Gulf herd at each age selected for the transfer of steers from the breeding property to the Northern Downs growing property.

Table 64 - Herd structure at each age of steer transfer (in months; m) from the Northern Gulf property to the Northern Downs property

Numbers of steers in each age of transfer group highlighted grey. 'm', months

Age at start of year	NQ Gulf with weaner transfer		NQ Gulf with 18 m steer transfer		NQ Gulf with 30 m steer transfer	
	Number kept whole year	Number sold	Number kept whole year	Number sold	Number kept whole year	Number sold
Weaners 5 months	288	288	531	0	475	0
Heifers 1 year but less than 2	281	0	259	0	231	0
Heifers 2 years but less than 3	131	143	121	131	108	117
Cows 3 years plus	799	108	737	100	659	89
Steers 1 year but less than 2	-	-	-	259	231	-
Steers 2 years but less than 3	-	-	-	-	-	226
Bulls all ages	40	6	37	6	33	5
Total	*1,539*	*544*	*1,685*	*495*	*1,737*	*437*

At the same level of grazing pressure applied to the Northern Gulf breeding property, 288 weaner steers, 259 x 18 month-old steers or 226 x 30 month-old steers could be transferred each year to the

Northern Downs property. The number of breeders mated and kept on the Northern Gulf property was reduced by more than 150 between sending the steers as weaners and sending them at 30 months of age.

3.13.2.5 Steer transfer prices and costs

The prices paid by the Northern Downs property, for the steers produced on the Northern Gulf property, were set to be equivalent to their net value at the farm gate of the Northern Gulf property based on the long term (July 2008 to June 2019; last 11 years) market price analysis completed in this report (Section 2.3.1). The Northern Downs property paid this value plus the cost of transporting the steers from the Northern Gulf property. Transferring the steers at market value did not distort the profitability of either property, or the combined properties, as the steer sale income generated for the Northern Gulf property was cancelled out by the cost of the steers to the Northern Downs property with only the cost of freight remaining. This cost, or a similar steer selling cost, is incurred by the properties in all scenarios so it is not an additional cost to the overall business. The distance to transport the steers between the two properties was set at 400 km with the trucking cost set at $2.00/deck.km. As all transfers were done at market prices, the steers produced on the Northern Gulf property cost the Northern Downs property a very similar amount to steers of the same age and quality purchased through local selling centres.

Table 65 - Prices and costs for steer transfer from the Northern Gulf property to the Northern Downs property

Parameter	**Age of steer transfer**		
	6 months (weaners)	**18 months**	**30 months**
Liveweight in the paddock (kg)	194	308	421
Weight loss to get to saleyards or works	8.00%	8.00%	8.00%
Liveweight at saleyards or works (kg)	178	283	387
Sale price at yards or works ($/kg liveweight)[A]	$2.25	$2.30	$2.09
Gross sale price ($/head)	$402	$651	$809
Commission and insurance % on sales	3.50%	3.50%	3.50%
Commission and insurance ($/head)	$14.06	$22.77	$28.33
Transaction levy, yard dues etc. ($/head)	$15.00	$15.00	$15.00
Transport cost per head calculator			
Distance to usual point of sale (km)	600	600	600
$/km	$2.00	$2.00	$2.00
Rate on truck	40	33	27
Transport cost ($/head)	$30.00	$36.36	$44.44
Value on farm net of selling expenses	*$342.52*	*$576.55*	*$721.72*
Transport cost to Northern Downs property			
Distance to the Northern Downs property (km)	400	400	400
$/km	$2.00	$2.00	$2.00
Rate on truck	40	33	27
Transport cost ($/head)	$20.00	$24.24	$29.63
Induction costs ($/head)	$5	$5	$5
Cost/head landed Northern Downs property	*$367.52*	*$605.79*	*$756.35*

[A]The sale yard prices are the prices paid for each class of cattle as extracted from the North Queensland prices database maintained by MLA and adjusted to reflect the average price paid over the last 11 years to mid-2019. Long-term and medium-term price data at the market place is shown in the cattle price data section of this report (Section 2.3.1).

3.13.2.6 Operating the Northern Downs property with steers transferred from the Northern Gulf property

The steers transferred from the Northern Gulf property to the Northern Downs property were assumed to achieve, on average, the same annual weight gains (ca. 140 kg/head.annum) predicted for the weaner steers already being produced by the breeding herd run on the Northern Downs property. Table 66 shows the change in herd structure and sales of the Northern Downs property at each age selected for the transfer of steers from the Northern Gulf property.

Table 66 - Herd structure for age of steer transfer (in months; m) from the Northern Gulf property to the Northern Downs property

Numbers of steers in each age of transfer group highlighted grey; data for steers transferred at 18 months and kept for 2 years not shown

Age at start of year	Northern Downs with weaner transfer kept 24 months		Northern Downs with 18 m steer transfer kept 12 months		Northern Downs with 30 m steer transfer kept 12 months	
	Number kept whole year	Number sold	Number kept whole year	Number sold	Number kept whole year	Number sold
Weaners 5 months	520+288	0	597	0	592	0
Heifers 1 year but less than 2	252	4	290	4	287	4
Heifers 2 years but less than 3	199	50	228	57	226	57
Cows 3 years plus	385	179	442	205	438	204
Steers 1 year but less than 2	256+285	-	294+259	-	291	-
Steers 2 years but less than 3	-	252+282	-	289+256	+226	287
Steers 3 years but less than 4	-	-	-	-	-	224
Bulls all ages	24	4	28	4	27	4
Total	*1,636+573*	*488+282*	*1,877+259*	*495+256*	*1,862+226*	*556+224*

3.13.3 Results and discussion

3.13.3.1 Northern Gulf property as a stand-alone entity

Table 67 shows the net profit generated by the Northern Gulf property turning off live export steers from native grass pastures. The net profit figure was generated using the 11-year average north Queensland livestock prices (July 2008 to June 2019; last 11 years) with adjustments made for the different classes of cattle being sold, weight loss and distance to the point of sale. As the Northern Gulf property had no debt in this analysis, the operating profit figure of -$54,500 represents the expected contribution of a 30,000 ha Northern Gulf property to the overall profit generated by the two properties when they are run as separate entities and the Northern Gulf property produces live export steers.

In our previous work, a number of pasture development and other strategies were assessed for their ability to improve the performance of the Northern Gulf property over time (Bowen *et al.* 2019a). Although some of these strategies showed considerable promise, for the purpose of this exercise, the owners of the Northern Gulf property were considered to be running the breeding herd in a sustainable and efficient way without immediate consideration of improved pastures or other investments that may improve the returns of the Northern Gulf property over time.

Table 67 - Profit analysis for the Northern Gulf base herd at long term average prices (July 2008 to June 2019; last 11 years) turning off live export steers in two cohorts at 29 and 41 months

Parameter	Breeder herd turning off 29 and 41 month old steers
Net cattle sales	$289,400
Husbandry costs	$63,100
Net bull replacement[A]	$27,300
Gross margin	$199,000
Operating overheads[B]	$253,500
Operating profit	*-$54,500*

[A]Bull sales are included in net bull replacement, not net cattle sales.

[B]Operating overheads include an allowance for plant replacement and operators labour and management.

3.13.3.2 Northern Downs property as a stand-alone entity

Table 68 shows the net profit generated by the Northern Downs property turning off feed-on steers from native grass pastures. The net profit figure was generated using the 11-year average north Queensland livestock prices (July 2008 to June 2019; last 11 years) with adjustments made for the different classes of cattle being sold, weight loss and distance to the point of sale. The comparative figures for the same Northern Downs property run as a steer turnover operation (no breeders) are also shown. These are the figures developed in a previous scenario (Section 3.10) where conversion from a breeding enterprise to a steer turnover enterprise was examined. It can be seen while the operating profit of the base Northern Downs property was much greater than that of the base Northern Gulf property ($183,500 cf. -$54,534), the alternative enterprise of turning over steers on the Northern Downs property is 1.6 times more profitable than the breeding and growing enterprise used as a base in this scenario.

Table 68 - Profit analysis for the Northern Downs base herd at long term average prices (July 2008 to June 2019; last 11 years) with breeders turning off 31-month old steers or as a steer turnover operation

Parameter	Breeder herd turning off 31-month old steers	Steer turnover
Net cattle sales	$492,000	$1,261,200
Husbandry costs	$38,800	$44,300
Net bull replacement[A]	$17,000	$679,200[B]
Gross margin	$436,200	$537,000
Operating overheads[C]	$252,700	$252,700
Operating profit	*$183,500*	*$285,000*

[A]Bull sales are included in net bull replacement, not net cattle sales.

[B]Net purchases.

[C]Operating overheads include an allowance for plant replacement and operators labour and management.

3.13.3.3 Integration of the Northern Gulf and Northern Downs properties and comparison with operation as separate entities

The effect on the expected profit of the Northern Gulf property of selling steers at the different ages of transfer was calculated and compared to selling steers from the Northern Gulf property as live export steers in two cohorts at 29 and 41 months. Table 69 shows the change in performance of the Northern Gulf herd at each age selected for the transfer of steers from the breeding property to the Northern Downs property. Transferring the steers as weaners and running a larger breeder herd on the Northern Gulf property reduced the expected profit of the property by more than $39,000/annum when compared to the expected level of profit to be generated selling live export steers as per the base scenario. Transferring the steers at 18 months or 30 months of age didn't substantially impact the expected profit generated by the Northern Gulf property.

Table 69 – Operating profit of the Northern Gulf property with alternative ages of steer turnoff

Parameter	Base herd (29 and 41 months)	Weaners (6 months)	18 months	30 months
Total adult equivalents (AE)	1,500	1,500	1,500	1,500
Total cattle carried	1,739	1,539	1,685	1,737
Weaner heifers retained	233	288	266	237
Total breeders mated	805	997	920	822
Total breeders mated and kept	751	930	858	767
Total calves weaned	465	576	531	475
Weaners/total cows mated	57.76%	57.76%	57.76%	57.76%
Weaners/cows mated and kept	61.91%	61.91%	61.91%	61.91%
Overall breeder deaths	2.50%	2.50%	2.50%	2.50%
Female sales/total sales	47.89%	46.52%	47.15%	47.78%
Total cows and heifers sold	202	250	231	206
Maximum cow culling age	11	11	11	11
Heifer joining age	2	2	2	2
Weaner heifer sale and spay	0.00%	0.00%	0.00%	0.00%
One year-old heifer sales	0.00%	0.00%	0.00%	0.00%
Two year-old heifer sales	60.55%	60.55%	60.55%	60.55%
Total steers and bullocks sold	220	288	259	226
Maximum bullock turnoff age	3	0	1	2
Average female price	$619.88	$619.88	$619.88	$619.88
Average steer/bullock price	$745.31	$342.52	$578.05	$723.31
Capital value of herd	$965,399	$904,395	$925,169	$960,628
Imputed interest on herd value	$48,270	$45,220	$46,258	$48,031
Net cattle sales	$289,409	$253,863	$292,872	$291,180
Direct costs excluding bulls	$63,107	$60,345	$64,811	$63,497
Bull replacement	$27,302	$33,808	$31,184	$27,870
Herd gross margin	*$198,999*	*$159,711*	*$196,877*	*$199,813*
Operating overheads	$253,533	$253,534	$253,535	$253,536
Operating profit	***-$54,534***	***-$93,823***	***-$56,658***	***-$53,723***
Difference to export steers	*Base*	*-$39,289*	*-$2,124*	*$811*

Table 70 shows the expected profit of the Northern Downs property operated as an integrated breeding and growing operation with steers of different ages transferred from the Northern Gulf property. When compared to the property operated solely as a breeding and growing operation with no steers transferred from the Northern Gulf property, transferring weaner steers from the Northern Gulf property and holding them for two seasons was the only scenario that improved the expected profit of the Northern Downs property (in isolation). This outcome was not unexpected as the breeder herd running on the Northern Downs property was reduced to accommodate the weaner steers coming from the Northern Gulf and the gross margin/AE for the Northern Gulf weaner steers growing on the Northern Downs property was better than the gross margin/AE for the integrated breeding and growing operation running on the downs property.

Table 70 - Operating profit of the Northern Downs property with an integrated breeding and growing operation and steers transferred from the Northern Gulf

Gross margin calculation	**Transfer age of steers from Northern Gulf property**				
	No transfer of steers	**Weaners, held 24 months**	**18 months, held 12 months**	**18 months, held 24 months**	**30 months, held 12 months**
Steers transferred	0	288	259	259	226
Livestock sales	-	$243,943	$209,035	$274,325	$222,683
Livestock purchases	-	$105,846	$156,900	$162,958	$170,935
Treatment expenses	-	$720	$648	$673	$565
Total expenses	-	$106,566	$157,547	$163,630	$171,500
Gross margin for transferred steers	-	*$137,377*	*$51,488*	*$110,695*	*$51,183*
Transferred steer AEs grazing Mitchell grass	-	453	226	528	239
AEs available after transfer for Northern Downs herd	2,000	1,546	1,774	1,471	1,760
Gross margin for residual Northern Downs herd	*$436,179*	*$337,166*	*$334,197*	*$320,810*	*$383,838*
Northern Downs property gross margin	*$436,179*	*$474,543*	*$385,685*	*$431,505*	*$435,021*
Northern Downs property operating overheads	$252,700	$252,700	$252,700	$252,700	$252,700
Northern Downs property operating profit	***$183,479***	***$221,843***	***$132,985***	***$178,804***	***$182,320***

AE, adult equivalent

Table 71 summarises the profit expected to be generated by each combination of the alternative ways of managing the two properties either run separately or as integrated enterprises with alternative ages of transfer of steers from the Northern Gulf breeding property to the Northern Downs breeding and growing property. The alternative scenario of operating the Northern Downs property, as a steer turnover enterprise run separately from the Northern Gulf enterprise, is also included for comparison.

Table 71 - Profit analysis of alternative ways to manage a Northern Downs property and a Northern Gulf property with the same ownership

When run as integrated entities, all steers were transferred from the Northern Gulf property to the Northern Downs property. The alternative scenario of operating the Northern Downs property as a steer turnover enterprise (cf. breeding and growing) was included for comparison. 'm', months

Strategy	Operating profit			
	Northern Downs property	Northern Gulf property	Combined total	Difference to base
Separate breeding and growing entities	$183,500	-$54,500	$128,900	Base
Transfer weaners keep 24 m	$221,800	-$93,800	$128,000	-$900
Transfer 18 m steers keep 12 m	$133,000	-$56,700	$76,300	-$52,600
Transfer 18 m steers keep 24 m	$178,800	-$56,700	$122,100	-$6,800
Transfer 30 m steers keep 12 m	$182,300	-$53,700	$128,600	-$300
Separate entities - Northern Gulf, breeding and growing; Northern Downs, steer turnover	$285,000	-$54,500	$230,500	$101,500

At the long term average prices applied in this analysis, all strategies for operating the properties as integrated breeding and growing operations, with transfer of steers from the Northern Gulf property to the Northern Downs property, reduced the expected profit generated by operating the properties as separate entities (i.e. operating profit reduced by $300 to $52,600/annum). As it is likely that the prices of all categories of livestock capable of being produced by beef properties in these regions will continue to move in parallel, the opportunity cost of transferring steers from the Northern Gulf property to the Northern Downs property is unlikely to change.

It has to be noted that the Northern Downs property can also be converted over time to a steer turnover (growing) operation that is likely to be substantially more profitable over time than the breeding operation turning off feed-on steers ($285,000 cf. $183,500). Even with an allowance for the price risk associated with the purchase of steers, the steer turnover operation is likely to substantially out-perform the breeding and growing operation on the Northern Downs property over the longer term. Sourcing weaner steers from the Northern Gulf property to replace purchased, turnover steers for the Northern Downs property would have a similar impact on the combined profit of the two properties as that shown in Table 71. Turning the Northern Gulf property into a weaner production unit would reduce its profitability substantially more than the size of any benefit gained by the Northern Downs steer turnover property due to being supplied with weaner steers, thereby reducing the total profit available from the properties run as separate entities.

Given that there is a substantial advantage in operating the Northern Downs property as a steer turnover operation and not running the property as a standalone breeding and growing operation, it appears that the main consideration of beef producers who own combinations of similar properties across these two regions is, firstly, how to manage the price risk associated with steer purchasing (turnover) activities and, secondly, how to improve the profitability of the Northern Gulf property. The report compiled by Bowen *et al*. (2019a) identified a number of viable strategies that can provide a substantial marginal return on investment and improve the drought resilience and profitability of the Northern Gulf property.

3.14 Prickly acacia control

3.14.1 Introduction

Prickly acacia (Acacia *nilotica* subsp. *indica*) is an exotic woody weed that, since its introduction in the 1890s, has become a major weed in Queensland, particularly of the Mitchell grass downs located in the central west and north west parts of the state. While at low densities, prickly acacia can increase livestock productivity by providing shade and fodder; however, dense infestations reduce pasture production and hence the productivity of affected properties (The State of Queensland 2004). The spread of prickly acacia within paddocks and across landscapes is characterised by sudden increases in plant density and range of distribution during sequences of wetter years (Grice *et al.* 1999). The plant will then survive dry years without substantial increase in numbers until the next sequence of wet years.

The invasiveness, potential for spread, and economic and environment impacts of prickly acacia resulted in its declaration as a noxious weed in Queensland in 1957 and, more recently, as a weed of national significance (Australian Government 2020). Currently, over 6.6 million ha are estimated to be infested in Queensland with major areas of infestation occurring from Barcaldine north to Hughenden and west to Longreach, Winton and Julia Creek (Australian Government 2020). The focus region of this report, the northern Mitchell grass downs of Queensland, is currently a critical area of infestation. Extensive efforts to reduce the impact of the weed have been funded by various government, non-government agencies and private landholders over recent decades. However, there has been a lack of economic analysis at the property level to determine the most economically advantageous approach to prickly acacia control for a private landholder.

3.14.2 Methods

This scenario should be considered with a clear understanding that each property will have substantially different levels of infestation, treatment costs and access to capital and equipment to undertake treatment and that the results of the scenario analysis may not represent the reality faced by any individual property owner located on the Northern Downs of Queensland. This scenario is provided as a framework that sets out the information required, and assumptions that have to be made, to assess the potential costs and benefits of prickly acacia control on a property with a substantial and established infestation. The positive economic results for treating new outbreaks effectively and early have been well established (Miller and Scanlan 1997; ArGyll Consulting 2017) and will not be covered here.

The assumptions used in our analysis for impact of prickly acacia density on pasture production were determined with reference to Carter *et al.* (1989), ArGyll Consulting (2017) and Desert Channels Queensland NRM body (DCQ), pers. comm. The change in pasture production over time, (1) with and without prickly acacia treatment, and (2) with and without the occurrence of a series of wetter than average years, was determined after reference to Grice *et al.* (1999), ArGyll Consulting (2017), and DCQ, pers. comm. Assumptions about pasture recovery following treatment of prickly acacia were derived from data of March and Cullen (2017) and DCQ, pers. comm. The methods and costs of prickly acacia control for different densities of infestation were provided by N. March, pers. comm.

The constructed, base property previously applied in this analysis was converted to one with a substantial infestation of prickly acacia. This level of infestation was characterised as:

- 5% of the property (800 ha) having a High level of canopy cover (>50%) where pasture production was at 10% of its potential;
- 15% of the property (2,400 ha) having a Moderate level of infestation (>25% canopy cover to <50% canopy cover) where pasture production was at 50% of its long term potential;
- 60% of the property (9,600 ha) having a Low type infestation of generally >10% canopy cover to <25% stems/ha where pasture production was at 75% of its potential; and
- 20% of the property (3,200 ha) having Minimal infestation (<10% canopy cover) where pasture production was at 100% of its potential.

Failure to treat the prickly acacia infestation could have a range of consequences dependent upon the amount and frequency of rainfall occurring over the following years. It was assumed that the occurrence of a series of wetter than average years would cause pasture production to:

- have no additional rate of decline above 0.5%/annum in the High level of infestation,
- decline from 50 to 10% over 5 years in the Moderate level of infestation,
- decline from 75 to 10% over 10 years in the Low level of infestation, and
- decline from 100 to 80% over 20 years in the Minimal level of infestation.

The likely occurrence of a series of wet years sufficient to have these impacts is unknown. The effect of a sequence of wet years sufficient to cause the above falls in pasture production was tested in the investment model by having the wet years occur either:

- 5 years after the treatment takes place with pasture production reducing from Year 6 of the analysis,
- 10 years after the treatment takes place with pasture production reducing from Year 11, or
- 20 years after the treatment takes place with pasture production reducing from year 21.

Where the sequences of wet years did not occur until later in the analysis period, the impact of the existing prickly acacia infestation was to reduce pasture production by 0.5%/annum in all levels of infestation up until the wet sequence occurred. Where no treatment was applied, following the impact period of the series of wet years (defined above), pasture production continued to decline at a rate of 0.5%/annum. Treating a prickly acacia infestation was assumed to return pasture production to 100% of its potential over 5 years. A direct relationship between changes in pasture production and changes in carrying capacity of the property was assumed. It was estimated that the infestation had already reduced the carrying capacity (cf. the base property with no prickly acacia infestation) by 25% (to 1,500 AE) at the start of the analysis period.

Two sub-scenarios were examined. Firstly, the value of controlling prickly acacia at a rapid rate over the entire property was investigated, i.e., property-level treatment in Year 1 plus ongoing maintenance over 30 years. Secondly, the best investment of an initial $10,000 in Year 1 of the analysis plus ongoing maintenance costs over 30 years was assessed.

3.14.2.1 Calculation of per hectare prickly acacia treatment costs

In this analysis, the costs of plant and equipment were apportioned on an hourly and rate of use basis. This allowed inclusion of a proportional amount of operating and overhead costs incurred in using plant and equipment to treat prickly acacia, improving the validity of the comparison where different control methods require different amounts of machinery inputs.

The operating costs of plant and equipment were costed on the basis of the Fuel, Oil, Repairs and Maintenance (F.O.R.M.) used on a per hour basis. For each combination of machines, the following rule of thumb calculations of cost were made:

- Fuel = fuel consumption (L/h) multiplied by the fuel cost (c/L, net of rebates);
- Oil was assessed as 10% of fuel cost;
- Repairs and Maintenance was included as the hourly cost of repairs and maintenance and calculated by multiplying the replacement cost of the machine by the percentage of the replacement cost of the machine spent on repairs over the life of the machine divided by the hours of life of the machine. For example, if a machine cost $10,000 and about $3,000 was expected to be spent on repairs and maintenance over its 5-year life, then about 30% of the cost of the machine was spent on repairs. If the machine was used for 100 h/annum, the hourly cost of repairs and maintenance was about $6/h of use.

The overhead and capital costs associated with the plant and equipment were calculated as an hourly rate and apportioned based on the expected rate of depreciation, the opportunity cost of the funds tied up in the plant and equipment, a minimal allowance for sheltering the plant and equipment and an allowance for insurance costs. Labour costs were included at an hourly rate. The hourly rate for each combination of machines used was converted to a per hectare rate by identifying the expected work rate at different densities of prickly acacia.

Other costs such as chemicals and wetting agents applied were included per tree or per hectare as required. The final treatment costs/ha were calculated using a pseudo ‘contract’ rate to cost machinery operations based on the economic costs of machine ownership and use over time. This contract rate apportions overhead, operating and labour costs on a per hectare basis for the use of the machines or combinations of machines. This figure includes an allowance for profit and minor travel costs. The amount added to cover profit and other was applied as a 20% increase in total costs. The final figure roughly represents the rate that could be charged by a property owner who 1) had the equipment on hand, 2) was asked to do some work on a contract basis for a neighbour, and 3) who also wanted to recover a proportional share of the costs of owning and operating the machines plus the labour associated with the activity and some small measure of profit. The contract rate does not represent what should be charged by a contracting business to undertake the same activity as that form of business would incur different costs. Table 72 contains estimates of cost/ha for a range of control methods applied to prickly acacia growing at different densities.

Table 72 – Control costs for prickly acacia ($/ha) calculated at contract rates

Treatment method	**Density (plants/ha)**								
	25	**50**	**100**	**150**	**300**	**750**	**1,000**	**1,500**	**2,000**
Basal Bark spray (Starane) hand application	$14	$26	$49	$83	$167	$379	$505	$683	$861
Basal Bark spray (Access) hand application	$15	$28	$54	$90	$179	$411	$548	$747	$946
Soil applied from quadbike hand applicator (Tebuthiuron)	$12	$24	$44	$65	$125	$359	$439	$538	$837
Aerial application (Tebuthiuron)	-	-	-	-	$256	$256	$256	$256	$256
Mechanical grubbing - loader and bucket	$60	$141	$175	$227	$303	$471	$488	$609	$609
Mechanical - double chain pulling	$26	$52	$75	$113	$164	$285	$305	$381	$406
Overall foliar spraying / misting	-	-	-	-	$120	$120	$120	$120	$120
Marshall tree saw	$21	$33	$63	$89	$172	$381	-	-	-
Epple Skattergun with buggy	$11	$21	$39	$57	$109	-	-	-	-
Epple Skattergun with tractor	$14	$25	$44	$63	$118	-	-	-	-

The costs/ha applied in this analysis for various prickly acacia control scenarios were derived with reference to Table 72 and the expert opinion of experienced DAF Biosecurity Officer, N. March. They were intended to represent a combination of appropriate treatment methods that would be effective in achieving control for each specified level of prickly acacia infestation. Table 73 gives a sample spreadsheet table used to calculate the per hectare cost of a combination Buggy and Skattergun control methods. As each combination of machines applied to treat prickly acacia will likely have different repair, capital and overhead costs for each paddock and property, the values shown here should be taken as an indication only and an example of how to appropriately calculate the full costs of control.

Table 73 – Sample cost calculation for combination Buggy and Skattergun control methods of prickly acacia control

Plants per ha	**25**	**50**	**100**	**150**	**300[A]**
Fuel price net of rebates ($/litre)	$1.25	$1.25	$1.25	$1.25	$1.25
Interest rate (%)	7.50%	7.50%	7.50%	7.50%	7.50%
Inflation rate (%)	2.50%	2.50%	2.50%	2.50%	2.50%
Insurance cost ($ /$1000 insured)	$10.00	$10.00	$10.00	$10.00	$10.00
MACHINERY INPUTS :-					
Machine	Buggy	Buggy	Buggy	Buggy	Buggy
Fuel Consumption (L/hr)	2.50	2.50	2.50	2.50	2.50
Price to replace machine($)	$22,000	$22,000	$22,000	$22,000	$22,000
Repairs (% of New Value)	45%	45%	45%	45%	45%
Life of Equipment (hours)	2,500	2,500	2,500	2,500	2,500
Trade in value (% New Value)	10%	10%	10%	10%	10%
Usage per year (hours)	250	250	250	250	250
Labour cost ($/hour)	$25.00	$25.00	$25.00	$25.00	$25.00
Machine	Skattergun	Skattergun	Skattergun	Skattergun	Skattergun
Fuel Consumption (L/hr)	0	0	0	0	0
Price to replace machine($)	$5,000	$5,000	$5,000	$5,000	$5,000
Repairs (% of New Value)	25%	25%	25%	25%	25%
Life of Equipment (hours)	2,500	2,500	2,500	2,500	2,500
Trade in value (% New Value)	5%	5%	5%	5%	5%
Usage per year (hours)	500	500	500	500	500
Labour cost ($/hour)	$0.00	$0.00	$0.00	$0.00	$0.00
Work Rate (ha/hr)	20.00	14.00	10.00	8.50	6.50
COSTS ($/hour)					
Fuel & Oil	$3.44	$3.44	$3.44	$3.44	$3.44
Repairs & Maintenance	$4.46	$4.46	$4.46	$4.46	$4.46
Depreciation	$9.82	$9.82	$9.82	$9.82	$9.82
Interest	$2.68	$2.68	$2.68	$2.68	$2.68
Shelter	$0.49	$0.49	$0.49	$0.49	$0.49
Insurance	$0.98	$0.98	$0.98	$0.98	$0.98
Labour	$25.00	$25.00	$25.00	$25.00	$25.00
Operating Cost ($/hr)	**$7.90**	**$7.90**	**$7.90**	**$7.90**	**$7.90**
Total Cost ($/hr)	**$46.87**	**$46.87**	**$46.87**	**$46.87**	**$46.87**
TOTAL COSTS ($/ha)					
Fuel & Oil	$0.17	$0.25	$0.34	$0.40	$0.53
Repairs & Maintenance	$0.22	$0.32	$0.45	$0.52	$0.69
Ownership	$0.70	$1.00	$1.40	$1.64	$2.15
Labour	$1.25	$1.79	$2.50	$2.94	$3.85
Fuel, Oil, Repairs & Maintenance	$0.39	$0.56	$0.79	$0.93	$1.22
Total Cost ($/ha)	**$2.34**	**$3.35**	**$4.69**	**$5.51**	**$7.21**
Total Cost plus 20% ($/ha)	**$2.81**	**$4.02**	**$5.62**	**$6.62**	**$8.65**
Kilograms per ha chemical	0.53	1.05	2.10	3.15	6.30
Cost of chemical per kilogram	$16	$16	$16	$16	$16
Mixed chemical cost per hectare	$8	$17	$34	$50	$101
Total cost of machines and chemical	**$10.74**	**$20.15**	**$38.29**	**$55.91**	**$108.01**
Total cost of machines (+20%) and chemical	**$11.21**	**$20.82**	**$39.22**	**$57.02**	**$109.45**

[A]Greater than 300 trees per hectare may be too inefficient for the Buggy/scattergun combination

3.14.2.2 Property-level scenario analysis

In this sub-scenario, prickly acacia was controlled at the property level in Year 1 of the analysis, with ongoing maintenance over 30 years. Treatment of the infestation was as follows:

- The High level of infestation was treated in Year 1 with a range of methods at a cost of $250/ha with a follow up treatment in Year 3 at a cost of $125/ha. Ongoing maintenance thereafter was achieved at a cost of $5/ha every 5 years.
- The Moderate level of infestation was treated in Year 1 with a range of methods at a cost of $100/ha with a follow up treatment in Year 3 at a cost of $25/ha. Ongoing maintenance thereafter was achieved at a cost of $2/ha every 5 years.
- The Low level of infestation was treated in Year 1 with a range of methods at a cost of $50/ha with a follow up treatment in Year 3 at a cost of $15/ha. Ongoing maintenance thereafter was achieved at a cost of $2/ha every 5 years.
- The Minimal level of infestation was treated in Year 1 at a cost of $2.50/ha with ongoing maintenance thereafter achieved at a cost of $2/ha every 5 years.

3.14.2.3 Best investment of $10,000 in Year 1 plus maintenance

In this scenario, the best investment of an initial $10,000 in Year 1 plus ongoing maintenance over 30 years was examined. This allowed us to pose the question:

- If $10,000 was available, which level of infestation (i.e. High, Moderate, Low or Minimal) should be tackled first?"

The initial funding of $10,000 was applied to identify the area to be treated in the first year. However, the initial treatment was followed in each case by ongoing maintenance to maintain control over the 30-year investment period, as defined above for each level of infestation.

3.14.3 Results and discussion

3.14.3.1 Managing prickly acacia, property-level

Figure 17 indicates the change in carrying capacity of the property if no treatment were undertaken and a wet series of years occurred after 5, 10 or 20 years into the 30-year analysis period.

Figure 17 - Total AEs grazing the property where a wet series of years occurred after 5, 10 or 20 years and no treatment of prickly acacia was undertaken

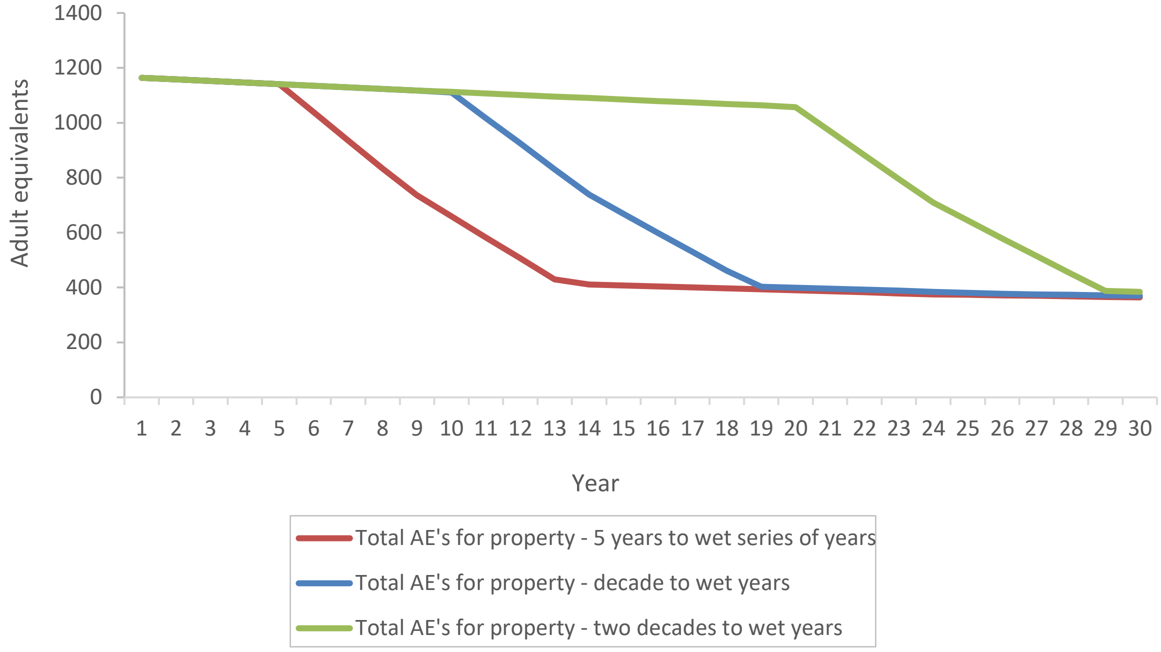


Figure 18 shows the cumulative prickly acacia treatment costs at the property level incurred over the investment period. Most of the expenditure is in the first 3 years of the investment period. Follow up costs were incurred for the entire 30 year investment period, but at a reducing rate.

Figure 18 - Cumulative property level treatment costs for prickly acacia control

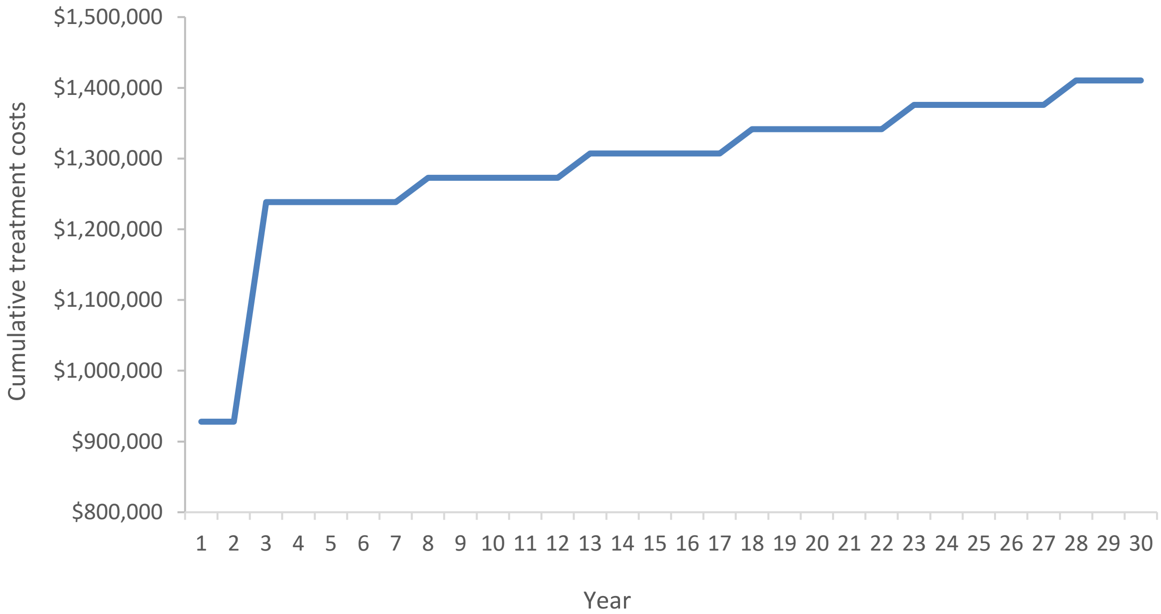


Figure 19 indicates the level of change in carrying capacity for each level of infestation and for the total property. The level of change was based on the pasture regaining full production over a period of 5 years after the treatment of prickly acacia has begun.

Figure 19 - Response in property carrying capacity with effective treatment and ongoing control of prickly acacia

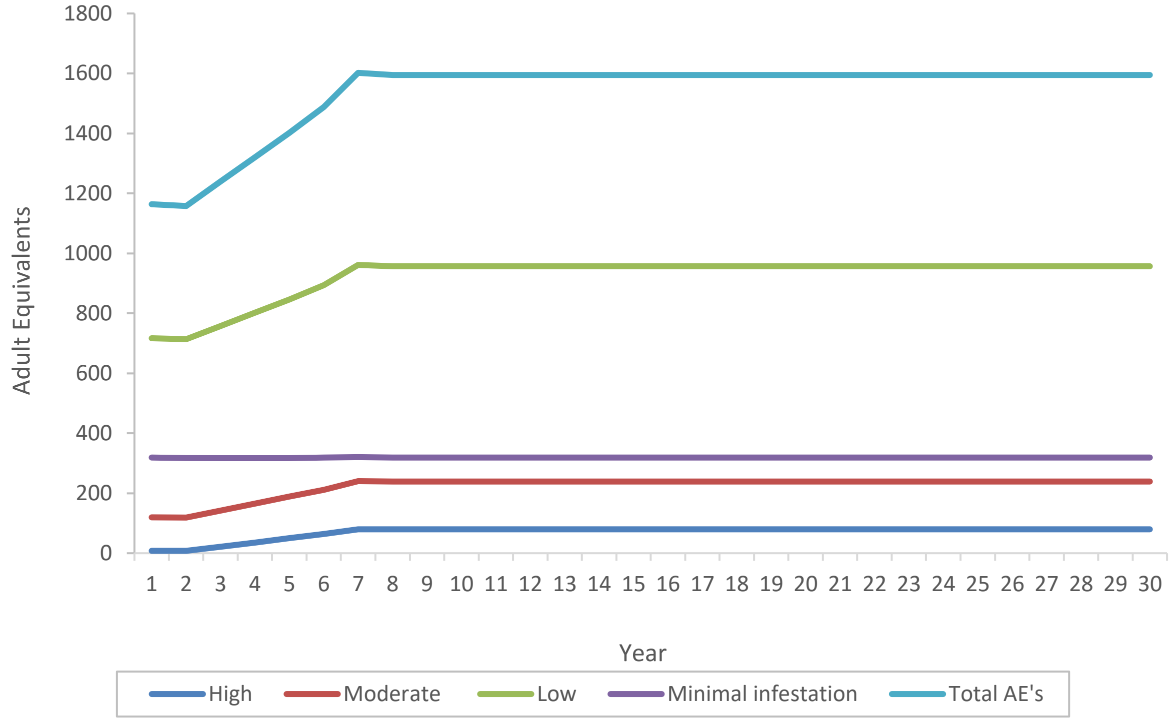


Table 74 indicates the extra returns generated by investing to control prickly acacia at the property scale where a series of wet years were received after 5, 10 or 20 years into the investment period. The resulting values in Table 74 are speculative in nature but have the same general rate of return for the control of prickly acacia as estimated by Miller and Scanlan (1997). Property-level control in our analysis resulted in positive returns of 8-13%. However, the value of treatment was negatively related to the number of years prior to the onset of a series of wet years capable of causing the rapid increase of prickly acacia. Additionally, more than $1.3 million cash deficit over the first 4 years of treatment would be beyond the capacity of many managers to fund and hence prevent them adopting a rapid approach to property-level control.

Table 74 - Returns for investment in the control of prickly acacia at the property level

All terms defined in the Glossary of terms and abbreviations

Factor	**5 years to wet years**	**10 years to wet years**	**20 years to wet years**
Period of analysis (years)	30	30	30
Discount rate for NPV	5%	5%	5%
NPV	$1,987,300	$1,413,800	$686,000
Annualised NPV	$129,300	$92,000	$44,600
Peak deficit (with interest)	-$1,328,300	-$1,328,300	-$1,328,300
Year of peak deficit	4	4	4
Payback period (years)	13	17	not calculable
IRR	13%	11%	8%

3.14.3.2 Managing prickly acacia, best investment of $10,000 in Year 1 plus maintenance

The preceding property-level analysis identified that property owners could be expected to target only part of the infestation with the resources available. The alternative approach of targeting a set expenditure ($10,000 in this example) in Year 1 to prickly acacia control with ongoing maintenance over 30 years, showed positive returns of 6-20%, dependent on infestation level and number of years prior to the onset of wet years (Table 75).

The implication of Table 75 is that, where the biosecurity of a treated area can be maintained and there is follow up treatment to keep prickly acacia under control, it is more economically efficient to clear up the 'at risk' areas that currently have a minimal infestation. This would be followed by the next level of infestation and then the next until the high density infestations are treated. The critical criteria would be that each treated area needs to be effectively followed up and reinfestation from the more heavily infested paddocks on the property strictly prevented.

Table 75 – Returns over 30 years for control of prickly acacia at different densities, and assuming a series of wet years occurs 5, 10 or 20 years after treatment, by investment of $10,000 in Year 1 plus maintenance

Density of prickly acacia and number of years prior to series of wet years	Annualised NPV	Peak deficit (with interest)	Year of peak deficit	Payback period (years)	IRR
High density infestation (treat 40 ha)	$1,900	-$16,024	5	25	6%
Moderate density (treat 100 ha)					
5 years to wet years	$25,500	-$13,100	3	11	16%
10 years to wet years	$20,800	-$13,100	3	13	14%
20 years to wet years	$14,270	-$13,100	3	14	12%
Low density (treat 200 ha)					
5 years to wet years	$50,600	-$13,600	3	10	20%
10 years to wet years	$36,600	-$13,600	3	13	16%
20 years to wet years	$19,100	-$13,600	3	15	12%
Minimal density (treat 4,000 ha)					
5 years to wet years	$130,100	-$34,700	8	12	18%
10 years to wet years	$103,700	-$39,400	8	15	16%
20 years to wet years	$63,100	-$39,400	8	17	13%

4 General discussion

This study represents a detailed attempt to assess the economic implications of a comprehensive range of management decisions that can be applied to prepare for drought in the Northern Downs region of Queensland. In this study 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 properties in the region. The results of this analysis 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 profitability and drought resilience in the Northern Downs region 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. However, there is an obvious challenge in adequately accounting for the high annual rainfall variability that occurs in this region. Regardless, the example property constructed in this study provides a broad understanding of the range of opportunities available for improvement, the potential response functions and an appropriate framework to support decision making.

The key to improving the performance of individual beef 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). 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 each separate property. Managers and their advisors can use the tools and models developed in this study to conduct their own analyses specific to their circumstances.

A number of alternative beef production strategies are available and it is shown in this study that some are likely to both reduce profit and increase drought risk while others could both improve profit and reduce drought risk. The key insight is that the value of any change in management to build drought 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 properties that exhibit drought resilience are predominately those that spend considerable time and resources preparing for drought. 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 assessing options when responding to and recovering from drought.

The major challenges facing beef property managers in the Northern Downs region 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, beef 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 results of the economic analysis summarised in Table 1 indicate the difference in returns between the constructed, base property and the same property after investing in the specified management strategy. They are a guide to possible strategies that may improve profitability and business resilience prior to drought. It is important to note that a negative NPV does not necessarily indicate that a property implementing such a strategy is unprofitable, just that the strategy causes the property to be less profitable than the base scenario.

A key insight gained from the analysis is that appropriately managed beef cattle properties in this region (as modelled for the constructed, base property) appear to have been historically profitable, with that profit applied over time to build resilience to manage the inherent variability of the region. The recent, and apparently ongoing, escalation in capital values combined with the decoupling of asset values and rates of return on investment (McCosker *et al.* 2010; McLean *et al.* 2014) suggests that building resilience in the future through an increase in the size of holdings within the region may be more risky than it has been in the past. For the same reason, both of the strategies that looked at property purchase outside of the region were shown to be inherently risky and unlikely to be the best investment available.

However, many existing businesses in the region operate a breeding property within the Northern Gulf region in association with a breeding and growing property located in the more productive Northern Downs region (Rolfe *et al.* 2016). The Northern Gulf property commonly turns off weaner steers to the Northern Downs property for growing out to market weights. At the long term average prices applied in this analysis, it was found to be most profitable to operate the properties as separate entities, turning off steers at the optimal age for each region (i.e. live export steers from the Northern Gulf property and feed-on steers from the Northern Downs property). All strategies for operating the properties as integrated breeding and growing operations, with transfer of steers from the Northern Gulf property to the Northern Downs property, reduced the expected total business profit generated by operating the properties as separate entities (i.e. operating profit reduced by $300 to $52,600/annum).

The remaining options considered to improve the efficiency of the constructed property showed that selecting an appropriate market (age of turnoff) for steers and deciding on the balance between the relative size of a breeder herd and a more flexible steer growing or turnover operation were key options for further analysis. This balance underpins the capacity of the property to appropriately respond to the unpredictable variability in feed supply typical of the production system. The analysis showed that a steer turnover operation was more profitable than a combination breeding and steer growing operation (by $62,500/annum). Furthermore, a steer turnover operation lends itself to more timely destocking during dry periods. However, it is impossible to prescribe what a suitable balance might be between a breeding component and a steer growing/trading component for any individual property as this is 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 technical management of livestock are secondary considerations in deciding the balance.

Strategies that involved improving the nutritional status of cattle by providing supplements to steers or breeders always reduced profitability and resilience of the property despite improving steer growth rates or breeder reproduction performance. Again, these results are consistent with those for other regions across northern Australia (Bowen and Chudleigh 2018b; Bowen *et al.* 2019a; Chudleigh *et al.* 2019b). Other strategies that improved breeder herd efficiency, such as genetic improvement of weaning rate or reducing foetal/calf loss (should an effective technology or management strategy be identified), had relatively minor effects on business profitability. This finding is also common to other regions across northern Australia that are both more productive (Bowen and Chudleigh 2018b) and less productive (Bowen *et al.* 2019a; Chudleigh *et al.* 2019b).

Ash *et al.* (2015) reported results of whole-farm-scale dynamic simulation modelling to assess a range of technology interventions that may improve productivity and profitability of northern Australian beef enterprises. While Ash *et al.* (2015) reported substantial increases in enterprise profit from strategies to improve reproductive efficiency of breeders through genetic gain, our study showed such a strategy to result in either a small decrease or small increase in enterprise profit dependant on whether the bull herd was immediately or gradually replaced. The difference in the results of the two studies is largely due to the economic methods used by Ash *et al.* (2015) which did not consider the implementation phase required for each of the scenarios but assumed the that the strategies were fully implemented from the start of their 25-year scenario runs. The poor economic performance of the improved breeder genetics strategy in our study was partly a result of the extended period of time before the improved genes predominated in the herd, in addition to the pre-existing, moderate level of reproduction efficiency. The results for investment in genetic improvement of weaning rate in the Northern Downs are similar to the results for the same genetic improvement applied in a representative beef herd in the Fitzroy NRM region of central Queensland where returns were also slightly reduced or changed minimally as a result of implementing these alternative strategies (Bowen and Chudleigh 2018b; Chudleigh *et al.* 2017, 2019a).

The inability to identify alternative investments that improve breeder herd efficiency highlights the critical importance of implementing low cost strategies to get body condition and herd structure right as key factors in being drought prepared. An analysis of the impact of breeder condition score on mortality, due to falling body condition and weight loss during a drought, demonstrated the importance of the day-to-day management of the breeder herd and its nutrition in preparing for drought. Selecting the appropriate age for female culling and steer sale can also reduce drought risk. This has been shown to be universally important across northern Australia's grazing regions (Bowen and Chudleigh 2018b; Bowen *et al.* 2019a; Chudleigh *et al.* 2016, 2019b).

The exotic woody weed, prickly acacia (*Acacia nilotica*), is spread over millions of hectares of Mitchell grasslands in north Queensland, including the Northern Downs region, and is having an ongoing negative effect on carrying capacity and productivity of affected properties (The State of Queensland 2004; Australian Government 2020). The analysis conducted to examine the returns for investment in property-level control, where 80% of the property had infestation levels ranging from low to high, indicated positive returns of 8-13% IRR which were negatively related to number of years prior to the onset of wet years capable of causing prickly acacia spread. However, for the requirement for >$1.3 million to be invested over the first 4 years of treatment is unlikely to enable many managers to adopt property-level control if it were to be self-funded. The alternative approach of targeting $10,000 in Year 1 to prickly acacia control with ongoing maintenance over 30 years, also showed very positive returns of 6-20% IRR, dependent on level of infestation and the number of years prior to the onset of wet years. This analysis indicated that it is most economically efficient to treat and maintain areas with minimal infestation first, moving on the increasingly higher levels of infestation as funds allowed. The critical criteria would be that 1) each treated area needs to be effectively maintained with follow-up treatment, and 2) re-infestation from the more heavily infested paddocks on the property must be strictly prevented.

The importance of incorporating the implementation phase in any analysis of change in the management of beef properties in northern Australia have been conclusively demonstrated in the studies of Chudleigh *et al*. (2016, 2017, 2019a,b), Bowen and Chudleigh (2017, 2018b,c), and Bowen *et al.* (2019a,b). These analyses, as well as our current study, have highlighted the importance of appropriately modelling the steps in moving from an existing herd structure and target market to a different target market and consequently a different herd structure when implementing alternative management strategies. 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 strategies to improve the economic performance of breeding herds run under extensive grazing conditions in northern Australia. These analyses indicated that capital constraints and perceived risk are likely to play a large role in the level and rate at which a management strategy is likely to be adopted and implemented. Applying a method that appropriately highlights the financial risks associated with the implementation of a management 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 northern beef industry.

5 Conclusions

The Northern Downs region has high levels of climate variability and a history of extended and extensive droughts and intermittent flooding. The significant challenges for beef producers in maintaining control given the considerable production uncertainty and volatility were highlighted by the collective analyses detailed in this report. The central understanding gained was that the capacity of producers to deal with variability is key and that the application of a logical, rational framework is critical to evidence-based decision making. This study represents the first known attempt for the Northern Downs region to assess the economic implications of a comprehensive range of management decisions. 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 businesses in the Northern Downs region of Queensland. The scenarios modelled here are aimed at providing a broad understanding of the range of opportunities available for improvement, the potential response functions in a production system and an appropriate framework to support decision making. The property-level, regionally-specific herd and business models that we have developed can be used by consultants, advisors and producers to assess both strategic and tactical strategies for their own alternative scenarios.

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7 Glossary of terms and abbreviations

AE	Adult equivalent. In the Dynamaplus program 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.
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.
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://www.daf.qld.gov.au/animal-industries/beef/breedcow-and-dynama-software. The 30-year version of the models applied in this analysis are available from the authors of this report.
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.
DCQ	Desert Channels Queensland. A natural resource management (NRM) body providing funding, information and technical support targeted to sustainable management of Queensland section of the Lake Eyre Basin.

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).
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.
EU	European union. One of the market options for Australian beef producers.
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, consultants 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.
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.
HGP	Hormonal growth promotant. HGP implants are used to increase growth rates in cattle.
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.
M8U	Molasses mix containing 8% urea by weight; used as a supplement for beef cattle in northern Australia.
Marginal	Extra or added. Principle of marginality emphasises the importance of evaluating the changes for extra effects, not the average level of performance.
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.
MSA	Meat Standards Australia. A grading system developed to improve the supply of consistently high quality beef to the consumer.
N	Nitrogen
n/a	Not applicable
n/c	Not calculable
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 operators 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. Annualised NPV converts the Marginal 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.
NT	Northern Territory of Australia
Operators allowance	An allowance for the owners 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	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 gross margin (total receipts minus variable costs) 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.
P	Phosphorus
Payback period	The number of years it takes for the cumulative present value to become positive. Other things being equal, the shorter the payback period, the more appealing the investment.
PCAS	Pasturefed Cattle Assurance System. One of the market options for Australian beef producers.
PDS	Producer demonstration site. This term has commonly been applied to research or technology demonstrations sites on commercial producer properties that are co-funded by Meat and Livestock Australia.
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 in calf)
PTIC	Pregnancy tested in calf
Rate of return on assets	An estimate of how profitable a business is relative to its total assets. It is the net income of a business divided by total assets.
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).
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).
VRD	Victoria river district of the Northern Territory
WIWO	Walk-in, walk-out. Term used to describe the purchase conditions of a property.
Year of peak deficit	The year in which the peak deficit is expected to occur.

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9 Appendix 1. Breedcow and Dynama software

9.1 Brief description of the Breedcow and Dynama software

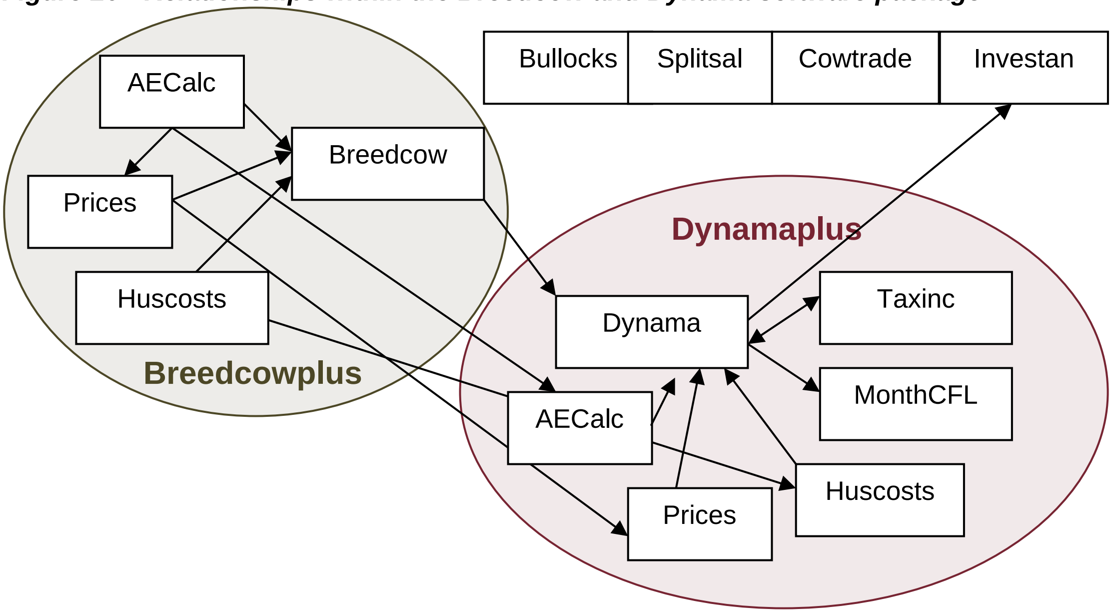
The Breedcow and Dynama package of software programs is used to assess choices for the management of beef cattle herds run under extensive conditions. **It is not an accounting package or a paddock records package and does not record individual animals**. It presents budgeting processes, adapted to the 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 20 indicates the relationships between the individual components of the Breedcow and Dynama 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 20.

Figure 20 - Relationships within the Breedcow and Dynama software package



9.2 Summary of the components of the Breedcow and Dynama software

The package currently comprises eleven components that make up six separate programs: Breedcowplus, Dynamaplus, Investan, Cowtrade, Bullocks and Splitsal.

9.2.1 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.

9.2.2 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.

9.2.3 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.

9.2.4 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.