Northern Gulf 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 that can be applied to prepare for, respond to, or recover from drought in the Northern Gulf Natural Resource Management (NRM) region of Queensland. Accompanying reports in this series present results for other regions across Queensland's grazing lands. It is intended that the results of these analyses will support the implementation of resilient grazing, herd and business practices necessary in managing 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 their own properties.

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 beef properties in the Northern Gulf region. In doing this, we developed property-level, regionally-specific herd and business models for a representative, constructed beef cattle property which was based on the median herd data from relevant industry surveys and research. The starting base property was 30,000 ha of native pastures on representative land types and was considered to be in ca. B- land condition on average (scale A-D) with a carrying capacity ca. 65% of the safe, long term carrying capacity of these land types when in A condition. The property initially carried ca. 2,500 adult equivalents (AE) with estimated ratio of AE to safe carrying capacity of 1.54 given the B- land condition status. It was assumed that under this sustained stocking rate the land condition would continue to decline at a rate of 0.5% decrease in safe carrying capacity per year over the next 30 years resulting in a decrease in herd performance. The management features of the self-replacing Brahman breeding herd included continuous mating and minimal (inadequate) phosphorus (P) supplementation. The average mortality rate of the base herd was 7.5% and the average weaning rate from all cows mated was 47.4%. The average annual post-weaning weight gain for steers was ca. 86 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 largely not adopted a sustainable approach to pasture management.

Production systems 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 representative 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 which are considered in response to, or recovery from, drought tend to need consideration of both short term and long term implications and were examined using herd models in conjunction with spreadsheets designed to assess tactical decisions.

Preparing for drought

Preparing for drought by improving profit and resilience

The major challenges facing beef producers in the Northern Gulf are the inherently low productivity and profitability of the region. Financial pressures appear to be contributing to high stocking rates and consequent land condition decline across the region which will inevitably further reduce long-term

productivity and profitability. Hence the first priority, in terms of management strategies for the Northern Gulf, was to address the decline in land condition through a reduction in stocking rates and implementation of a systematic wet season spelling regime. The second priority was to implement adequate wet season P supplementation for cattle due to the known biological and economic benefits of this strategy. Addressing these two issues for the representative property substantially improved profitability over the medium term (Table 1) but appeared unlikely to make the property sufficiently resilient to survive as a separate production system into the future. This was because total profit was insufficient to pay total costs when livestock prices were maintained at the level of the longer term average. That is, cumulative cash flow after 30 years was negative and declining. Even so, it was critical that these two issues were addressed before anything else was considered.

Table 1 – Value of implementing two key strategies to improve profitability and drought resilience of a representative beef property in the Northern Gulf region, compared to the base situation of declining land condition

The analysis was conducted for a 30-year investment period

Scenario	Annualised NPV[A]	Cumulative cash flow after 30 years[B]
Reducing cattle numbers and systematic wet season spelling to improve land condition (grazing land management) (p. 42)	$15,100	-$1,824,600
Grazing land management + adequate wet season P supplements (p. 49)	$59,800	-$319,000

[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 representative, 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]**Cumulative cash flow is the predicted final bank balance of the property after 30 years due to the implementation of the strategy.** The predicted cumulative cash flow of the property without change was -$2,212,900.

The remaining question was whether additional strategies were available to make the property more viable. The results of the investigation of additional strategies for their ability to improve profitability and resilience, and hence prepare for drought, are summarised in Table 2. These results are the net difference in returns between the representative property, with land condition improvement and adequate wet season P supplementation implemented, and after investing in the specified additional management strategy. They are a guide to possible strategies that may further build profit and 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 payback period of 'not calculable' means the investment did not pay back in the 30 years of the analysis based on the assumed set of input costs and prices. The benefits of Table 2 are additive to those identified in Table 1. That is, the representative property can potentially add benefits from Table 2 to those identified in Table 1.

The strategies that appear worthy of further consideration include planting stylo for steers, fertilising existing stylo pastures with P, optimising the age of turnoff for steers over the longer term and using home-bred bulls. Planting leucaena on suitable land types also shows some promise but is unlikely to be widely applicable. The advantage provided by home-bred bulls appears to arise from the high average value some beef property managers pay for herd bulls and the difference between that cost and the costs associated with breeding your own. Investment in strategies that may reduce calf loss by 50%, or improve the fertility of the breeder herd, seem unable to add substantially to the profit and resilience of the representative property over the longer term, even if able to be achieved at a low cost.

Table 2 – Profitability and financial risk of implementing alternative strategies to improve profitability and drought resilience of a representative beef property in the Northern Gulf region, compared to a new base scenario of stable land condition and adequate wet season P supplementation (i.e. these responses are additive to those in Table 1)

The analysis was conducted for a 30-year investment period using current input costs and a weighted average of cattle prices over the period Jan 2006-Feb 2018

Scenario[E]	Annualised NPV[A]	Peak deficit (with interest)[B]	Year of peak deficit	Payback period (years)[C]	IRR (%)[D]
Stylo for steers (500 ha paddock) (p. 58)					
20% utilisation, May sale	$5,100	-$66,400	6	12	11
40% utilisation, May sale	$17,300	-$92,700	6	9	20
20% utilisation, September sale	$5,100	-$60,900	6	12	12
40% utilisation, September sale	$18,200	-$61,000	6	9	22
Stylo for all steers (property-level)[F] (p. 58)					
20% utilisation, May sale	$31,000	-$270,600	9	15	10
P fertiliser on existing stylo (500 ha paddock) (p. 67)					
20% utilisation May sale	$12,700	-$70,600	2	6	22
20% utilisation, September sale	$11,000	-$60,900	2	6	22
20% utilisation, September sale + 10 c/kg live	$12,900	-$59,800	2	5	25
Increasing age of steer turnoff to 41 mths (cf. two cohorts at 29 and 41 mths) (p. 74)	$32,500	-$95,500	2	8	24
Leucaena for steers (frontage country, 500 ha paddock)[G] (p.77)					
June sale	$54,600	-$464,200	5	10	16
October sale same price	$43,300	-$454,300	5	10	15
October sale + 10 c/kg live	$53,200	-$454,300	5	10	17
Molasses production mix for steer tail (p. 83)	-$5,900	-$252,500	-	not calculable	n/a
Feeding silage to home-bred steers (p. 88)	-$18,400	-$784,000	-	not calculable	n/a
Sending steers on agistment (p. 98)	-$7,600	-$116,300	-	not calculable	n/a
Genetic improvement of weaning rate (p. 100)					
Immediate changeover of bulls	$4,100	-$94,400	5	17	9
Gradual changeover of herd bulls	$6,800	n/a	n/a	n/a	n/a
Home-bred bulls (p. 105)	$16,600	-$25,000	2	3	59
Supplementing first calf heifers (p. 106)	-$3,500	-$147,000	-	not calculable	n/a
Reducing foetal/calf loss by 50% by spending (p. 109)					
$5/breeder	$5,300	-$6,000	1	4	-
$7.50/breeder	$2,300	-$16,700	4	8	-
$10/breeder	-$700	-$37,000	-	not calculable	-
$50,000 capital	$8,100	-$50,000	1	6	-
$75,000 capital	$6,600	-$75,000	1	9	-
$100,000 capital	$5,000	-$100,000	1	13	-

[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 representative, 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.** It is compounded at the discount rate and, other things being equal, the shorter the payback period, the more appealing the investment. Not calculable means the investment did not pay back in the 30 years of the analysis using current input costs and a weighted average of cattle prices over the period Jan 2006-Feb 2018.

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

[E]All strategies (other than property-level stylo development) were compared to the new base property after 10 years of land condition improvement and adequate wet season P supplementation.

[F]The property-level stylo development strategy was implemented concurrently with land condition improvement and adequate wet season P supplementation from Year 1 of the analysis and was compared to a base herd which implemented land condition improvement and adequate wet season P supplementation but no stylo.

[G]The assumption was that an area of frontage country was available on the property. The comparison was the 500 ha frontage paddock with and without leucaena development.

Assessing the potential impact of drought on the herd as well as the effect of herd structure on drought risk and profitability

The results of our study of the Northern Gulf representative property suggest that, other than P supplementation, investments focused on improving the performance of the breeder component of the herd in isolation are unlikely to substantially improve profit and resilience. This 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. An analysis of the impact of breeder condition score on mortality risk, due to falling body condition and weight loss during a drought, demonstrated the importance of good nutritional management of the breeder herd in preparing for drought. Selecting the appropriate age for female culling and steer sale can also reduce drought risk.

Responding to drought

The capacity of the representative property to respond to drought is initially defined by the way the breeder herd is already segregated and managed. In this analysis, the representative breeder herd had the bulls left in for the entire year (continuously mated) and had been segregated on pregnancy status. Herd segregation on foetal aging provides a tactical opportunity for the manager to rapidly reduce grazing pressure if the following season were to be below average. This capacity is part and parcel of having an efficient production system in place prior to drought and provides substantially more sell-down options than those available to the producer with unsegregated, continuously mated breeder herds.

Drought response strategies are often seen as tactical, short-term decisions which are highly dependent on the individual circumstances prevailing at the time. This is not always correct as the options available to respond to drought are often determined by herd management and stocking rate decisions made prior to the drought. Likewise the actions taken in response to drought conditions will often determine the medium term property outcomes once the drought breaks. Flexibility is the key when analysing response and recovery steps as viable alternatives are often only revealed as the drought progresses. Therefore a key element is the ability of a management team to assess and reassess options as a drought progresses and apply logical decision making during a time of high stress and physical workload.

The consideration of alternative responses should initially be undertaken by looking at impacts on components of the herd in isolation together with the extra costs and benefits associated with the option. It is not possible or practical to create scenarios to reflect every possible assumption or management decision. Hence, examples were developed to demonstrate a) the key drought response strategies, and b) the analysis tools available in the Breedcow and Dynama suite of programs. The key finding from these analyses was that assessing the sale of alternative classes of cattle should be done on the basis of the impact on both future profit and future cash flow and that all classes of cattle should be incorporated in the assessment.

Recovering from drought

The choices available during the drought recovery phase depend partly upon the decisions previously made during the drought response phase. Each alternative strategy implemented during a drought will impact on herd structure and therefore options available for recovery. Drought recovery strategies should be targeted at returning the property to the optimum (most profitable) herd structure and age of turnoff as quickly as possible.

As for drought response strategies, the relative value of recovery strategies needs to be assessed using the relevant input figures at the time of the decision. A limited number of examples were developed to demonstrate a) key strategies which may be considered in the drought recovery phase, and b) how to assess strategies using tools available in the Breedcow and Dynama suite of programs. Key findings from these analyses included:

- After a significant herd reduction during drought, allowing herd numbers to rebuild slowly from retained progeny is likely to seriously impact the ongoing viability of the property.
- If breeders had been sent on agistment in response to drought cash flow deficits would be increased in the short term compared to the sale of breeders. However, cash flow and profit could be more rapidly returned to the optimum level in the drought recovery phase by retaining these breeders through agistment.
- Purchasing PTIC (pregnancy tested in calf) cows to rapidly restore the breeder herd at the conclusion of the drought would increase and extend cash flow deficits in the short term but potentially provide a better medium term outcome than just allowing the herd to return to normal numbers through foregoing sales.
- If the spare grazing capacity created by selling cattle at the start of the drought can be filled by agistment stock, at a suitable price once the drought breaks, cash balances in the early years improve while the herd is rebuilding. Whether this is more profitable than purchasing PTIC cows depends upon the amount per head received for agisting stock and the purchase price of PTIC cows.
- The short term trading of large numbers of stock when recovering from drought is the most risky of the options considered due to the price risk associated with trading cattle, the significant additional interest and expenses which are likely to initially reduce cumulative cash flow, and the capacity to fund the steer purchases. Hence any benefits in projected long-term cumulative cash-flow and profitability, above those available from other recovery strategies, must be carefully considered.

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1 General introduction

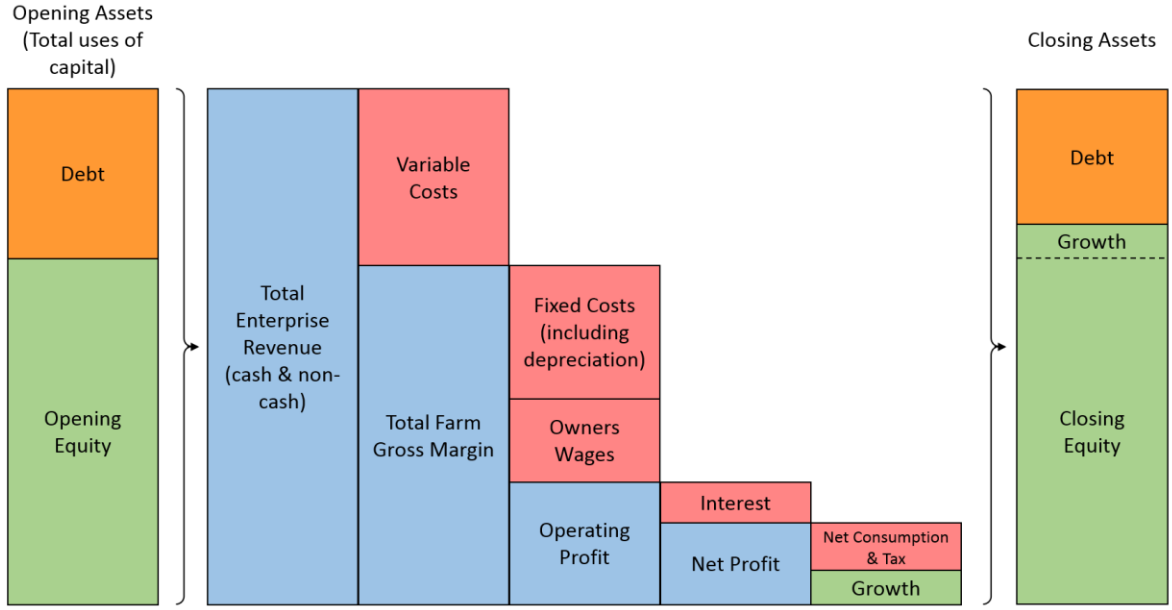
More than 80% of Queensland's total area of 173,047,559 ha is used for grazing livestock on lands extending from humid tropical areas to arid western rangelands (QLUMP 2017). Most extensive grazing enterprises occur on native pastures with introduced (sown) pastures constituting less than 10% of the total grazing area and occurring on the more fertile land types (McIvor 2005; QLUMP 2017). Grazing industries, and particularly beef cattle, make an important contribution to the Queensland economy. In 2016-17 the beef cattle industry accounted for ca. 41% ($5.7 billion) of the total gross value of Queensland agricultural production while sheep meat and wool accounted for ca. 1% ($0.1 billion), (ABS 2018*b*).

Queensland's variable rainfall, and extended periods of drought, is one of the biggest challenges for grazing land managers. As well as causing degradation of the grazing resource, drought regularly has a severe impact on viability and provides the context for many of the production and investment decisions made by beef producers. 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).

To remain in production, and to build drought resilience, beef and sheep properties need to be profitable and to build equity (Figure 1). Building resilience usually means investments have to be made and alternative management strategies considered well before encountering extended dry spells or drought. To make profitable management decisions graziers need to 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).

Decision making during drought often has a much more tactical, short term focus but once again 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 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.

Figure 1 – The link between profit and growth in equity



Although we have identified that regularly achieving a profit is a key ingredient of a drought resilient beef production system we do not see what is commonly termed the 'profit motive' as necessarily driving the goals of the vast majority of beef producers. The factors that motivate them are much more complex and diverse. However, to be a beef 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 knowledge and skills of advisors and graziers in assessing the economic implications of management decisions which can be applied to prepare for, respond to, or recover from drought. Scenario analysis was applied to a range of management strategies and technologies to build 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 Gulf Natural Resource Management (NRM) region to prepare for, respond to, or recover from drought.

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 representative beef cattle property in the Northern Gulf region of Queensland using scenario analysis. The levels of production associated with this representative, 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 staff. An exhaustive approach, of conducting workshops, training events and discussions with skilled and experienced scientific and extension colleagues, has been applied over recent years 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 Breedcow and Dynama programs (Version 6.02; Holmes *et al.* 2017) were applied to test the relative and absolute value of changing herd management strategy. In all cases, a change in the current 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 the existing beef production 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 principal 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 consider changes in management strategies such as different ways of financing the beef property or the impact of different levels of equity on farm risk, these other equally critical aspects of managing a beef property were not considered here and the results should be interpreted in the context of this caveat. It is also important to note that many properties in the region with similar characteristics to our representative 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 herd target and 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 adult equivalents; 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. Additional detail and description of the Breedcow and Dynama suite of programs is provided by Holmes *et al*. (2017).

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 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 (Version 6.02; 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 (2018). 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 which, in turn, was calculated as: *operating profit = (total receipts – variable costs = total gross margin) – overheads*. Operating profit was defined as the return to total capital invested after the variable and overhead (fixed) costs involved in earning the revenue were deducted. Operating profit represents the reward to all of the capital managed by the property. The calculation of operating profit included an 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 operators allowance was that it is the value of the owners 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 examination of short-term, tactical strategies that can be applied in the response or recovery phases of drought were also analysed using a farm management economics framework (Malcolm 2000). These analyses were conducted with reference to Breedcow base herd model and with use of the ‘Cowtrade’, ‘Bullocks’ and ‘Splitsal’ programs from within the Breedcow and Dynama suite where applicable (Version 6.02; Holmes *et al.* 2017). The Cowtrade program was used to calculate the relative profitability of breeder groups while the Bullocks programs was used to calculate the relative profitability for groups of steers and empty cows or heifers. The Splitsal program was used to estimate potential weight distributions and averages for groups within the herd.

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.

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 therefore provides a measure of the net impact of the investment in current value terms and takes into account the timing of benefits and costs over the life of the investment. 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 discovered. IRR was calculated as the discount rate at which the present value of income from a project equals the present value of total expenditure (capital and annual costs) on the project (i.e. the break-even discount rate). An amortised (annualised) NPV was calculated at the discount rate (5%) over the investment period to assist in communicating the difference between the representative, base property and the property after the management strategy was implemented.

This measure is not the same as the average annual difference in operating profit between the two strategies but is automatically calculated in the Investan program and is therefore already presented to users of the program as a measure of the average annual difference between the 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 vale whereas the average annual change in operating profit is undiscounted. The annualised NPV can be considered as an approximation of potential average annual change in profit over 30 years, resulting from the management strategy.

The financial criteria were peak deficit, the number of years to the peak deficit, and the payback period in years. The beef property started with no debt but accumulated debt and paid interest as required by the implementation of each strategy. Peak deficit in cash flow was calculated assuming interest was paid on the deficit and compounded in each additional year that the deficit 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 extra capital invested in developing an existing operation.

For tactical strategies, the break-even point of alternative courses of action was usually the key decision criteria. However, alternatives were also considered on the basis of least cost and the lowest impact on the future productivity of the herd.

3 The Northern Gulf region and the representative, beef cattle property

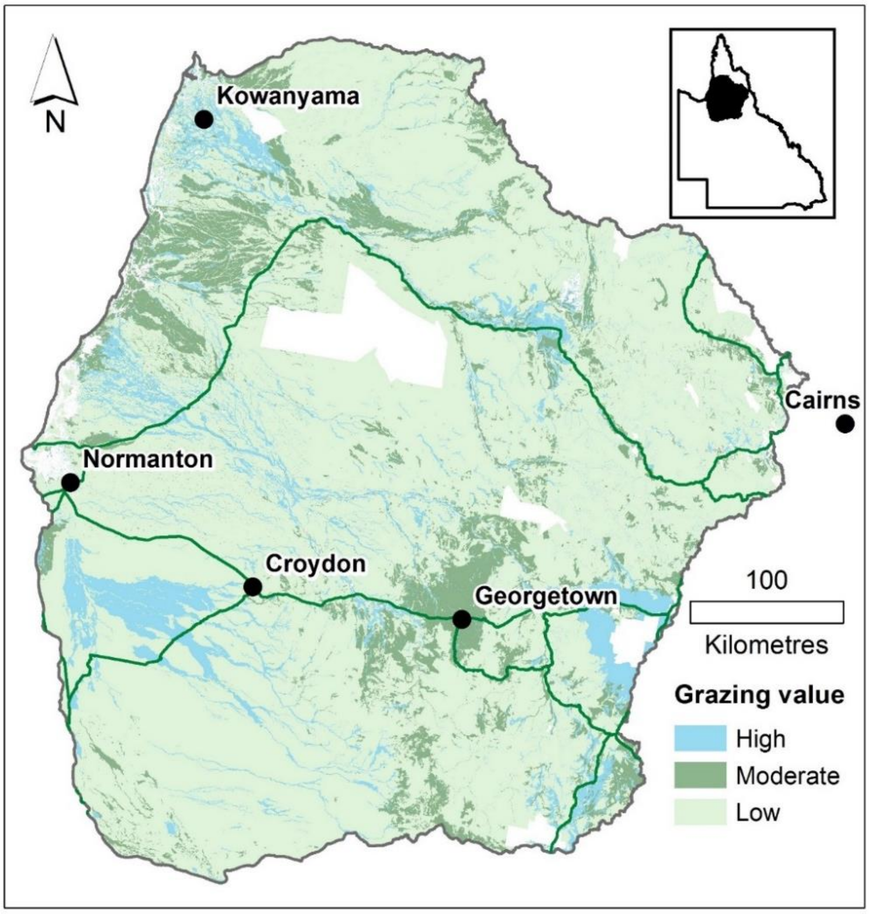
3.1 Introduction

3.1.1 The land resource

The Northern Gulf NRM region encompasses 18.3 million ha of grazing land which constitutes 94% of the NRM region (DNRM 2010; DNRM 2017). The Northern Gulf region comprises the catchments of the Norman, Gilbert, Staaten and Mitchell River systems, all of which flow into the Gulf of Carpentaria. The region is situated between 15^0 and 19^0S and 141^0 and 145^0E. The majority of the region consists of land types which are low in fertility and grazing value (Figure 2). Native, tropical (C_4) pastures are the predominant forage type on grazing lands with areas oversown to introduced legume species from the Stylosanthes (hereafter, stylo) group which are adapted to low fertility soils. There are smaller areas of high-fertility, basalt-derived soils and frontage country in the region which are capable of supporting sown, high-quality forages such as leucaena (*Leucaena leucocephala* subsp. *glabrata*).

Figure 2 – Map of the Northern Gulf Natural Resource Management region of Queensland showing the distribution of land types with grazing value 7-10 (High), 3-6 (Moderate) or 1-2 (Low), (highest value 10)

Land used for purposes other than grazing is marked white on the map. Grazing value (scale 1-10) is a subjective rating related to pasture biomass production and soil fertility when in the land is in A condition, reflecting the land type's productive capacity (kg beef/ha); (Shaw et al. 2007)



3.1.2 Rainfall and drought

The Northern Gulf NRM region has a monsoonal climate with a 4-month wet season (December to March) followed by an extended, 8-month dry season (April to November). Annual rainfall in the region ranges from 1,250 mm in the north of the region to 650 mm in the south. Examples of seasonal distribution of rainfall are shown for seven locations from north to south across the Northern Gulf region (BOM 2018*a*; Table 3). The amount and distribution of rainfall are primary determinants of pasture growth and quality. The long dry season results in poor forage quality for much of the year with diet crude protein (CP) and dry matter digestibility (DMD) levels less than 7% and 50%, respectively (Bray *et al.* 2014). The Southern Oscillation Index (SOI) affects the time of the break of the monsoon in this region with the wet season likely to arrive earlier when sea surface temperatures around northern Australia are high and the SOI is strongly positive. Once the monsoon has commenced, rainfall is relatively reliable although extended dry periods are still possible. Flooding of low flat country is common after heavy rain.

The variability of annual rainfall in the Northern Gulf region ranges from 'low to moderate' in the north to 'moderate' in the south (scale low to extreme) based on an index of variability determined by percentile analysis (BOM 2018*b*; 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 2018*a*; Table 4).

Queensland's variable climate, especially long periods of drought, is one of the biggest challenges for beef property managers. Drought regularly has a severe impact on profitability and provides the context for many production and investment decisions made by managers of beef properties. While there is no universal definition of drought, one that is common in agriculture is the 'drought percentile method' (BOM 2018*a*). 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 2018). 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 in (Table 5) for Georgetown. Using this definition, there have been 31 droughts at Georgetown since 1900, the longest lasting 12 months.

Table 3 - Median seasonal distribution of rainfall (mm) at Kowanyama, Rookwood Station (near Chillagoe), Mount Garnet, Croydon, Georgetown, Mount Surprise and Gilberton for the 30-year 'climate normal' period 1961-1990; (BOM 2018a)

Town	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Kowanyama	270.8	371.5	213.2	37.1	1.0	0.6	0.2	0.0	0.0	1.3	66.4	129.6	1,250.4
Rookwood Station	148.2	199.2	133.8	13.7	0.0	0.0	0.0	0.0	0.0	0.0	44.7	142.9	792.5
Mount Garnet	129.1	155.0	111.1	35.8	17.0	13.5	7.8	4.0	4.2	14.7	65.0	125.1	839.0
Croydon	159.7	162.4	96.0	2.8	0.0	0.5	0.0	0.0	0.0	2.5	24.9	95.9	655.6
Georgetown	179.1	208.4	112.7	17.6	2.1	1.4	0.0	0.0	0.0	5.2	50.2	89.2	841.3
Mount Surprise	165.9	179.4	93.7	23.1	6.4	0.8	0.0	0.0	0.4	4.5	43.5	121.2	822.8
Gilberton	146.7	170.2	70.9	8.3	11.9	2.5	0.0	0.0	0.0	10.7	51.6	107.4	681.9

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

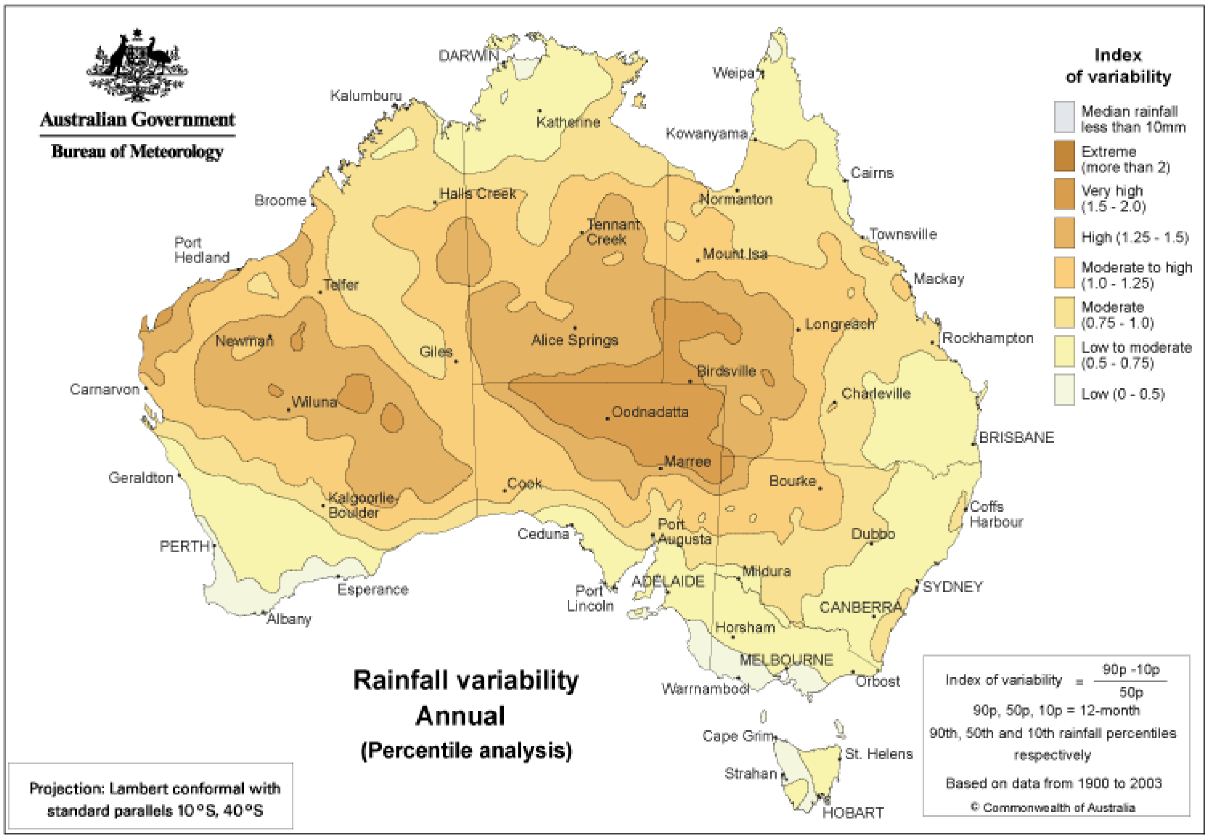


Table 4 – Mean annual rainfall (mm) and rainfall variability (coefficient of variation) at Kowanyama, Rookwood Station (near Chillagoe), Georgetown and Gilberton for the 30-year 'climate normal' period 1961-1990; (BOM 2018a)

Town	Mean annual rainfall (mm)	Rainfall variability expressed as the Coefficient of variation (%)
Kowanyama	1,217	29
Rookwood Station	843	39
Georgetown	839	40
Gilberton	728	40

Table 5 - Historical droughts (1900–2018) at Georgetown ranked by depth and duration and with subsequent recovery rainfall[A]

Rank	Drought period	Drought length (months)	Drought depth (percentile)	Subsequent recovery rainfall (mm)
1	Feb 1926 - Dec 1926	11	0	235
2	Jan 1985 - Dec 1985	12	0	458
3	Jan 1952 - Dec 1952	12	0.9	312
4	Mar 1905 - Feb 1906	12	0	403
5	Mar 1902 - Nov 1902	9	0.9	43
6	Jan 1994 - Dec 1994	12	1.7	368
7	Feb 1919 - Dec 1919	11	0.9	275
8	Feb 1961 - Oct 1961	9	4.3	236
9	Mar 1969 - Nov 1969	9	5.1	51
10	Mar 2013 - Oct 2013	8	4.3	100
11	Dec 1982 - Feb 1983	3	3.4	219
12	Nov 1923 - Jan 1924	3	1.7	243
13	Mar 1988 - Jul 1988	5	3.4	44
14	Jan 1967	1	0.9	75
15	Mar 1931 - Aug 1931	6	7.8	18
16	Feb 1947	1	2.6	136
17	Jan 1954	1	2.6	132
18	Feb 1935	1	3.4	71
19	Aug 1928 - Nov 1928	4	7.8	22
20	Jan 1912	1	4.3	80
21	Nov 1935 - Dec 1935	2	6	31
22	Nov 1915	1	5.2	32
23	Jan 1970	1	6	110
24	Dec 1932	1	6.8	94
25	Feb 2003	1	6.8	189
26	Jan 1988	1	8.5	39
27	Dec 1961	1	8.5	69
28	Dec 2005 - Jan 2006	2	9.4	282
29	Feb 2016	1	9.4	19
30	Sep 1915	1	9.5	3
31	Oct 1932	1	9.5	5

[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).

3.1.3 Northern Gulf region beef production systems

Extensive grazing, primarily on native pastures, is the principal land use across the Northern Gulf NRM region. The region has a total herd size of ca. 796,531, supporting 3% of Australia's (7% of Queensland's) cattle numbers and producing 3% of Australia's (7% of Queensland's) gross value of cattle in 2016-17 (ABS 2018*a*,*b*). The region is ranked eighth out of all NRM regions in Australia, in terms of number of cattle (ABS 2018*a*). There were 196 commercial grazing businesses in the region in 2016-17 (ABS 2018*a*).

Producers in the region target the live export, slaughter and United States grinding beef markets with many managers transporting weaners to southern growing and fattening properties endeavouring to lift animal performance (Rolfe *et al.* 2016*b*). High female mortalities, poor reproductive performance and low annual liveweight gains are characteristic of the region (Henderson *et al*. 2013; McGowan *et al*. 2014). This low productivity and corresponding low returns has resulted in significant profitability challenges in the region (McCosker *et al.* 2010; McLean *et al.* 2014; Rolfe *et al.* 2016*b*). These financial pressures appear to be driving high stocking rates and land condition decline on many properties (Rolfe *et al.* 2016*b*). As reported by Shaw *et al.* (2007) land condition was assessed at 260 sites across the Northern Gulf region in 2003-2004 with only 47% found to be in A condition (scale A-D; Quirk and McIvor 2003; DAF 2011). A total of 34% of sites were in B condition, 17% in C condition and 2% in D condition. Loss of perennial pasture species and weed invasion were key indicators of declining land condition on more fertile land types whereas native woodland thickening was the major factor contributing to declining land condition on lower grazing value land types. Subsequent site evaluations have indicated continued degradation of the land resource and loss of landscape productivity (Gobius 2013; Shaw *et al.* 2017).

Rolfe *et al*. (2016*b*) collected whole-of-business data for 18 beef businesses across the Northern Gulf region encompassing 39 properties and using 5 years of financial data (2008-2013). These properties covered an area of 1.104 million ha and represented 29 families, employing 56 full time equivalents (FTE). The data indicated:

- Most businesses operated a breeding enterprise in the Northern Gulf and one or more finishing properties located outside the region. On average, each family had assets of $9.4 million and liabilities of $3 million. The average return on assets was weak at less than 1%, with six businesses recording negative return on assets. Debt to income ratios, comparing borrowings to annual income, were weak (<2) on 12 businesses. Low profitability and significant liabilities led to most businesses negotiating interest-only repayment terms with their respective lenders. At the time of analysis only two were making regular principal and interest payments.
- Average area managed by each beef business: 61,313 ha (range, 11,331-213,422 ha).
- Average breeders per business: 2,500 (range, 368-6,500).
- Average total AE per business: 4,332 (range, 690-14,309).
- Average age of turnoff: 22 months (range, 8-48 months).
- Average cattle numbers, as calculated across the previous 5 years, exceeded long-term safe carrying capacities on at least 12 of the 18 businesses analysed. The cattle carried (AE) to safe carrying capacity ratio ranged from 1.2 to 1.9 on six businesses. Only 1/3 of businesses studied actively managed stocking rates and routinely spelled significant areas of pasture each wet season with the objective of maintaining land condition and carrying capacity. This

sub-group of businesses had high average equity (92%) indicating that equity levels are possibly a key driver of conservative grazing strategies.

- Average weaning rates were 56% (range, 42-70%). Weaning rates were ≤50% for eight businesses and ranged from 50-60% on three. The remaining seven businesses had weaning rates >60%. Low annual liveweight gain (70–90 kg/head) was a major constraint for those production systems located solely in the Northern Gulf savannas. Growing cattle on the more fertile soils (alluvial, basalt, red duplex and black soils) achieved average liveweight gains of 110 kg/head. Four businesses used pasture improvement on their Gulf breeding operations and/or finishing properties located outside the region to increase annual liveweight performance (120–150 kg/head).
- Female sales, expressed as a percentage of total annual sales, were used as an indicator of death rates due to the inherent difficulty in measuring mortalities on extensive breeding properties. Missing females and/or high mortalities constrain sales income and female replacement. The average female sales as a percentage of total sales was 41%. The female sales were weak (<40%) for six of the businesses studied. Weak female sales (40–44%) were recorded for eight businesses whereas female sales were strong (≥45%) for four. The lowest female sales (34%) and the highest (48%) indicate female losses (mortalities and missing animals) range from 3% to 9%.
- Managers running extensive beef production systems in the Northern Gulf region face a complex mix of biophysical, productivity, family and financial challenges. It is inherently difficult for each family to successfully manage such large scale and diverse grazing landscapes in a variable climate. Inadequate fencing and water infrastructure constrains rotational wet season spelling to maintain and improve land condition. Low profitability and debt servicing pressures make pasture improvement and the installation of additional infrastructure unaffordable for most businesses. Breeder management and weaning options are also limited by poor paddock infrastructure and lack of improved pastures. Additionally, investing heavily in an attempt to lift herd performance was identified as problematic as the financial gain may not exceed the additional operating costs resulting in reduced return on assets for the business.

3.2 Methods

3.2.1 Representative beef cattle property

The base property, herd and business characteristics were informed by recent industry surveys and research relevant to the region (Bray *et al.* 2014; McGowan *et al.* 2014; Rolfe *et al.* 2016*a*; Rolfe *et al.* 2016*b*). The representative, constructed property was a total area of 30,000 ha of native pastures growing on a number of land types as described in Shaw *et al.* (2007) and with a long-term safe carrying capacity of ca. 12 ha/AE for land in A condition. The property was considered to be currently in ca. B- land condition on average (scale A-D; Quirk and McIvor 2003; DAF 2011), with a carrying capacity ca. 65% of the safe, long-term carrying capacity in A condition. The base property carried ca. 2,500 AE with an estimated ratio of AE carried to safe carrying capacity of 1.54 given the ca. B- condition status. Given these assumptions, without a change in management, the property faced ongoing land condition and carrying capacity decline similar to that predicted for the region (Rolfe *et al.* 2016*a*; Shaw *et al.* 2017).

The self-replacing Brahman (>75% *Bos 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 phosphorus (P) on average (4-5 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 and increasing fertility. The wet season P supplementation program was minimal and failed to address the P deficiency in the herd. 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 live export market (410-418 kg average liveweight in the paddock).

Bulls were left with the breeding herd year-round (continuous mating) with two main musters undertaken to wean calves and identify cull breeding 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 in this region and receiving the current supplementation program of the representative herd (Table 6; McGowan *et al* 2014; J. Rolfe and B. English, pers. comm.). A starting mortality rate, common across the region, of 7.5% was applied to reflect the current supplementation strategy, land condition and level of over-stocking although it was assumed that all breeders were vaccinated against Botulism.

Table 6 – Initial reproduction parameters and mortality rates for the representative 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	65	23	60	55
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	50	5	5	5
Female death rate (%)	7.5	7.5	7.5	7.5	7.5	7.5*
Male death rate (%)	7.5	7.5	7.5	7.5	7.5	n/a

PTE, pregnancy tested 'empty' (not in calf).

n/a: not applicable.

*the 10-11 year age group had a 10% mortality rate.

The application of the data for reproduction efficiency and mortality rates to the herd model produced an expected average weaning rate of 47.35% (weaners from all cows mated). The base property produced about 782 weaners from 1,651 females mated and sold 549 head per annum. Cull female sales made up 39.8% 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 7.

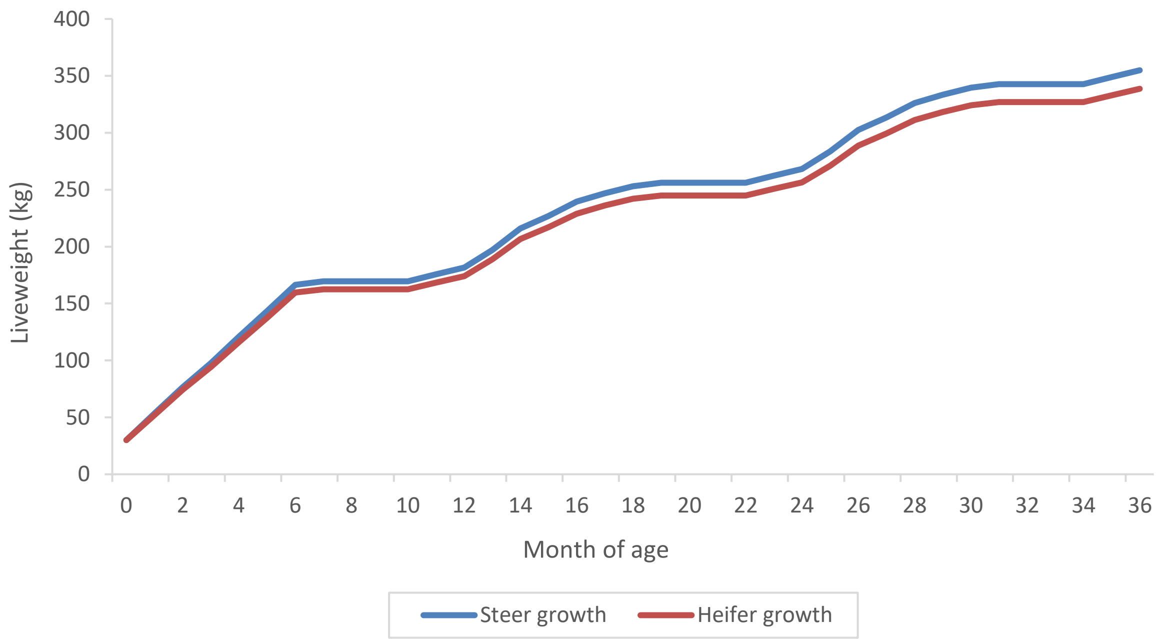
Table 7 – Average herd structure for the representative base property

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	274
Weaners 5 months	782	0	0.20	0.03	159
Heifers 1 year but less than 2	362	0	0.47	0.23	171
Heifers 2 years but less than 3	254	81	0.65	0.26	187
Cows 3 years plus	1,311	134	0.90	0.45	1,242
Steers 1 year but less than 2	362	0	0.49	0.20	179
Steers 2 years but less than 3	134	201	0.68	0.29	150
Bullocks 3 years but less than 4	0	124	0.74	0.30	37
Bulls all ages	66	10	1.43	0.71	101
Total number.	*3,270*	*549*	-	-	*2,500*

n/a, not applicable.

The average weaning weight at 6 months of age was estimated to be ca. 167 kg for steers and 160 kg for heifers. Average annual post-weaning weight gain for steers was assumed to be ca. 86 kg/head and 82 kg/head for heifers. Figure 4 shows the estimated average growth path for steers and heifers grazing land in ca. B- condition (65% of the long-term safe carrying capacity of the same land in A condition) and a stocking rate to safe carrying capacity ratio of 1.54.

Figure 4 - Estimated average steer and heifer growth paths for the starting land condition (ca. B-; 65% of long-term safe carrying capacity in A condition) and stocking rate (65% greater than the safe stocking rate for ca. B- land condition) of the representative base property



It was assumed that 60% of each steer cohort were sold at 29 months old at ca. 365 kg liveweight in the paddock (lead), the remainder were sold 12 months later at about 369 kg liveweight in the paddock (tail), (Table 8).

Table 8 - Splitsal analysis of expected steer liveweight distribution for the representative base herd

Parameter	**Value**
First sale date at an average of 29 months of age	
Average liveweight of total group (kg)	334
Standard deviation of weights (kg)	50
Liveweight range in total group for 95% of group, assuming a normal distribution (kg)	236-432
Cut-off weight for first sale group (lead) (kg)	320
% of total group above cut-off weight	60
Average weight of heavier group (lead) (kg)	365
Average weight of lighter group (tail) (kg)	282
At second sale date 12 months later	
Expected gain over 12 months (kg)	87
Weight of lighter group (tail) (kg)	369

Price data by sale class was referred to for Darwin and Townsville live export markets and for North Queensland over the hooks markets (see MLA market statistics database at http://statistics.mla.com.au/Report/List). Figure 5 and Figure 6 show price trends for selected classes of sale cattle since 2006. Long term data was not available for the period 10/01/2006-16/11/2013 for export steers from Townsville so the price trends for Darwin for the same class of steers was used for that period. Prices for sale stock have shown large variability with the last three years showing a substantial (up to 70%) increase in the prices paid compared to the average of the previous years.

Figure 5 - Cattle prices over time for slaughter cattle in north Queensland

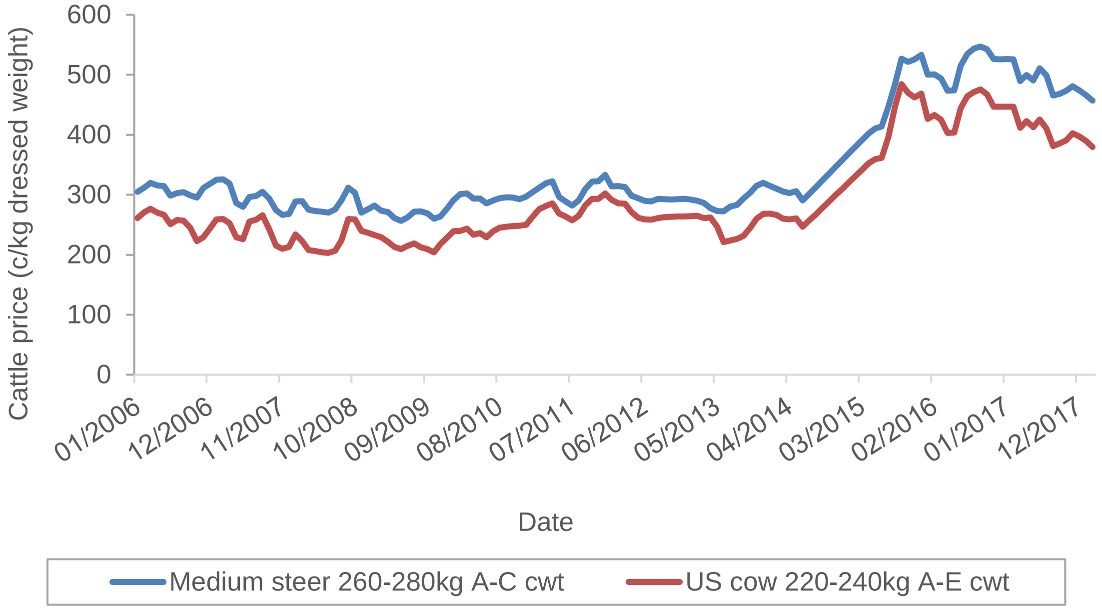
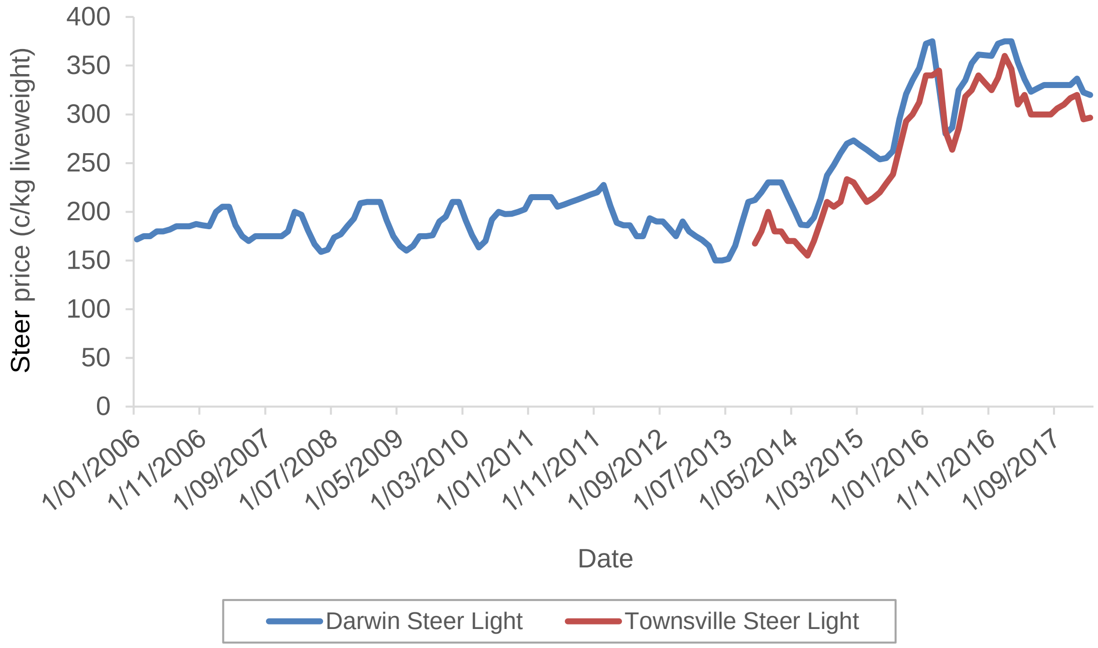


Figure 6 indicates that live export steers in Townsville have received lower prices on average than those exported from Darwin. For the period 2014 to end 2017, the same weight range of steers were, on average, 30 c/kg liveweight lower in Townsville than Darwin.

Figure 6 - Cattle prices over time for live export steers at Darwin and Townsville



The recent volatility in prices made it very difficult to identify appropriate prices for budgeting purposes. In this analysis an ‘average of averages’ value was calculated for use in the economic analysis (Table 9). This involved determining the average of the 2006 to 2018 price data and the separate average of data for the last 5 years (Feb 2013-Feb 2018). These two separate values were then combined to produce an ‘average’ price that was weighted more heavily towards the recent price spike. 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 with selling costs to calculate the net price per head of stock sold (Table 10).

Table 9 – Cattle prices for live export cattle at Darwin and Townsville and for slaughter cattle in North Queensland markets (c/kg liveweight equivalent)

North Queensland prices were converted to liveweight equivalent prices using an assumed dressing percentage of 52%

Parameter	**Darwin live export**		**Townsville live export**		**North Queensland slaughter markets**	
	Light heifer	**Light steer**	**Light steer**	**Medium steer**	**Heavy steer**	**US cow**
	260-350 kg	**260-350 kg**	**260-350 kg**	**260-280 kg dressed weight**	**300-400 kg dressed weight**	**220-240 kg dressed weight**
Median: Jan 2006 – Feb 2018	185	200	n/a	158	163	136
Average: Jan 2006 - Feb 2018	207	225	n/a	179	184	152
Average: Feb 2013- Feb 2018	272	294	264	217	222	186
'Average of averages'	*240*	*260*	*239**	*198*	*203*	*169*

* based on 30 c/kg less than the Darwin export price.

n/a, not applicable.

Table 10 - Sale prices, selling costs, gross and net prices applied in the analysis for the Northern Gulf representative property

Parameter	**Group description**				
	Heifers 2 years	**Cows 3 years plus**	**Steers 2 years**	**Steers 3 years**	**Cull bulls**
Paddock weight (kg/head)	318	410	365	369	650
Weight loss to sale (%)	8	8	8	8	8
Sale weight (kg/head)	293	377	336	339	598
Price ($/kg)	$2.10	$1.70	$2.40	$2.40	$2.00
Commission (% of value)	4	0	4	4	0
Other selling costs ($/head)	$15.00	$5.00	$15.00	$15.00	$5.00
Freight ($/head)	$31.25	$37.04	$33.33	$33.33	$45.45
Gross price ($/head)	$614.38	$641.24	$805.92	$814.75	$1,196.00
Total selling and freight costs ($/head)	$70.83	$42.04	$80.57	$80.92	$50.45
Net price ($/head)	$543.55	$599.20	$725.35	$733.83	$1,145.55

The selected sale prices, sale weights, selling costs, treatment costs and bull replacement strategy were applied to the herd structure shown in Table 7 to produce the herd gross margin shown in Table 11.

Table 11 - Herd gross margin for the representative base property

Parameter	$/herd	$/AE
Net cattle sales	$360,332	$144.13
Husbandry costs	$100,191	$40.08
Net bull replacement	$54,701	$21.88
Gross margin	$205,439	$82.18
Gross margin less interest on livestock capital	*$117,687*	*$47.07*

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

3.2.2 Continuation of current herd management and stocking rate

The effect of declining land condition on herd productivity, gross margins and asset value was considered under the assumption that the current herd management strategy and stocking rate applied to the representative, base property was continued over the next 30 years. It was assumed that land condition would decline linearly from the current 65% of the original carrying capacity of the land in A condition to 50% over the next 30 years (0.5% decrease in carrying capacity per year; Rolfe *et al.* 2016*a*; Shaw et al. 2017). The assumption was that by Year 30 the same number of breeders as that in the representative base herd had been maintained but herd performance had fallen. Specifically, by Year 30:

- steer growth rates decreased from ca. 86 kg/head.annum post weaning to ca. 82 kg/head.annum. Heifers continued to grow at a rate 5% slower than steers under declining land condition;
- weaners from all cows mated decreased from 47.35 to 46.92%;
- mortality rates increased on average by 40% across all classes of stock from 7.5 to 10.5%
- average cull cow sale weights decreased by 5% from 410 to 390 kg;
- the reduction in reproductive performance resulted in the proportion of pregnancy tested empty (PTE; not in calf) 2-3 year old heifers sold to fall from 50 to 10%;
- the proportion of mature PTE breeders sold was maintained at 5%;
- all prices of livestock were maintained on a c/kg basis although it took longer for steers and heifers to achieve target sale weights.

Table 12 shows the expected parameters for mortality rate and reproduction at the end of the 30 year period of continued overstocking of the property starting in ca. B- land condition. Parameters for conception rate and calf loss were modified from data reported for the Northern Forest region in the CashCow final report (McGowan *et al.* 2014). Calf loss estimates were maintained at the median of the CashCow data for the Northern Forest region.

Table 12 - Predicted reproduction parameters and mortality rates at Year 30 after a continued decline in land condition under 12 ha/AE stocking rate regime so that the property now safely supports only 50% of the carrying capacity in A condition (i.e. 24 ha/AE)

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	65	23	60	55
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	10	5	5	5
Female death rate (%)	10	10.5	10.5	10.5	10.5	10.5
Male death rate (%)	10	10.5	10.5	10.5	10.5	n/a

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

Table 13 shows the expected steer sale weights at the end of the 30-year period as calculated in Splitsal.

Table 13 - Splitsal analysis of expected steer liveweight distribution at Year 30 after a continued decline in land condition under 12 ha/AE stocking rate regime so that the property now safely supports only 50% of the carrying capacity in A condition (i.e. 24 ha/AE)

Parameter	**Value**
First sale date at an average of 29 months of age	
Average liveweight of total group (kg)	324
Standard deviation of weights (kg)	50
Liveweight range in total group for 95% of group, assuming a normal distribution (kg)	226-422
Cut-off weight for first sale group (lead) (kg)	320
% of total group above cut-off weight	53
Average weight of heavier group (lead) (kg)	362
Average weight of lighter group (tail) (kg)	282
At second sale date 12 months later	
Expected gain over 12 months (kg)	82
Weight of lighter group (tail) (kg)	364

3.3 Results and discussion

3.3.1 Continuation of current herd management and stocking rate

Table 14 provides a summary of the herd performance at the beginning and end of the 30-year period if land condition were allowed to continue to decline and animal performance per head was reduced by the amount predicted. Although the number of cows mated, the total cattle carried and the prices per kg were similar, the reduction in animal and herd performance attributable to declining land condition reduced the expected herd gross margin by ca. 56% by the end of the third decade. The relatively small change in herd parameters caused the percentage of females sold each year to reduce to ca. 32% of total sales by Year 30. This is similar to the bottom level of herd performance recorded in the survey data reported by Rolfe *et al.* (2016*b*) for the Northern Gulf region.

Table 14 - A comparison of steady state herd performance in Year 1 of the analysis (land condition safely supporting 65% of the carrying capacity in A condition (i.e. 18 ha/AE) but stocked at 12 ha/AE) with that in Year 30 after a continued decline in land condition under 12 ha/AE stocking rate regime so that the property now safely supports only 50% of the carrying capacity in A condition (i.e. 24 ha/AE)

Parameter	**Year 1** **12 ha/AE stocking rate but 18 ha/AE safe carrying capacity**	**Year 30** **12 ha/AE stocking rate but 24 ha/AE safe carrying capacity**
Total AE	2,500	2,410
Total cattle carried	3,270	3,289
Weaner heifers retained	391	388
Total breeders mated	1,651	1,653
Total breeders mated and kept	1,565	1,653
Total calves weaned	782	776
Weaners/total cows mated	47.35%	46.92%
Overall breeder deaths	7.68%	10.5%
Female sales/total sales %	39.78%	32.44%
Total cows and heifers sold	214	142
Maximum cow culling age	11	11
Heifer joining age	2	2
Two year old heifer sales %	25.54%	6.75%
Total steers & bullocks sold	324	295
Maximum bullock turnoff age	3	3
Average female price	$578.24	$563.36
Average steer/bullock price	$728.59	$563.36
Capital value of herd	$1,755,051	$1,723,133
Imputed interest on herd value	$87,753	$86,157
Net cattle sales	$360,332	$293,081
Direct costs excluding bulls	$100,191	$99,974
Bull replacement	$54,701	$54,752
Herd gross margin	$205,439	$138,355
Herd gross margin less interest on livestock capital	*$117,687*	*$52,198*

Figure 7 shows the change in livestock numbers over 30 years for the declining land condition scenario with continued over-stocking at 12 ha/AE. We have shown the outcome of the continued land management policy as a gradual decline between two steady states but the years in between are likely to show huge variation about the trend line. The end result of the continuing decline in land condition was a slightly smaller number of calves being produced by the same number of breeders. The relatively higher mortality rates also caused a larger reduction in livestock sales over time. The falling herd performance led to a similar downwards trend in cash flow and beef gross margin (Figure 8). The years with relatively larger cash deficits correspond to the replacement of a number of significant plant items.

Figure 7 - Livestock numbers and sales over 30 years with a continuous decline in land condition under 12 ha/AE stocking rate regime so that by Year 30 the property safely supported only 50% of the carrying capacity in A condition (i.e. 24 ha/AE)

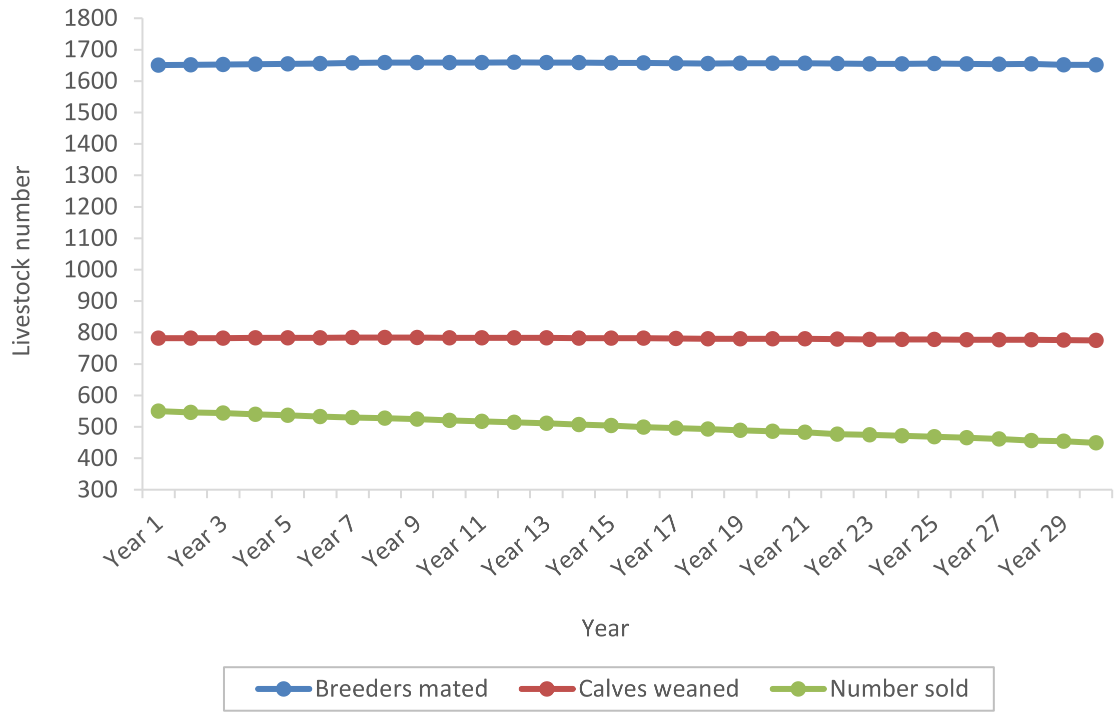
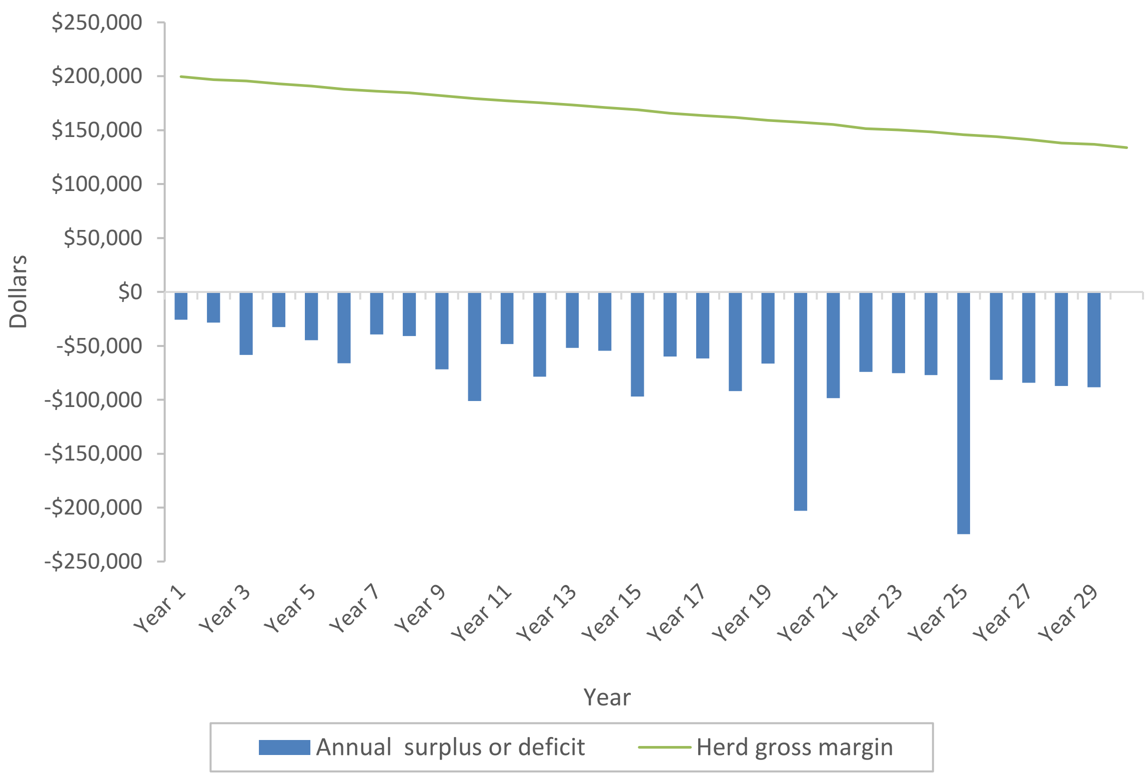


Figure 8 – Herd gross margin and annual surplus over 30 years with a continuous decline in land condition under 12 ha/AE stocking rate regime so that by Year 30 the property safely supports only 50% of the carrying capacity in A condition (i.e. 24 ha/AE)



Even though land condition, livestock productivity, gross and net income fall, the beef producer who chooses to chance the potential impact of a continued fall in land condition could have almost double the wealth currently held if land value increased at 3%/annum above the rate of inflation over the 30 year period (Table 15). In this example land appreciated at the same rate regardless of land condition as there is no market evidence that land condition is linked to current land values. It should be noted that this scenario did not include any consideration of the opening level of debt and the impact of that debt on closing equity. It can be inferred from these results that some beef producers may be likely to continue to follow a course of action that causes land condition to decline as, given the potential increase in real land value over time, this can be seen as a low risk course of action.

Table 15 - Effect of declining land condition over 30 years on closing asset value of the Northern Gulf representative, base property, assuming an annual increase in land value of 3% in real terms

Parameter	Year 1 Land condition considered to safely support 65% of the carrying capacity of A condition	Year 30 Land condition considered to safely support 50% of the carrying capacity of A condition
Land and improvements	$3,750,000	$9,102,234
Livestock capital	$1,755,932	$1,332,096
Plant and equipment	$380,171	$380,171
Total value of assets	$5,886,102	$10,814,501
Pre-tax rate of return	1.17%	1.33%

4 Key strategies to build profit and drought resilience

The representative, base beef production system defined in section 3.2.1 (i.e. prior to 30 years of declining land condition) was used to test two key strategies for their ability to improve the long term profitability and drought resilience of the Northern Gulf representative base property. They were: 1) improving land condition and 2) adequate wet season P supplementation, were phased in sequentially so that by ca. Year 10 both strategies were implemented and continued to Year 30. The outcome of implementing these strategies was compared to the outcome of continued land condition decline over 30 years.

4.1 Improving land condition by managing to long-term carrying capacity and wet season spelling

4.1.1 Introduction

Preparation for drought requires having in place a beef production system that is profitable, sustainable and capable of withstanding shocks to the system, i.e. it is resilient. A series of surveys across the Northern Gulf suggest land condition has declined over recent decades with a prediction that it will continue to decline (Shaw *et al.* 2007; Shaw *et al.* 2017). An interim project report by Shaw *et al.* (2017) summarising land condition assessments made in 2004, 2012 and 2016 indicated that since 2004 the proportion of original carrying capacity retained, for grazing land across the region, had declined from 72% to 66% of original carrying capacity. In this framework, grazing land considered to be in A condition is assumed to support 100% of original carrying capacity, land in B condition to support 75%, land in C condition to support 45% and land in D condition to support only 20% of original carrying capacity (scale A-D; Quirk and McIvor 2003; DAF 2011). The authors suggested that these trends indicate that 50% of original carrying capacity will be lost by 2046 which would equate to the majority of grazing land being in C+ land condition (Shaw *et al.* 2017). Another key finding from this survey data was that the higher value grazing lands (more fertile and productive land types) tended to have lower land condition ratings than lower value grazing lands, reflecting likely higher grazing pressure over time. The decline in land condition was indicated by a 24% decline in 3P (palatable, productive and perennial) pasture species from 2012 to 2016, weed invasion on higher value (more fertile) land types, and timber thickening as well as increase in timber basal area across most land types. The most recent summary (Shaw *et al*. 2017) of the regional land condition assessments over time is currently being compared with remote sensing data to validate, or otherwise, this trend in land condition decline.

Changing the predicted outcome for land condition and carrying capacity in the Northern Gulf requires a change in management. Unfortunately managing native pastures in the Northern Gulf is not simple. Paddocks are often measured in thousands of hectares and usually encompass a range of soil and vegetation types, rainfall is variable and capital available to implement change is scarce (Rolfe *et al.* 2016*b*). Grazing research and pasture modelling from northern Australia has indicated that stocking around the 'safe' long-term carrying capacity will maintain land condition (Hunt *et al.* 2014; O'Reagain *et al.* 2014; Scanlan *et al.* 2014). The commonly accepted approach to determining the safe long-term carrying capacity for a particular land type is the use of the safe pasture utilisation rates concept (Hunt 2008). For the majority of pasture types in Australia, safe stocking rates are those that result in the utilisation of ca. 20-30% of annual pasture biomass growth although for less productive and ecologically fragile land types the recommended safe utilisation rates are lower (Whish 2011).

To improve land condition once pastures are in degraded state, e.g. C condition with only 20% perennial grasses, the recommendation is to first lower stocking rate to match pasture growth and then rest (spell) pastures during the growing (wet) season (Scanlan *et al.* 2014). The modelling study of Scanlan *et al.* (2014) indicated that the rate of recovery in land condition is likely to be positively related to the duration and frequency of rest. While modelling by Hunt *et al.* (2014) suggested that land in C condition could be returned to A condition with four wet season spells, modelling by Scanlan *et al.* (2014) found recovery may take much longer and will be related to number of years with good growing conditions.

However, there is little field research to indicate rates of degradation and recovery across land types and regions in northern Australia and the guidelines recommended by Scanlan *et al.* (2014) and Hunt *et al.* (2014), are yet to be tested experimentally. Recent field experiments with two native pasture systems in central and north Queensland, respectively, failed to improve land initially in C condition with wet season spelling strategies, over a 3 or 5-year period (Jones *et al.* 2016).

In contrast to these field experiment results successful beef producers in the Northern Gulf region consider land condition and pasture productivity can be restored through systematic wet season spelling and conservative stocking rates ($avannaPlan-Beef$ense Case Study; Rolfe 2016*a*). This case study highlighted the time it takes to see improvement in land condition:

> *"Country overgrazed and set stocked over several decades will not improve overnight. Changing stocking rates and implementing a systematic wet season spelling program requires patience. It took nearly 10 years to really see the value of spelling and reducing numbers on Blanncourt".* (*Glen and Cheryl Connolly; Blanncourt Station, Georgetown).*

The Northern Gulf 'Ecobeef' sites were established in 2006-2007 to demonstrate “best bet” management practices necessary to move land in C condition (>20% but <50% of original carrying capacity) to B condition (>50% but ≤75% of original carrying capacity). With a long history of overgrazing the Einasleigh town common (alluvial and black soils) was selected as a project site. Unpublished transect data in 2007 indicated most of the paddock (341 ha) was in poor condition with 76% of measured sites in C/D condition, while 24% of sites were in A/B condition. After four consecutive wet season spells the C/D condition sites had reduced to 16% while the sites in A/B condition had increased to 84% (J Rolfe, pers. comm.).

However, there are practical difficulties in implementing pasture spelling on commercial properties as cattle from rested paddocks are necessarily spread across the remainder of the property, increasing the short-term stocking rate on non-rested paddocks over the growing season when pastures are most vulnerable to heavy grazing pressure. Modelling by Scanlan *et al.* (2011) demonstrated that a rigidly applied four-paddock rotational system with 25% of the total area (1 of the 4 paddocks) rested for 6 months each year could actually lead to further deterioration of pastures. Hence, it would seem that any wet season spelling regime implemented at a property level would need to be closely monitored to ensure desired pasture composition and land condition outcomes were being achieved in practice. It should also be noted that the options available to address land condition decline due to native woodland thickening are limited at best. Fire is a critical woodland management tool however fuel loads are inadequate due to thickening across large areas of lower grazing value land types in the region.

4.1.2 Methods

The strategy considered was the implementation of changed grazing management practices with the objective of improving land condition from the starting ca. B- category. The approach was to reduce grazing pressure to match the pasture growth and hence the current safe carrying capacity of the property in its ca. B- land condition status as per recommendations of Hunt *et al.* (2014), O'Reagain *et al.* (2014) and Scanlan *et al.* (2014). Additionally, a wet season spelling regime was implemented with 20% of the property spelled every wet season for the whole of the growing season as per recommendations of Scanlan *et al.* (2014). The result of these measures was assumed to be a linear improvement in land condition from the current 65% of the safe, long term carrying capacity in A condition to 72.5% by the end of the 30 years of the analysis (0.25% increase per year in carrying capacity over 30 years). This rate of improvement in land condition is about half the rate of the land condition decline indicated in the surveys conducted by Shaw *et al.* (2017) and slower than recovery rates at demonstration field sites where cattle were completely removed from the experiment site rather than re-distributed across the remainder of a grazed area (Ash *et al.* 2011). As these assumptions have been made in the absence of any field research to indicate rates of land condition recovery, under the stated grazing management strategies implemented at a property level, the analysis should be viewed as a scoping exercise. Similarly there are limited field data to inform the cattle performance parameters under the selected grazing management regime.

To achieve the hypothesised linear improvement in land condition over 30 years in this scenario the total herd numbers were reduced for the first 10 years of the analysis. This reduction in grazing pressure was assumed to result in a linear improvement individual animal performance over the first 10 years. The specific assumptions include:

- Total grazing pressure was reduced from 2,500 AE to 1,500 AE in the first year of the analysis and then maintained at 1,500 AE for the first decade. This 40% reduction in stocking rate resulted in a slightly lower stocking rate than that estimated as the safe carrying capacity for the nominated land condition rating of ca. B- (i.e. 20 ha/AE cf. 18 ha/AE) but was selected as a conservative stocking rate to allow for the increased grazing pressure over 80% of the property each wet season during spelling of 20% of the grazed area.
- Steer growth rates remained at 86 kg/head.annum post weaning. Heifers still grew at a rate 5% slower than steers.
- Weaners per all cows mated improved linearly from 47.35% to 49.87% over the first decade were maintained at 49.87% to the end of the 30 year period. This improvement in weaning rate was due to an increase in conception rates in older cows of 2.5%.
- Mortality rates were reduced by 33% across all classes of stock (from 7.5% to 5% on average) over the first decade and were then maintained at 5% to the end of the 30-year period of the analysis.
- Cull cow sale weights were ca. 5% heavier by the end of the first decade (430 cf. 410 kg) and this weight was maintained to Year 30 of the analysis.
- The PTE first calf heifer cull rate was increased to 75%.
- All prices of livestock were maintained as per the base scenario.
- Cull females, steers and heifers were sold in the same month as for the base scenario but at heavier sale weights.

- The incremental improvement in individual animal performance led to a gradual fall in numbers to the end of the first decade as the goal was to maintain the same level of grazing pressure for the period (1,500 AE per 30,000 ha), not the same number of cattle (heavier cattle result in a greater AE rating per beast).
- After the first decade, the stocking rate was gradually increased from 1,500 to 1,813 AE over the following two decades in line with the assumed improvement in land condition and carrying capacity, i.e. stocking rate was matched to the assumed safe carrying capacity of the property.
- It was assumed that no additional capital expenditure was required for paddock subdivision or new watering points to effectively implement the wet season spelling system.

Table 16 shows the expected parameters for mortality rate and reproduction at the end of the first 10-year period during which grazing management strategies were implemented to achieve land condition improvement. After the first decade growth and mortality rates and reproduction efficiency did not change although the improvement in land condition allowed the AE carried by the property to increase from 1,500 AE to 1,813 AE, in line with safe carrying capacity, by the end of the third decade.

Table 16 - Predicted reproduction parameters and mortality rates at Year 10 after a continued improvement in land condition (0.25% increase in safe carrying capacity per year) under 20 ha/AE stocking rate regime and annual wet season spelling of 20% of the property

Initial cattle age	**Weaners**	**1**	**2**	**3**	**4**	**8**
Final cattle age	**1**	**2**	**3**	**4**	**8**	**11**
Expected conception rate for age group (%)	n/a	0	65	33	63	55
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	75	5	5	5
Female death rate (%)	5	5	5	5	5	5
Male death rate (%)	5	5	5	5	5	n/a

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

The expected steer sale weights at the end of the initial 10-year period, as calculated in Splitsal, were the same as for the representative, base herd and are described in Table 8.

4.1.3 Results and discussion

Table 17 provides a comparison of the herd performance at the end of the 30-year period for the scenario where land condition improved under changed grazing management strategies with the scenario where land condition declined under continued heavy grazing pressure. Although the number of cows mated and the total number of cattle carried and sold fall significantly with the land condition improvement scenario, the improvement in herd performance attributable to improving land condition over the 3 decades eventually produces a better gross margin.

Table 17 – A comparison of steady state herd performance in Year 30 of the analysis for the scenario where land condition improved under changed grazing management strategies with the scenario where land condition declined under continued heavy grazing pressure

Parameter	**Year 30 – land condition decline** **Stocked at 12 ha/AE but land condition only able to safely supporting 50% of the original carrying capacity in A condition (24 ha/AE)**	**Year 30 – land condition improvement** **Stocked at 17 ha/AE which is in line with the safe carrying capacity for the land condition (capable of supporting 72.5% of the original carrying capacity in A condition)**
Total AE	2,410	1,813
Total cattle carried	3,289	2,305
Weaner heifers retained	388	283
Total breeders mated	1,653	1,131
Total breeders mated and kept	1,608	1,056
Total calves weaned	776	565
Weaners/total cows mated	46.92%	49.95%
Weaners/cows mated and kept	48.24%	53.52%
Overall breeder deaths	10.50%	5.00%
Female sales/total sales %	32.44%	44.46%
Total cows and heifers sold	142	202
Maximum cow culling age	11	11
Heifer joining age	2	2
Two year old heifer sales %	6.75%	43.81%
Total steers & bullocks sold	295	250
Maximum bullock turnoff age	3	3
Average female price	$563.36	$585.76
Average steer/bullock price	$722.03	$728.64
Capital value of herd	$1,723,133	$1,252,933
Imputed interest on herd value	$86,157	$62,647
Net cattle sales	$293,081	$300,578
Direct costs excluding bulls	$99,974	$70,966
Bull replacement	$54,752	$37,483
Herd gross margin	$138,355	$192,129
Herd gross margin less interest on livestock capital	*$52,198*	*$129,482*

Figure 9 shows the change in livestock numbers over 30 years with a continuous improvement in land condition due to changed grazing management practices compared to the scenario where land condition was allowed to decline. The figure indicates that neither the number of cows mated nor calves weaned returns to the level for the scenario where land condition is allowed to fall, over the next 30 years.

Figure 9 - Livestock numbers and sales over 30 years for the land condition improvement scenario so that by Year 30 the property safely supported 72.5% of the carrying capacity in A condition and carried ca. 1,813 AE (17 ha/AE), compared to the scenario where land condition continued to decline under sustained heavy grazing pressure (12 ha/AE)

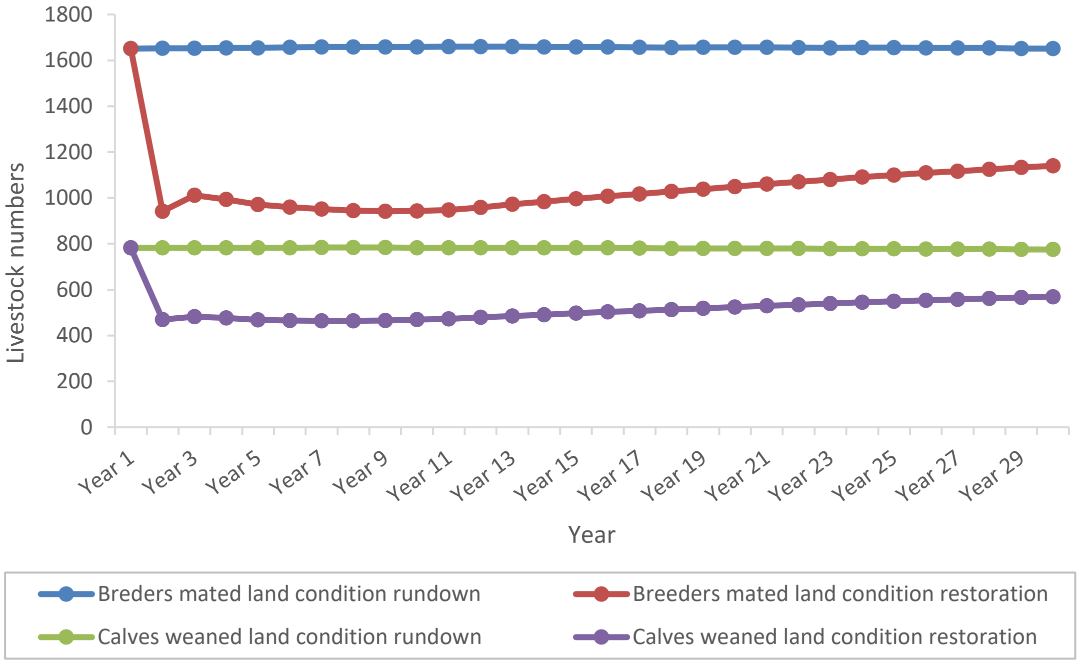


Figure 10 indicates that the cumulative cash flow of both the land condition improvement scenario and the land condition decline scenario was negative at the end of 30 years. Neither system was sufficiently profitable to pay the total costs of the property if livestock prices are maintained at the level of the longer term average. The land condition improvement scenario relied upon the initial release of capital associated with the herd reduction to carry the property through the transition. That is, the sell down of the herd provided a cash buffer during the early years but the long term herd output associated with the improved land condition scenario was not capable of making the property substantially more profitable than the scenario that allowed land condition to decline. Figure 10 indicates that a beef producer who makes no other change, other than to grazing management practices to improve land condition, is likely to have the same low chance of remaining viable as the beef producer who allows land condition to continue its steady decline.

Figure 10 - Cumulative cash flow over 29 years for the land condition improvement scenario so that by Year 30 the property safely supported 72.5% of the carrying capacity in A condition and carried ca. 1,813 AE (17 ha/AE), compared to the scenario where land condition continued to decline under sustained heavy grazing pressure (12 ha/AE)

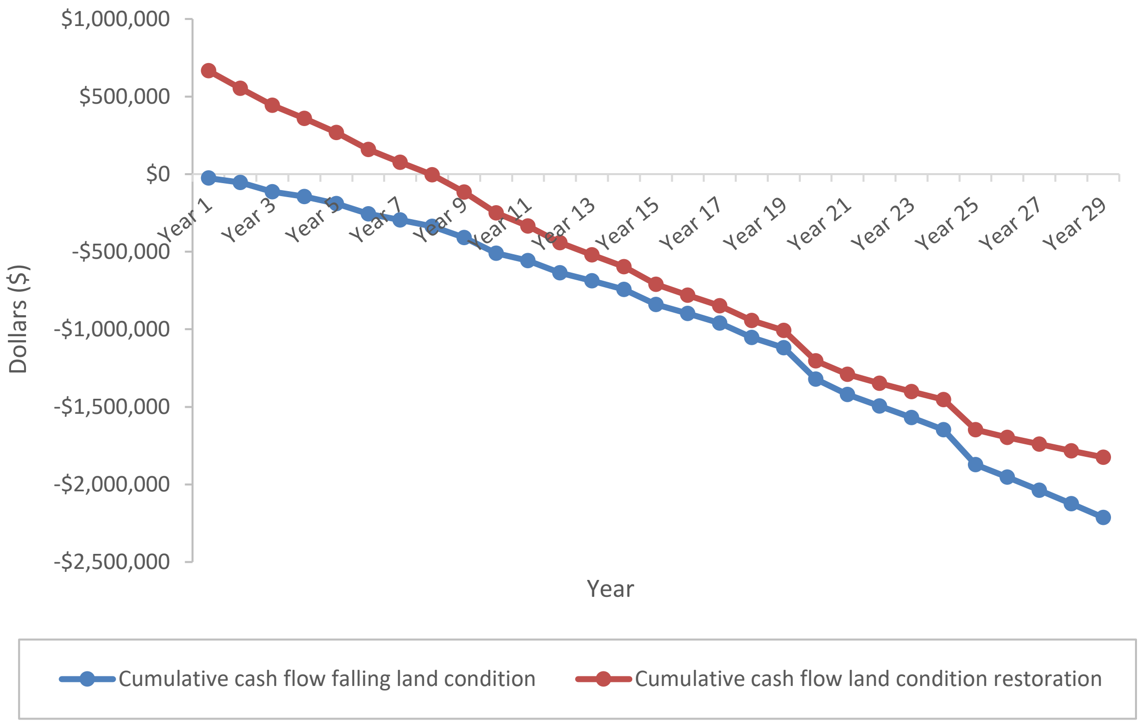


Table 18 indicates the extra returns generated by the land condition improvement scenario compared to the scenario where land condition declined. The NPV was improved but this was due to the early release of capital facilitated by the herd reduction. Any tax liability created by the sale of additional cattle early in the changeover or any extra capital required for additional fences and waters could reduce the net benefits to the point where the beef producer may be no better off with the change. The expected lower cash surpluses due to lower stock sales (data not presented) encountered after the initial phase of the changeover suggest the scenario to improve land condition may be more likely to suffer cash operating deficits and would rely heavily on the initial cash surplus generated by the stock reduction for some time. Focusing on improving land condition through a rapid reduction in stock numbers appeared unlikely to make the Northern Gulf property substantially more profitable or less exposed to risk despite the positive NPV. That is, despite the improvement in land condition resulting in a positive NPV, the property was still unviable as indicated by the negative and declining cumulate cash flow. It appeared that land managers would need to seek additional ways to improve performance if the property were to be profitable over the longer term. This analysis should be considered as a scoping exercise as the assumptions made here about land condition recovery and animal performance parameters have been made in the absence of any field research to indicate rates of land condition recovery and animal performance under the stated grazing management strategies implemented at a property level.

Table 18 - Results for the land condition improvement scenario compared to the scenario where land condition declines over 30 years

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5.00%
NPV	$232,600
Annualised NPV	$15,100
Peak deficit (with interest)	n/a
Year of peak deficit	n/a
Payback period (years)	n/a
IRR	n/a

4.2 Adequate wet season phosphorus supplementation to improve herd performance

4.2.1 Introduction

P deficiency occurs in cattle grazing many rangeland regions of northern Australia due to low soil P, and may severely reduce cattle growth and breeder productivity (Winks 1990; McCosker and Winks 1994). P deficiency results in poor appetite and feed intake, poor growth, high breeder mortality, reduced fertility and milk production, bone breakage and, in severe cases, bone deformities. In addition to such poor performance there is an increased risk of deaths from botulism when cattle chew bones in their craving for the mineral. Feeding a P supplement to P-deficient cattle will increase feed consumption by 10–40%, growth rates up to 100 kg/annum, weaning rates by 10-30%, and weaner liveweights by 10-40 kg (Winks 1990, Wadsworth *et al.* 1990; McCosker and Winks 1994; Jackson *et al.* 2012). The biological response to P supplements is related to soil P status (Table 19). Maps showing the P status of land in the Northern Gulf NRM region of Queensland indicate that most grazing lands fall in to the ‘acute’ or ‘deficient’ categories, with smaller areas identified as ‘marginal’ or ‘adequate’ (McCosker and Winks 1994).

Past research from the 1970’s to the 1990’s concluded that P supplementation is most effective when fed during the wet season when the pasture diet has adequate protein and energy (Winks 1990; McCosker and Winks 1994; Dixon 1998; Jackson *et al.* 2012). This is still the established recommendation although recent research has indicated that breeders can store P fed during the dry season in bones and soft tissue and then use this P later during the wet season (Anderson *et a*l. 2017; Dixon *et al*. 2017). Dry season supplementation programs generally involve fewer practical and logistical difficulties than feeding supplements during the wet season when access to paddocks is often difficult. However, recent analysis of P supplementation strategies in central Queensland indicated that supplementation during the wet season alone was more efficient and profitable than either supplementing with nitrogen (N)+P during the dry season or supplementing with (N)+P during the dry season combined with P supplements during the wet season (Bowen and Chudleigh 2018*b*).

Table 19 – Definition of categories of phosphorus (P) deficiency in terms of soil P (ppm) from 1) McCosker and Winks (1994), 2) Jackson et al. (2012) and 3) a modified definition adopted in this report

Category of P deficiency	**Soil P (ppm)**		
	McCosker and Winks (1994) definition	**Jackson *et al.* (2012) definition**	**Modified ranges – adopted in this report**
Very severely deficient (e.g. South Africa)	-	-	</=2
Acute	<2	<4	2-3
Deficient	3-5	5	4-5
Marginal	6-8	6-8	6-8
Adequate	>8	-	>8

4.2.2 Methods

An adequate wet season P supplementation strategy was examined in combination with the scenario to reverse land condition decline, rather than in isolation, as addressing land condition decline was seen as the first essential step in improving the resilience of the Northern Gulf beef property. The cattle herd was distributed across soils considered to be a mixture of Acute and Deficient in P (Table 19). The base herd received some dry season P and wet season P supplementation as proprietary blocks but this was not considered to provide any significant additional P to cattle due to difficulties in achieving target P intakes with lick blocks.

Annual supplement costs for the base herd (P blocks during the wet season) were weaners: $2.24/head, heifers and steers: $4.48/head, and breeding females: $6.72/head. The improved wet season P supplementation strategy involved a change from blocks to a loose mix in ‘bulka’ bags. The cost of feeding improved wet season P supplementation program was ca. 50% greater for weaners, 85% greater for young stock and about 76% greater for breeders on a per head basis, as compared to the original supplementation program using blocks (Table 20).

Table 20 - Expected supplement costs estimated to provide adequate wet season P for a beef herd grazing land types considered to be a mixture of Acutely deficient and Deficient in P

Class of cattle	**Daily intake of P (g/head.day)**	**Supplement intake (g/head.day)**	**Number of days fed**	**Supplement cost per ton landed ($/t)**	**Annual supplement cost ($/head.annum)**	**Daily supplement cost ($/head./day)**
Weaners	2.8	20	140	$1,190	$3.33	$0.02
Heifers and steers	7	50	140	$1,190	$8.33	$0.06
Breeders	9.94	71	140	$1,190	$11.83	$0.08

Biological responses to each of the supplement regimes were assigned with reference to existing data and publications (Winks 1990; McCosker and Winks 1994; Miller *et al.* 1997; Dixon 1998; Dixon *et al.* 2011; Jackson *et al.* 2012; Schatz and McCosker 2018) as well as the expert opinion of DAF and QAAFI staff, particularly J. Rolfe, B. English and R. Dixon. A key assumption was that although P is the major factor limiting breeder performance the supplementation program will not return breeder herd performance to the level of P-Adequate, when grazing on Deficient and Acute P land types due to other nutritional constraints expected to be associated with land types typical of that level of P status.

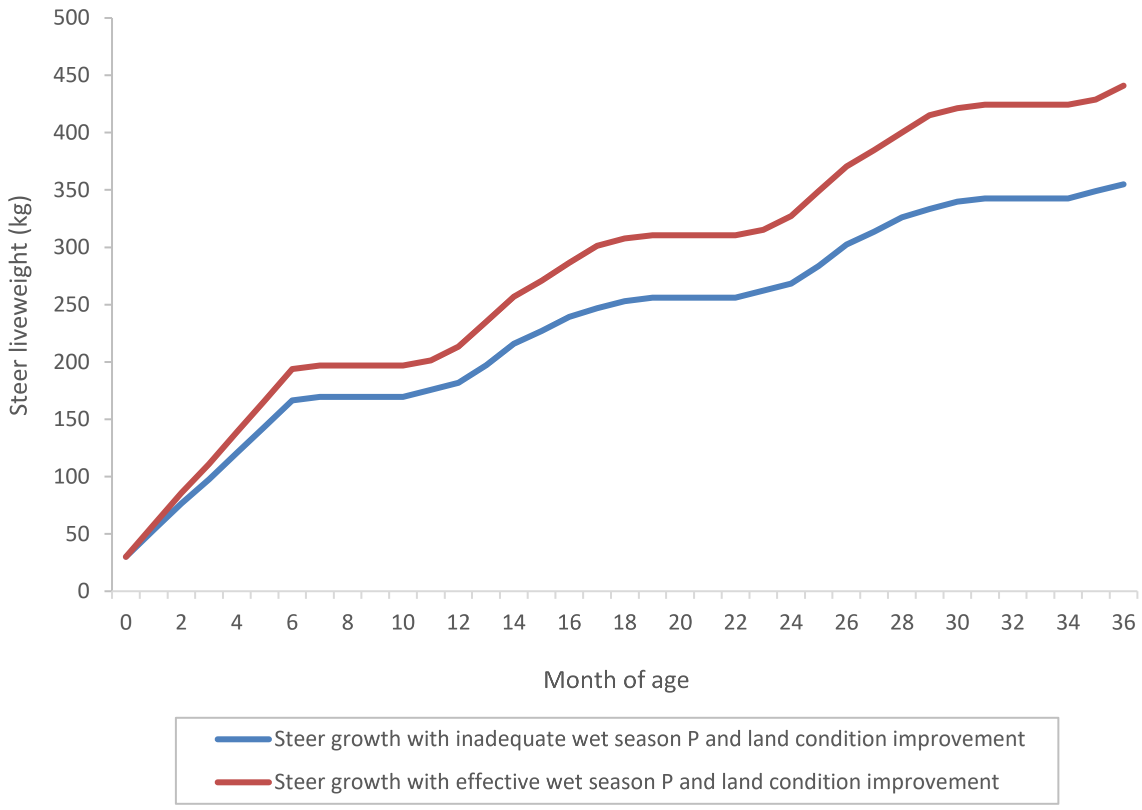
Compared to the herd which was receiving dry season N and P, minimal wet season P supplementation as blocks and benefiting from improvements in land condition, the assumptions were that an adequate supply of P in the diet of the herd during the wet season would by the end of year 4:

- increase the weaning rate from cows mated to 57.76%
- improve the pre-weaning growth rate in steers to 0.9 kg/day
- improve the post-weaning growth rate of steers from 86 to 113 kg/head.annum
- improve the pre-weaning growth rate in heifers to 0.86 kg/day
- improve the post-weaning growth rate in heifers from 82 to 107 kg/head.annum
- result in cull cows of 450 kg average liveweight in the paddock (20kg heavier than the land condition improvement scenario by Year 10)
- the average herd mortality rate was decreased to 2.5% by Year 10 of the analysis.

The improvement (compared to the original base herd) in biological parameters for reproduction performance, growth rates and liveweight as a result of land condition improvement plus adequate P, were implemented incrementally in this scenario over Years 1 to 4. While land condition improvements were assumed to be occurring linearly over the first 10 years of changed grazing management practiced, the biological benefits due to additional P would be expected to occur by the second season after implementation under conditions of adequate pasture availability to allow animal intakes to be maximised. We adopted the approach of implementing the improvement in biological parameters over 4 years as a balance between the two strategies which were occurring simultaneously in this scenario. The level of animal performance attained at the end of the first decade was continued until the end of the third decade and the land condition and safe carrying capacity improved at the same rate as outlined for the land condition improvement scenario. The number of cattle carried was less than that outlined for the land condition improvement scenario as fewer heavier stock can be carried at the same AE rating.

Figure 11 shows the expected growth rate of steers for the scenario where land condition is improved and adequate wet season P is fed compared to the scenario where land condition is improved and inadequate wet season P is fed.

Figure 11 - Steer growth with land condition improvement and with and without adequate wet season P supplementation



One effect of adequate wet season P supplementation is that the steers will reach a heavier sale weight range at the same time as expected for the scenario when inadequate P is fed under the same land condition improvement parameters. Table 21 shows that the 83% of steers sold in May will have a minimum weight of 320 kg in the paddock and an average weight of 418 kg. The remaining 17% will be sold in May the following year and average 414 kg in the paddock at sale.

Table 21 - Splitsal analysis of expected steer liveweight distribution at Year 10 for steers receiving adequate wet season P supplementation and grazing land with improved condition

Parameter	**Value**
First sale date at an average of 29 months of age	
Average liveweight of total group (kg)	415
Standard deviation of weights (kg)	50
Liveweight range in total group for 95% of group, assuming a normal distribution (kg)	317-513
Cut-off weight for first sale group (lead) (kg)	320
% of total group above cut-off weight	97
Average weight of heavier group (lead) (kg)	418
Average weight of lighter group (tail) (kg)	300
At second sale date 12 months later	
Expected gain over 12 months (kg)	114
Weight of lighter group (tail) (kg)	414

Table 22 indicates the expected parameters for reproduction rates, calf loss and mortality at the end of the Year 10 for a breeder herd receiving adequate wet season P in addition to continued improvement in land condition as outlined for the previous scenario.

Table 22 - Predicted reproduction parameters and mortality rates at Year 10 for a breeder herd receiving adequate wet season P supplementation and after a continued improvement in land condition (0.25% increase in safe carrying capacity per year) under 20 ha/AE stocking rate regime and annual wet season spelling of 20% of the property

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

PTE, pregnancy tested 'empty' (not in calf).

n/a: not applicable.

*10 to 11 year old cows have a 60% conception rate

The adjustments made to the herd structure when adequate wet season P was fed (improved weaning rate and growth rate, lower mortality rate, earlier sale of some steers) led to 43 more stock being sold at the same grazing pressure (1,500 AE) at Year 10 of the analysis (Table 23).

Table 23 - Change in herd structure by Year 10 due to feeding adequate wet season P (1,500 AE herd)

	Land condition improvement		**Land condition improvement + adequate wet season P**	
	Number held	**Number sold**	**Number held**	**Number sold**
Weaners 5 months	470	0	465	0
Heifers 1 year but less than 2	223	0	227	0
Heifers 2 years but less than 3	129	83	106	115
Cows 3 years plus	749	85	645	87
Steers 1 year but less than 2	223	0	227	0
Steers 2 years but less than 3	40	172	38	183
Bullocks 3 years but less than 4	0	38	0	37
Bulls all ages	38	6	32	5
Total	*1,873*	*384*	*1,739*	*427*

4.2.3 Results and discussion

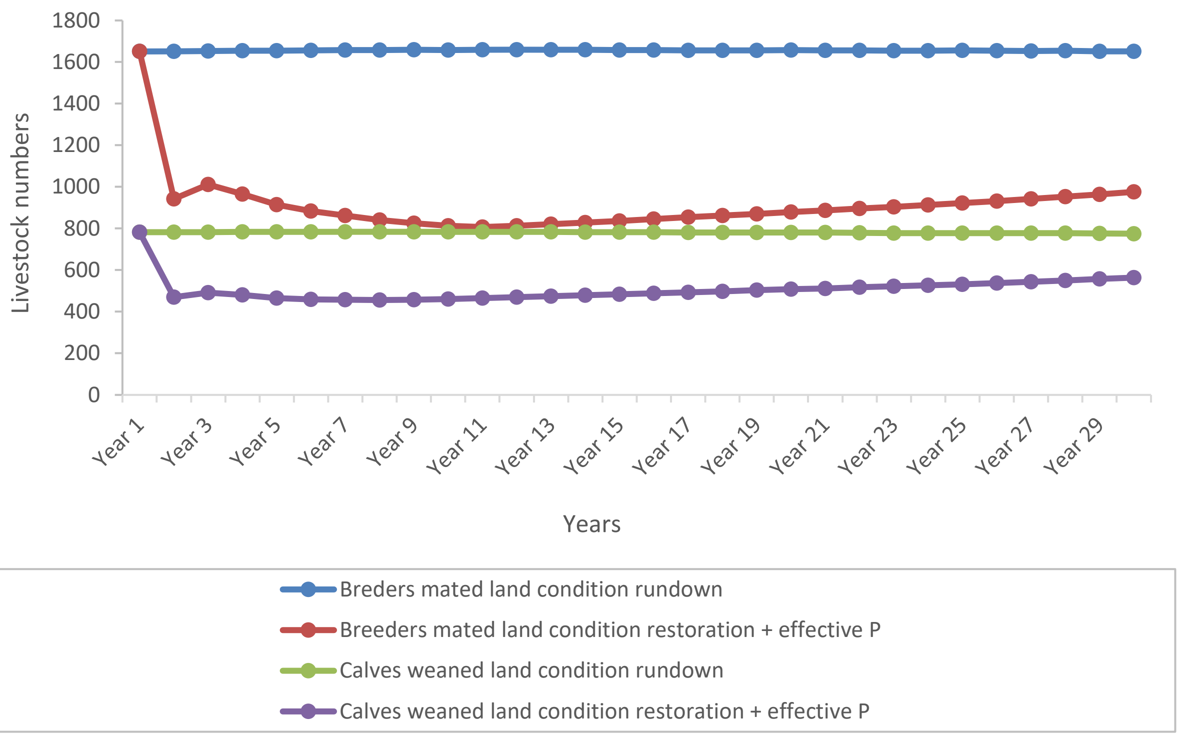
Table 24 provides a comparison of the herd performance at the end of the first 10-year period for the scenario where adequate wet season P was fed (in conjunction with land condition improvement under changed grazing management strategies) with the scenario where land condition improved but inadequate wet season P was provided. The improvement in herd performance attributable to improving land condition with effective wet season P supplementation produced a substantially better gross margin than just improving land condition alone.

Table 24 – A comparison of 1) steady state herd performance in Year 10 of the analysis for the scenario where adequate wet season P was provided in conjunction with land condition improvement with 2) land condition improvement and inadequate P supplementation

Parameter	**Year 10 – land condition improvement**	**Year 10 – land condition improvement + adequate P**
Total AE	1,500	1,500
Total cattle carried	1,907	1,739
Weaner heifers retained	234	233
Total breeders mated	938	805
Total breeders mated and kept	874	751
Total calves weaned	468	465
Weaners/total cows mated	49.87%	57.76%
Weaners/cows mated and kept	53.52%	61.91%
Overall breeder deaths	5.00%	2.50%
Female sales/total sales %	44.73%	47.89%
Total cows and heifers sold	167	202
Maximum cow culling age	11	11
Heifer joining age	2	2
Two year old heifer sales %	43.81%	60.55%
Total steers & bullocks sold	207	220
Maximum bullock turnoff age	3	3
Average female price	$585.76	$671.27
Average steer/bullock price	$728.64	$841.87
Capital value of herd	$1,036,764	$996,850
Imputed interest on herd value	$51,838	$49,842
Net cattle sales	$248,670	$321,056
Direct costs excluding bulls	$51,838	$63,107
Bull replacement	$31,062	$26,309
Herd gross margin	$158,897	$231,640
Herd gross margin less interest on livestock capital	*$107,058*	*$181,798*

Figure 12 shows the change in livestock numbers over 30 years with adequate wet season P supplementation in addition to a continuous improvement in land condition as compared to the scenario where land condition continued to decline and inadequate wet season P was provided. The figure indicates that by the end of the third decade, 60% of the original breeder number produced 73% of the original weaners produced by the property with falling land condition and no effective wet season P supplement.

Figure 12 - Livestock numbers and sales over 30 years for the scenario where adequate wet season P was provided in conjunction with land condition improvement, compared to the scenario where land condition continued to decline under sustained heavy grazing pressure



As shown in Figure 13, the feeding of adequate wet season P in conjunction with land condition improvement is considered likely to improve the net cash flow relative to the scenario where land condition declines, after the first decade. The combination of a significant herd reduction, improvement in land condition over time and the effective feeding of wet season P supplements improved the cumulative cash flow by more than $1.8 million over the 3 decades.

Figure 13 - Cumulative cash flow over 29 years for the scenario where adequate wet season P was provided in conjunction with land condition improvement scenario, compared to the scenario where land condition continued to decline under sustained heavy grazing pressure

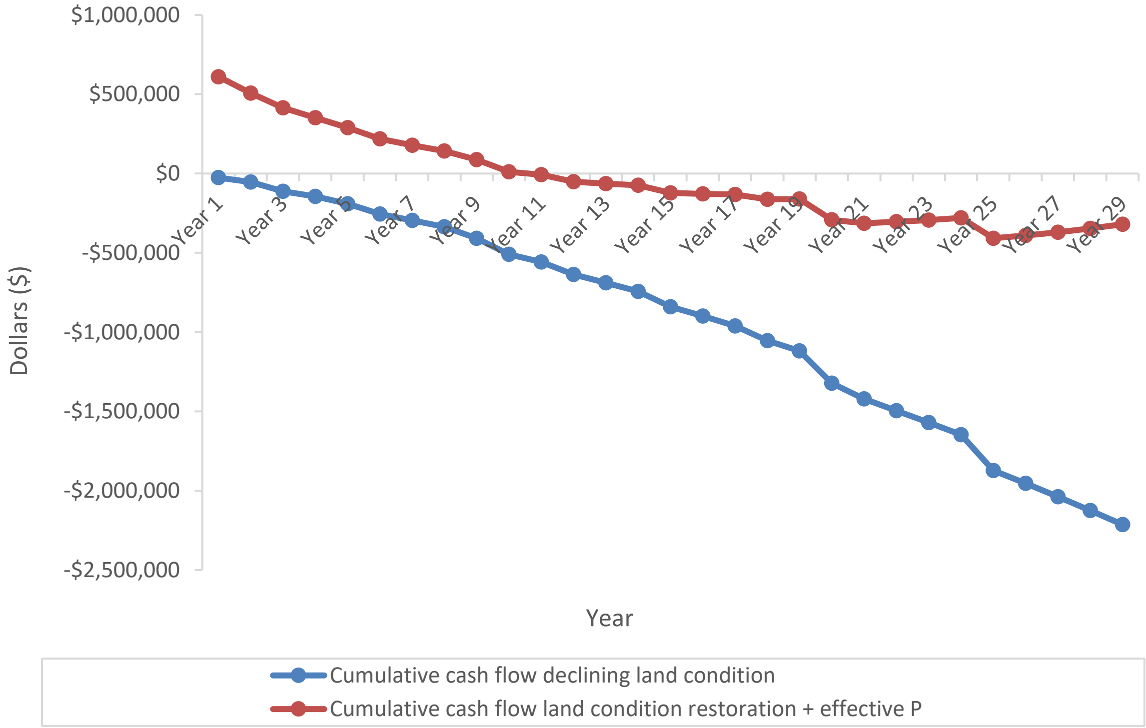


Table 25 indicates the extra returns generated by the land condition improvement scenario combined with an effective wet season P program when compared to the scenario of land condition decline and ineffective P supplementation. Over the longer term, the profitability of the beef property was improved relative to the scenario where land condition was allowed to decline. However, the property was still unlikely to be profitable and sustainable with the management changes implemented so far, as indicated by the continued negative cumulative cash flows maintained to Year 29 of the analysis (Figure 13). It is evident that further improvements to herd and property management need to be identified and investigated for their ability to improve profitability and resilience, and hence prepare for drought.

Table 25 - Returns for effective wet season P supplementation and land condition improvement compared to the scenario where land condition declines over 30 years

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5.00%
NPV	$918,700
Annualised NPV	$59,800
Peak deficit (with interest)	n/a
Year of peak deficit	n/a
Payback period (years)	n/a
IRR	n/a

5 Other strategies that may build profit and drought resilience

The representative beef property after implementing the two initial key strategies (defined in Section 4.1.2 and 4.2.2) was used as a new base to test additional strategies for their ability to improve long-term profitability and drought resilience. This approach was taken as addressing land condition decline and P deficiency for cattle were seen as the first essential steps in improving the resilience and long-term profitability of the Northern Gulf beef property.

Other than property-level stylo development, which was implemented concurrently with improvements in land condition and adequate wet season P supplementation, all other strategies were implemented for a base herd after 10 years of land condition improvement and adequate wet season P supplementation. For the latter analyses, a new 30-year investment model was constructed based on the 1,500 AE herd model at Year 10 of the preceding analysis (Section 4.2) in which the herd had benefited from improved land condition and reduced grazing pressure as well as effective P supplementation over the last 10 year period. The performance of the herd in Year 10 of the improved land condition plus effective P scenario was modelled as a steady state in Breedcowplus then transferred to Dynamaplus to build a 30-year herd model that had the same number of breeders, weaners, sales, deaths and costs in each year (Holmes *et al.* 2017). This model was used as the new base property for comparison to alternative management strategies which were added to this scenario in the following sections. Hence to simplify these analyses there was no change over time due to land condition improvements beyond what was achieved by Year 10. However, the comparative analysis gives the same answers for returns, as would be expected if the original scenarios modelled over 30 years had been used as the base, as the net differences would be expected to be the same. Some scenarios were considered for impact at the paddock level to simplify the analyses. In these instances, the comparison was for the paddock with and without the investment.

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 representative beef property through building resilience and profit over time. The results of this section therefore relate to the hypothetical property outlined in this report and the associated assumptions made for the expected production responses to changing the management strategy. Different results may be gained for different properties/production systems and hence it is recommended that 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 indicates the potential level of response to change revealed by relevant research and the expert opinion of scientists and beef extension officer with extensive knowledge of the region and of the northern Australian cattle industry. 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.

5.1 Stylo pastures on phosphorus deficient soils for steers

5.1.1 Introduction

Cooksley (2003) reported that legumes from the Stylosanthes genus (mainly *Stylosanthes scabra* cv. Seca and Siran, and *S. hamata* cv. Verano and Amiga) had been successfully over-sown into at least 600,000 ha of northern Australian pasture lands with ca. 60,000 ha sown annually. On the light-textured, largely P–deficient soils across north Queensland, stylos can add 1,000-2,000 kg DM/ha of biomass to the ca. 1,000-2,000 kg DM/ha of native pasture biomass typically produced and hence double carrying capacity (Cooksley 2003). Over-sowing native pastures with stylos results in greater annual beef cattle liveweight gains due to increased diet quality as well as higher carrying capacity due to the increased forage biomass (Gillard and Winter 1984; Miler and Stockwell 1991; Coates *et al.* 1997; Hasker 2000). Data summarised in Hasker (2000) for four sites across northern Australia indicated that the annual liveweight gain advantage to cattle grazing stylo-grass pastures compared to grass pastures was usually in the range of 30-60 kg/head with the over-sown pastures capable of being grazed at 2-3 times the rate for native grass pastures in northern regions. Cattle grow faster on stylo-grass pastures for most of the year but the main advantage occurs during the late wet and dry seasons when the growth advantage can average 0.25 and 0.15 kg/day, respectively. Pasture improvement with stylo pastures has previously been recommended for soils with >/= 4-5 ppm P to ensure that the legume can be maintained in the pasture without application of fertiliser (Partridge *et al.* 1996; Hasker 2000). However, to maximise yield potential, soil P concentrations of >8 ppm are required (Peck *et al.* 2015).

A risk with stylo-grass pastures is that, under continuous heavy grazing conditions, the stylo component of the pasture tends to dominate which can result in increased variability in animal production as well as pasture and land degradation. Trial sites have indicated that the target 50/50 balance of stylo to native 3P grass species can be maintained by periodically easing grazing pressure over the wet season to allow grass seed set (Cooksley 2003). Furthermore, research indicated that pastures which have become dominated by oversown stylo can be successfully rehabilitated by a regime of annual burning and wet season spelling (9-12 weeks from start of the wet season) under moderate stocking rates (ca. 2.3-3.5 head/ha), (Cooksley 2003).

5.1.2 Methods

The introduction of Stylosanthes (hereafter, stylo) pastures for steers was initially assessed by developing a 500 ha paddock to run steers from weaning to sale in two age cohorts, similar to the overall property, with steers sold either at the normal time in May or in September. Several levels of pasture utilisation were examined. The comparison was the 500 ha paddock with and without stylo development. In addition, a property-level scenario was examined where sufficient stylo-grass pastures were established to run all weaner steers produced by the property until sale in May. This property-level strategy was implemented concurrently with land condition improvement and adequate wet season P supplementation from Year 1 of the analysis and was compared to a base herd which implemented land condition improvement and adequate wet season P supplementation but no stylo. Stylos were sown to land types typical to the region and that were assessed as being P-deficient (ca. 4 ppm in the top 100 mm of soil).

The sale months (May or September) were selected to target the relative change in stock sale price that can regularly occur across the seasons in northern Australia. Figure 14 indicates the typical variation in the heavy steer dressed weight price for north Queensland. Over the longer term, prices later in the year can be 30 c/kg dressed greater than earlier in the year. Although the variation in prices in any year may not match this, the strategy of selling steers later in the year off stylo pastures may provide, on average, a relative price benefit.

Figure 14 - Weekly average prices for heavy steers from January 1993 to December 2017 (Source 'MLA - Australia North Queensland OTH cattle indicators weekly')

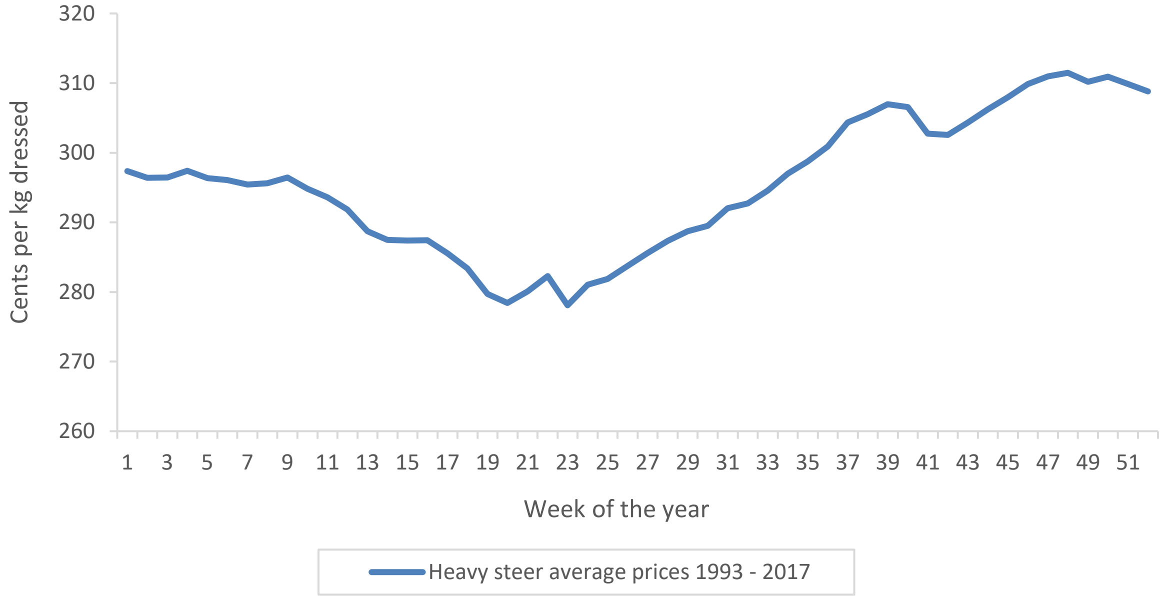


Table 26 indicates the seasonal variation in price for re-stocker steers, medium weight slaughter steers and US cow beef for the period of time originally applied, to decide sale prices to be used in this analysis. The prices shown are the average difference in price to the average price in May.

The price benefit for selling store and feed-on steers in September appears likely to average about 10 c/kg liveweight more compared to selling in May. Slaughter stock appear to sell for a lower premium later in the year, when compared on a liveweight basis to the premium gained by steers sold through the sale yards.

Table 26 - Annual variation in steer and cow prices

Month	Restocker steer variation in price Jan 2006 to Dec 2017 c/kg live weight	Medium slaughter steer variation in price Jan 2006 to Dec 2017 c/kg dressed weight	US cow Variation in price Jan 2006 to Dec 2017 c/kg dressed weight
Jan	8	11	12
Feb	7	15	15
Mar	4	11	10
Apr	1	4	5
May	-	-	-
Jun	0	3	2
Jul	5	10	9
Aug	7	15	14
Sep	11	23	21
Oct	11	22	18
Nov	13	21	18
Dec	17	24	21

The pasture development process involved selecting the typical land types grazed by steers on the property with ca. 4 ppm soil P to consider the potential of over-sowing stylos into such country. This also avoided a requirement for cultivation (e.g. as required for establishment of some sown pastures on frontage or red basalt country (J. Rolfe, pers. comm.)). The estimation of stylo-native grass production parameters for this analysis was informed by Peck *et al.* (2015) who concluded that that the production potential of stylo pastures would not be maximised at soil P <8 ppm. However, it was assumed that the over-sown stylos would be maintained in the pasture over time (Partridge *et al*. 1996; Hasker 2000). The required area was fenced and watered (at a cost of $3,000/km for the fencing and $2,500 for an additional water point) and then aerially sown to stylo after being burnt. Table 27 indicates the expected steps required to successfully establish the stylo pasture. It is acknowledged that the 4-year development phase before reaching full production is subject to suitable rainfall seasons.

Table 27 - Stylosanthes pasture development process for the Northern Gulf

Year 1	Year 2	Year 3	Year 4
remove steers and burn late in the growing season then aerially seed	stock from May to December; 1/3 of additional weight gain at Year 4	stock May to December; 2/3 of additional weight gain at Year 4	full stocking and full weight gain

The costs of sowing the pasture include the cost of the seed and the cost of flying the seed onto the burnt paddock (Table 28). An uncoated seed mix of 3/4 Seca and 1/4 Verano was used as representative of a typical stylo mix in this region.

Table 28 - Stylosanthes direct development costs for over-sowing native pastures to a 500 ha paddock in the Northern Gulf

Item or treatment	Cost/unit	Rate of application	Cost per hectare
Stylo seed mix, uncoated	$14/kg	2 kg/ha	$28.00
Aerial seeding	-	1	$9.00
Paddock fencing	$3,000/km ($15,000 total)		
Water point	$2,500		
Total			*$40.00*

Due to a lack of representative data for pasture composition, diet quality and legume composition, and animal liveweight response, assumptions were made with reference to published data from trial sites outside the region (e.g. Miller and Stockwell 1991; Coates 1996; Hasker 2000; Hendricksen 2010) as well as to PDS site data (Hasker 2000; Bray 2014; J. Rolfe, pers. comm.) and limited regionally-specific field research data (Cooksley 2003). A 20% pasture utilisation and a 40% pasture utilisation scenario were examined to indicate the sensitivity of the results to pasture utilisation rates, the ideal rate being poorly defined for the target region and pasture type (Table 29). The 20% utilisation rate reflects the average safe utilisation rate recommendations across suitable land types for stylo augmentation (Whish 2011). The 40% utilisation rate was selected based on the conclusion of Miller and Stockwell (1991) that stylo-grass pastures with live trees were stable at stocking rates up to 0.5 steers/ha. At 40% utilisation rates of the stylo-grass pastures in this example the calculated stocking rate was 0.28 steers/ha cf. 0.14 steers/ha at 20% utilisation (Table 30).

The native pasture grazed by the steers in the 'without-change' situation was considered to be a forest country land type such as Georgetown Granites in ca. B- condition (starting land condition of the base property). A mean annual biomass production of 1,500 kg DM/ha with 20% utilisation rate (of annual biomass grown) was assumed for the native grass-only pasture grazed by the steers.

In the stylo-grass scenarios, average annual stylo biomass production over 27 years after the establishment period was assumed to be 1,000 kg DM/ha. Native grass biomass production in the paddocks over-sown with stylo was assumed to be 1,500 kg DM/ha, the same as in the grass-only pasture. The assumed utilisation rates of grass pasture and stylo averaged across the annual cycle were 20 or 40%, depending on scenario, resulting in a 40% average stylo content in diet selected across the year which is considered broadly representative for these pasture systems (Coates 1996; J. Rolfe, pers. comm.). If stylo-grass pastures were assumed to be utilised at 40% of annual biomass growth the carrying capacity on these pastures was greater (3.5 ha/AE) than either the 20% utilisation scenario (7.0 ha/AE) or native pasture (13.4 ha/AE). The steers grazing stylo-grass pastures were expected to grow about 28% faster per annum (+45 kg liveweight) than steers grazing the same pasture without stylo (but with an effective wet season P supplement) with the advantage occurring in the late wet and dry seasons when the stylo is selectively grazed. The assumed diet digestibility and cattle liveweight gain data were kept constant for both levels of utilisation due to lack of data to indicate potential differences, particularly when averaged over a 30-year time-frame as in this analysis.

The carrying capacity of each pasture was calculated by multiplying the median annual pasture biomass production by the specified utilisation level and then dividing by the annual pasture consumption of a standard animal unit or AE. An AE, in this exercise, was defined in terms of the forage dry matter intake at the specified diet DMD, of a standard animal which was defined by

McLean and Blakeley (2014) as a 2.25 year old, 450 kg *B. taurus* steer at maintenance, walking 7 km/day. The spreadsheet calculator, QuikIntake (McLennan and Poppi 2016), which is based on the Australian Feeding Standards (NRDR 2007) with some modifications for tropical feeding systems (McLennan 2014), was used to calculate daily cattle dry matter intakes for the specified pasture DMDs.

Table 29 – Assumed forage and steer growth parameters for native grass and stylo-grass pastures grown in the Northern Gulf, with land condition improvement and adequate P supplementation

Biological parameter	Native grass	Stylo-grass pasture – 20% utilisation		Stylo-grass pasture- 40% utilisation	
		Stylo	Grass	Stylo	Grass
Median, annual pasture biomass production (kg DM/ha)	1,500	1,000	1,500	1,000	1,500
Utilisation of annual biomass growth (%)	20	20	20	40	40
Average, stylo content in the diet across the year (%)	0	40		40	
Average, annual diet DMD of grazing cattle (%)	49.5	54		54	
Average, annual steer LWG (kg/head)	113	158		158	
Daily liveweight gain (kg/day); annual average	0.31	0.43		0.43	
January	0.7	0.7		0.7	
February	0.7	0.7		0.7	
March	0.5	0.7		0.7	
April	0.5	0.6		0.6	
May	0.5	0.6		0.6	
June	0.2	0.5		0.5	
July	0.1	0.36		0.36	
August	0.0	0.3		0.3	
September	0.0	0.2		0.2	
October	0.0	0		0	
November	0.15	0.15		0.15	
December	0.4	0.4		0.4	
Carrying capacity (ha/AE)[A]	13.4	7.0		3.5	

DM, dry matter; DMD, dry matter digestibility; LWG, liveweight gain.

[A] AE defined in terms of the forage intake of a 2.25 year old, 450 kg *Bos taurus* steer at maintenance, consuming a diet of the specified DMD and walking 7 km/day (McLean and Blakeley 2014).

The maintenance of weight gains later into the year on stylo pastures was another factor underpinning the analysis of the timing of sale. Two possible sale times for steers grazing stylo-grass pastures were examined: either 1) at the same time as the lead of the steers grazing native pastures (i.e. after 700 days grazing, in mid-May), or 2) at in mid-September after 822 days grazing. As described previously for calculation of representative carrying capacity figures (AE/ha), the average dry matter intake by steers of each forage type was estimated using the QuikIntake Excel spreadsheet calculator (McLennan and Poppi 2016) modified from the Australian ruminant feeding standards (NRDR 2007) to better predict intake for *B. indicus* content cattle and tropical diets (McLennan 2014). The steers were assumed to be Brahman (>75% *B. indicus*), to have a standard reference weight (SRW) of 660 kg, to walk 7 km/day (as per McLean and Blakely 2014) and the terrain to be 'level 1'.

For a 500 ha paddock prior to the sowing of stylo and with steers sold in May: 21 weaner steers enter the paddock in June, one death is expected to the end of the year. A total of 20 yearling steers from the previous weaning will be in the paddock at the same time and one of these will die during the year. A total of 19 steers that are 24 months old will also start the year with 16 of these sold as the weaners enter the paddock. The remaining three older steers will be sold 12 months later. This age structure and sale pattern matches the steer herd age structure and sale pattern for the property. For a 500 ha paddock that has been developed to stylo and has a 20% utilisation rate with steers sold in May: 37 weaner steers will enter the paddock in June and join 36 yearling steers. A total of 35, 2-3 year old steers will be sold as the weaners enter.

The paddock development scenario was expanded from the initial 500 ha paddock development to assess the over-sowing of native pastures with stylo sufficient to run all steers produced by the property. The objective of this strategy was to increase the carrying capacity of the developed area as well as the growth rates of steers. Sufficient capital was allocated to planting 700 ha stylo each year on typical P-deficient soil types (ca. 4 ppm P in the top 100 mm soil). As the area of stylo increased, the numbers of steers able to be grazed from weaning to point of sale increased until all steers produced by the property could be grazed on stylo-grass pastures.

Table 30 shows the calculation of area required to run a steer from weaning at 6 months old until sale of the heavier cohort of steers (83%) grazing native grass pastures and of all steers grazing an established stylo-grass pasture with either 20% or 40% utilisation and sale of steers in mid-May. The greater assumed DM production and average digestibility of the stylo-grass pastures result in a lesser area of pasture required than for native grass-only pastures. A similar process was followed for calculation of the grazing area required for the tail of the steers grazing native pastures from the sale of the first cohort until the sale of the tail and for the stylo steers sold in mid-September (data not presented).

At the property level, prior to the development of the stylo pastures, the steers grazing native pastures with improved land condition and adequate wet season P supplementation need access to about 5,110 ha for 700 days from weaning to the sale of the first cohort (233 head x 21.93 ha). The top 83% were removed at this time and sold at an average liveweight of 415 kg in the paddock. The residual 37 steers then grazed 468 ha for 365 days (37 head x 12.65 ha) until they were sold. Total area of native pasture allocated to the steers was ca. 5,579 ha.

If all of the yearling steers were grazed on stylo-grass pastures utilised at 20% this would free up 2,048 ha of land to be grazed by other classes of stock in the breeding herd. If 13.5 ha is allocated per AE in the native pasture country/paddock to be planted to stylo, then the breeder herd component of the overall beef herd can expand in size once the stylo is fully established. Proportionally expanding the breeding herd and replacement heifers to graze this spare pasture allows the breeders to produce more weaner steers, increasing the area of stylo required but also reducing the spare grass available for breeder herd expansion. An iterative process was used to approximately identify the relationship between the size of the breeder herd and the numbers of steers grazing the stylo grass pasture that optimised the size of each.

Table 31 shows the change in herd structure enabled by the 20% utilisation of stylo grass-pastures. A stylo-grass paddock of 3,530 ha was required to provide an appropriate balance between an expanded breeder herd and suitably sized stylo-grass paddock for the steers. A total of 260 weaner steers are expected to enter the stylo paddocks in May each year with 248 steers sold off stylo between 24 and 36 months of age.

Table 30 – Property development scenario - example of calculation of parameters used in the calculation of grazing area required for a steer from weaning until sale of the heavier cohort of steers grazing native grass pastures and of all steers grazing stylo-grass pastures for the same period with either 20% or 40% utilisation

Figures are the average or total for the entire grazing period

Parameter	Native grass pasture: all steers until sale of heavier cohort in mid-May	Stylo-grass pasture – 20% utilisation; sale in mid-May	Stylo-grass pasture – 40% utilisation; sale in mid-May
Days on forage (post weaning)	700	700	700
Average LWG (kg/d)	0.32	0.43	0.43
Average age (years)	1.5	1.5	1.5
Average liveweight (kg)	304	344	344
Average DMD of diet (%)	49.5	54	54
Average DMI (kg/head.day)	9.4	9.7	9.7
Total biomass consumed per head (kg DM)	6,580	6,790	6,790
% of DM consumption as grass	100	60	60
% of DM consumption as stylo	0	40	40
Total grass consumed per head (kg DM)	6,580	4,074	4,074
Total stylo consumed per head (kg DM)	0	2,716	2,716
Utilisation of grass biomass growth (% of DM)	20	20	40
Utilisation stylo biomass growth (% of DM)	-	20	40
Annual grass biomass production (kg DM/ha)	1,500	1,500	1,500
Annual stylo biomass production (kg DM/ha)	0	1,000	1,000
Annual paddock biomass production (kg DM/ha)	1,500	2,500	2,500
Total grass yield for grazing days (kg DM/ha)	2,877	2,877	2,877
Total stylo yield for grazing days (kg DM/ha)	0	1,918	1,918
Grass biomass available for consumption (kg DM/ha)	575	575	1,151
Stylo biomass available for consumption (kg DM/ha)	0	384	767
Area required to meet steer demand for 1 year (ha)	11.44	7.08	3.54
Total area required for the grazing period (area adjusted for number of days > 365), (ha)	21.93	13.58	6.79

DM, dry matter; DMD, dry matter digestibility; DMI, dry matter intake; LWG, liveweight gain.

Table 31 – Property development scenario - breeder herd components without the stylo development and with the stylo development at 20% utilisation rate, once fully established and with a sale target of mid-May

Breeder herd components	**Native grass pasture (new base herd)[A]**	**Stylo-grass pasture for steers – 20% utilisation; sale in mid-May**
Total cows and heifers mated	805	902
Calves weaned	465	521
Weaner steers	233	260

[A] Based on the 1,500 AE herd target

In the property development scenario, from Year 1 of the analysis, 700 ha of stylo was over-sown (and costed) each year for 6 years. However, to account for annual rainfall variation causing less successful establishment in some year, only 83% of the area sown was assumed to establish effectively, i.e., a total of 3,500 ha. This area was sufficient to run 260 weaner steers until sale in mid-May each year. The stylo paddocks were assumed to require part fencing (at $3,000/km) plus a water tank, poly pipe and trough costing $2,500 per paddock. The analysis of the stylo development also accounted for:

- the income foregone during the time it takes to develop the stylo paddock, and
- the time taken to retain additional heifers and cows to build up the herd numbers to the new level of steer production.

To allow for the seeding and spelling of the area sown a mix of ages of steers sufficient to destock the paddock area were sold in May in the first year of the development. A cohort of weaners, equivalent to 50% of the number of weaners that entered the paddock prior to development, grazed the paddock from June of the following year. No other stock were grazed in the paddock for this initial period. In Year 3 the paddock had another cohort of weaners enter the paddock to join the original cohort of weaners, now yearlings. From Year 4 a full complement of weaner steers entered the paddock from June. The original weaner steers were sold at the heavier weights expected with stylo consumption. It was Year 6 after the stylo was planted before the paddock was fully stocked and Year 7 before a full complement of steers were sold off the stylo paddock.

5.1.3 Results and discussion

Investing in a strategy of over-sowing native pastures on forest country with stylos, on 500 ha, selling the steers in May, and utilising the pasture at 20% resulted in an 11% return on the additional capital invested over the longer term (30 years); (Table 32). Holding steers on stylo pastures until later in the year to gain a price premium of 10 c/kg live and selling the steers at a heavier weight did not substantially improve economic performance. Increasing the utilisation rate of stylo-grass pastures from 20% to 40% substantially increased economic performance, almost doubling the return on additional capital invested.

Table 32 - Returns for investing in 500 ha of stylo-grass pastures for steers from weaning to sale

The comparison is the 500 ha paddock with and without stylo development. All terms defined in the Glossary of terms and abbreviations

Factor	**Stylo-grass pastures – 20% utilisation, May sale**	**Stylo-grass pastures – 20% utilisation, September sale**	**Stylo-grass pastures – 40% utilisation, May sale**	**Stylo-grass pastures – 40% utilisation, September sale**
Period of analysis (years)	30	30	30	30
Discount rate for NPV	5.00%	5.00%	5.00%	5.00%
NPV	$78,100	$78,500	$266,000	$279,100
Annualised NPV	$5,100	$5,100	$17,300	$18,200
Peak deficit (with interest)	-$66,400	-$60,900	-$92,700	-$81,100
Year of peak deficit	6	6	6	6
Payback period (years)	12	12	9	9
IRR	11%	12%	20%	22%

Table 33 shows the net return to developing a sufficient area of the property to stylos over time (6 years in this example), to run all steers from weaning to sale. The returns are similar in scale to the paddock returns at the same utilisation rate and timing of sale. The extended period of time for the development, the requirement to build up breeder numbers as the stylo development takes place and the additional area planted to allow for seasonal variability all conspire to reduce the return on capital.

Table 33 - Returns for investing in sufficient stylo-grass pasture to run all steers (May sale; 20% utilisation)

This strategy was implemented concurrently with land condition improvement and adequate wet season P supplementation and compared to a base herd which implemented land condition improvement and adequate wet season P supplementation but no stylo. All terms defined in the Glossary of terms and abbreviations

Factor	**Stylo-grass pastures – 20% utilisation May sale Property-level development**
Period of analysis (years)	30
Discount rate for NPV	5.00%
NPV	$476,700
Annualised NPV	$31,000
Peak deficit (with interest)	-$270,600
Year of peak deficit	9
Payback period (years)	15
IRR	10%

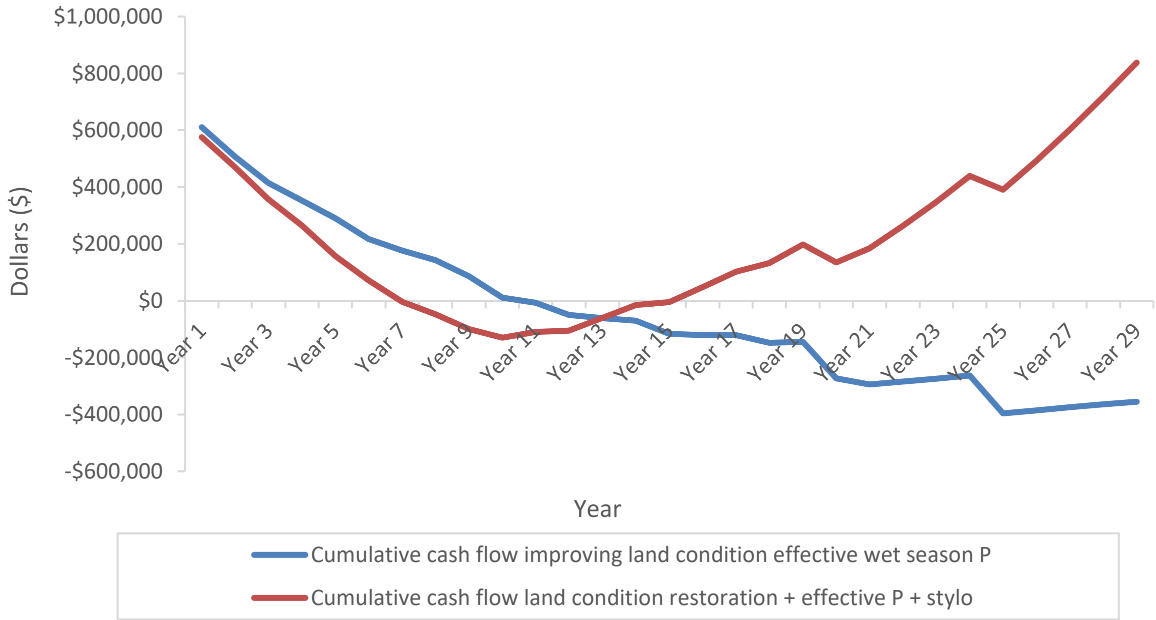
The annualised NPV of $31,011 for stylo-grass pastures approximately represents the average annual change in profit over 30 years resulting from the management strategy. The implementation of stylo pastures for steers resulted in a substantial peak deficit for the property of -$270,600 and a substantial payback period of 15 years. The extended payback period arises due to the development phase taking more than a decade.

It should be noted that these predicted returns are dependent on largely untested assumptions concerning the relative yields, utilisation rates, diet quality and animal performance from grazing of stylo-grass pastures under Northern Gulf conditions over 30 years. These results indicate the sensitivity of the outcome to stocking rate. The sensitivity of profitability to forage utilisation rates and hence stocking rate has been demonstrated by Bowen and Chudleigh (2018*a*) for tropical grass pastures and the same principle applies regardless of forage type.

The positive effect on profit from investing in perennial legumes for steers has also been reported for both leucaena-grass and shrubby legumes sown in central Queensland (Bowen and Chudleigh 2017, 2018*b*,*c*) but with much greater IRR's, e.g.: 34% and 26% for leucaena and desmanthus, respectively (Bowen and Chudleigh 2018*b*). The higher return to legumes sown in central Queensland (cf. stylos in the Northern Gulf) was linked to the greater expected productivity in terms of total forage biomass yield, individual animal performance and stocking rates even though there were relatively higher establishment and maintenance costs for legume-grass pastures in central Queensland.

Figure 15 shows the cumulative cash flow for the stylo development at the property level. Risk was increased in the medium term but a successful stylo development could improve the profitability and drought resilience of the property over the longer term. However, the return on total assets invested over the 30 years was still less than 1% per annum.

Figure 15 - Cumulative cash flow for the property with stylo planted for steers (20% utilisation, May sale of steers)



5.2 Stylo pastures and phosphorus fertiliser

5.2.1 Introduction

Studies conducted in northern Australia during the 1960s–1990s indicated pasture yield responses and cattle liveweight gain improvements to P applied to legume-based pastures containing either native or sown grasses (e.g., Jones 1990; Miller and Hendricksen 1993; Coates 1994; McIvor *et al.* 2011; Peck *et al.* 2015). On P-deficient soils (ca. 4 ppm) the addition of P fertiliser was shown to improve the total growth of legumes, increase the carrying capacity and weight gain of steers grazing the pasture plus maintain the productivity of legume pastures over the longer term. However, the relationship between the cost of P fertiliser and cattle prices during the 70s-90s was considered to make this strategy uneconomical (e.g. Miller and Hendricksen (1993), Coates (1994)) and hence dismissed as a viable strategy for northern beef properties. Contemporary prices for P fertiliser and cattle warrants reanalysis of this strategy.

Critical P levels (i.e. P required to achieve 95% of maximum yield) have been determined for many temperate and tropical legume species. Table 34, from Peck *et al.* (2015), ranks legumes in order of increasing P requirements. Legumes that have not had trials to determine critical P levels were included, with their place in the order based on field observations. Most stylo species suitable for sowing in the Northern Gulf require at least 8 mg/kg of P in the soil to maximise yield potential. Hence, a stylo-grass pasture response to P fertiliser is expected under Northern Gulf conditions where stylos have been sown on soils with < 8 mg/kg P.

Table 34 - Critical P requirements for legumes (to achieve 95% of maximum yield potential) (Peck et al. 2015)

Species	**Critical P* (mg/kg) in the top 100 mm of soil**	**Trial type**	**Reference**
Shrubby stylo (cv Seca)	8	Field	Gilbert and Shaw (1987)
Caribbean stylo (cv Verano)	10-12	Field	Probert and Williams (1985); Hall (1993)
Fine-stem stylo	?		
Round-leaf cassia	?		
Caatinga stylo	?		
Desmanthus	?		
Siratro	10-14	Field	Rayment *et al.* (1977)
Leucaena	>15	Field	Dalzell *et al.* (2006);
	25	Observation	S. Buck, pers. comm.
Butterfly pea (cv Milgarra)	25	Pot	Haling *et al.* (2013)
Annual medics	12-30	Field	Reuter *et al.* (1995)

* Expressed for Colwell P except shrubby stylo which is acid extractable P and Caribbean stylo where both Colwell and acid extractable P critical P levels were similar.

? No trial results found reporting critical P levels.

The legume response to soil P levels developed by Peck *et al.* (2015) are shown in Table 35. Phosphorus response curves for legume pasture have not been fully developed, therefore the Peck *et al.* (2015) analysis assumed three P response types to cover the likely responsiveness of adapted legumes. Although not specifically described, examples of the different types of legumes are:

- Low critical P – some of the Stylosanthes species and perhaps round-leaf cassia
- Medium critical P – Siratro and possibly desmanthus and Caatinga stylo
- High critical P – Leucaena, butterfly pea and medics.

Table 35 – Responses of pasture legumes to phosphorus

	Low critical P legume, low response	Medium critical P legume, medium response	High critical P legume, high response
<10% yield level	2	6	10
75% maximum yield (mg P/kg)	8	12	18
Critical Colwell P level (95% of maximum yield potential; mg P/kg)	10	15	25

The expected annual dry matter production in the year of fertiliser application for legumes with low P requirements are shown in Figure 16 (Peck *et al.* 2015). Expected changes in Colwell P levels were calculated in Peck *et al*. (2015) by assuming an annual P maintenance requirement of 1 kg P/dry sheep equivalent.ha (Guppy *et al*. 2013) and a soil Colwell P responsiveness of 0.3 mg/kg (Simpson *et al.* 2009) for every kilogram of P lost through the maintenance requirement. As discussed by Peck *et al.* (2015), the pasture growth assumption described in Figure 16 shows primarily a response to different levels of plant available P in the soil. P-deficient soils often also have other traits that limit plant growth, such as lower water holding capacity, sub-soil constraints or low levels of other nutrients (e.g. potassium or sulphur), (Ahern *et al.*, 1994).

Figure 16 - Annual dry matter yield for low P requiring legumes in the year of fertiliser application (Peck et al. 2015).

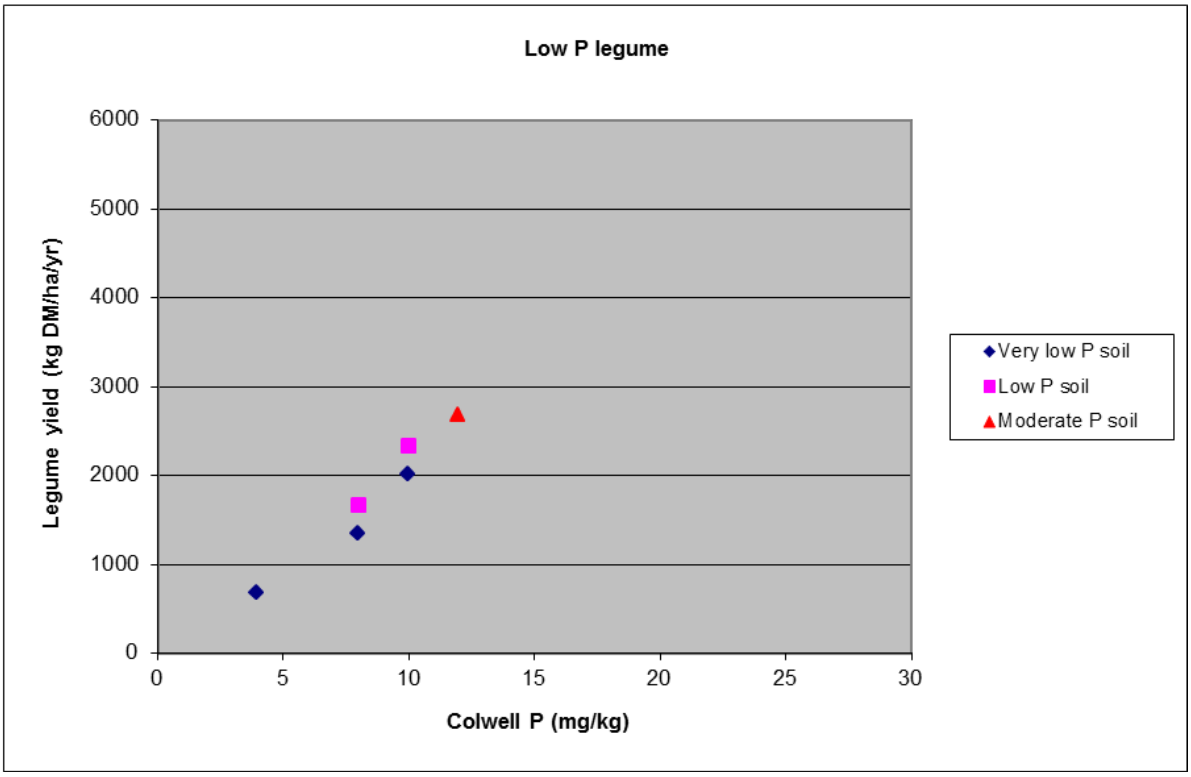
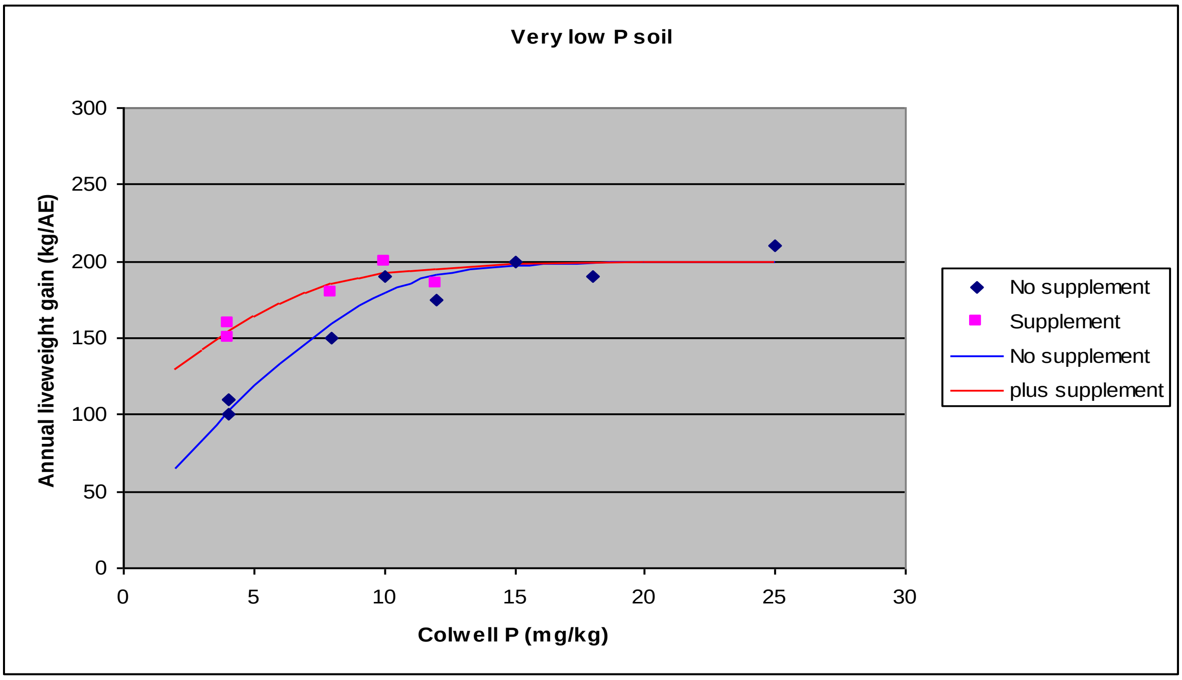


Figure 17 shows the summarised relationship developed by Peck *et al.* (2015) for supplemented or un-supplemented stock grazing legume-based pastures compared to soil P levels for a 'Deficient P' soil type.

Figure 17 - Steer liveweight gains across all scenarios on very low P soil (Peck et al 2015)

Note: a very low P soil has ca. 4 ppm Colwell P



5.2.2 Methods

This analysis extends the previous analysis of stylo pastures (Section 5.1) by adding P fertiliser to a 500 ha paddock with established stylo pastures growing on a P-deficient soil (ca. 4 ppm P in the top 100 mm). The returns were calculated for the extra capital required to buy and apply the fertiliser and the extra steers need to stock the stylo-grass paddock. The comparison therefore was of a 500 ha paddock of established stylo with and without P fertiliser.

Relationships for legume dry matter production vs. soil Colwell P levels were developed for stylo and P-deficient soil types (ca. 4 ppm) from the relationships given by Peck *et al.* (2015); Figure 16. These equations were then used to calculate the pasture dry matter production arising from P fertiliser applications. Stylo pastures growing on P-deficient soils were expected to double their yield with the application of a suitable amount of P fertiliser. For the purposes of this analysis, the estimates of legume dry matter production were made assuming there would be other limitations to plant growth, such that, for any particular soil P level the legume DM production was in the order: Acutely deficient P soil < Deficient P soil < Marginally deficient P soil.

Applications of P fertiliser need to be made at regular intervals to replace the P being extracted from the paddock by the increased levels of animal production. Table 36 shows the fertiliser application rate, the expected rate of P removal under the higher output of beef generated and the Colwell P level of the soil. The fertiliser was reapplied every 2 years from Year 3 at a rate of 4.9 kg P/ha for the remaining years of the analysis. Fertiliser was applied as triple superphosphate at a landed cost of $890/t and was spread at a uniform cost of $12/ha.

Table 36 - P fertiliser applications over the first decade for a P –deficient soil growing a low P requiring legume with P supplements fed to the steers (adapted from Peck et al. 2015)

Year	**Phosphorus fertiliser rate (kg P/ha)**	**Maintenance P (kg P removed in the prior year)**	**New Colwell P level**
Establishment	20		10
Year 2		2.6	9.2
Year 3	5	2.4	10
Year 4		2.5	9.2
Year 5	4.9	2.4	10
Year 6		2.5	9.2
Year 7	4.9	2.4	10
Year 8		2.5	9.2
Year 9	4.9	2.4	10
Year 10		2.5	9.2

As in the previous stylo analysis, the native pasture grazed by the steers in the 'without-change' situation was considered to be a forest country land type such as Georgetown Granites in ca. B-condition (starting land condition of the base property). A mean annual biomass production of 1,500 kg DM/ha with 20% utilisation rate (of annual biomass grown) was assumed for the native grass-only pasture grazed by the steers.

In the stylo-grass and P fertiliser scenarios, average annual stylo biomass production over 27 years after the establishment period was assumed to be 1,750 kg DM/ha (Table 37). Native grass biomass production in the paddocks over-sown with stylo was assumed to be 1,750 kg DM/ha. The assumed utilisation rate of grass pasture and stylo averaged across the annual cycle was 20%, depending on scenario, resulting in a 50% average stylo content in diet selected across the year which is considered broadly representative for these pasture systems (Coates 1996; J. Rolfe, pers. comm.). If the stylo-grass pasture was assumed to be utilised at 20% of annual biomass growth the carrying capacity on the pasture was greater (2.0 ha/AE) than the native pasture (13.4 ha/AE). Steer liveweight gain responses were informed using the 'plus supplement' response curve for steer liveweight gain given by Peck *et al.* (2015), (Figure 17). The steers grazing stylo-grass pastures with P fertiliser were expected to grow about 68% faster per annum (+77 kg liveweight) than steers grazing the same pasture without stylo (but with an effective wet season P supplement).

The carrying capacity of each pasture was calculated by multiplying the median annual pasture biomass production by the specified utilisation level and then dividing by the annual pasture consumption of a standard animal unit or AE. An AE, in this exercise, was defined in terms of the forage dry matter intake at the specified diet DMD, of a standard animal which was defined by McLean and Blakeley (2014) as a 2.25 year old, 450 kg *B. taurus* steer at maintenance, walking 7 km/day. The spreadsheet calculator, QuikIntake (McLennan and Poppi 2016), which is based on the Australian Feeding Standards (NRDR 2007) with some modifications for tropical feeding systems (McLennan 2014), was used to calculate daily cattle dry matter intakes for the specified pasture DMDs.

Table 37 – Assumed forage and steer growth parameters for P-fertilised native grass and stylo-grass pastures grown in the Northern Gulf, with land condition improvement and adequate P supplementation

Biological parameter	**Native grass**	**Stylo-grass pasture with P fertiliser – 20% utilisation**	
		Stylo	**Grass**
Median, annual pasture biomass production (kg DM/ha)	1,500	1,750	1,750
Utilisation of annual biomass growth (%)	20	20	20
Average, stylo content in the diet across the year (%)	0	50	
Average, annual diet DMD of grazing cattle (%)	49.5	54	
Average, annual steer LWG (kg/head)	113	190	
Daily liveweight gain (kg/day); annual average	0.31	0.52	
January	0.7	0.7	
February	0.7	0.7	
March	0.5	0.7	
April	0.5	0.7	
May	0.5	0.7	
June	0.2	0.6	
July	0.1	0.5	
August	0.0	0.4	
September	0.0	0.3	
October	0.0	0	
November	0.15	0.35	
December	0.4	0.6	
Carrying capacity (ha/AE)[A]	13.4	2.0	

DM, dry matter; DMD, dry matter digestibility; LWG, liveweight gain.

[A] AE defined in terms of the forage intake of a 2.25 year old, 450 kg *Bos taurus* steer at maintenance, consuming a diet of the specified DMD and walking 7 km/day (McLean and Blakeley 2014).

The maintenance of weight gains later into the year on stylo pastures with P fertiliser was another factor underpinning the analysis of the timing of sale. Two possible sale times for steers grazing stylo-grass pastures were examined: either 1) at the same time as the lead of the steers grazing native pastures (i.e. after 700 days grazing, in mid-May), or 2) at in mid-September after 822 days grazing. As described previously for calculation of representative carrying capacity figures (AE/ha), the average dry matter intake by steers of each forage type was estimated using the QuikIntake Excel spreadsheet calculator (McLennan and Poppi 2016) modified from the Australian ruminant feeding standards (NRDR 2007) to better predict intake for *B. indicus* content cattle and tropical diets (McLennan 2014). The steers were assumed to be Brahman (>75% *B. indicus*), to have a standard reference weight (SRW) of 660 kg, to walk 7 km/day (as per McLean and Blakely 2014) and the terrain to be 'level 1'.

For a 500 ha paddock prior to the sowing of stylo and with steers sold in May: 21 weaner steers enter the paddock in June, one death is expected to the end of the year. A total of 20 yearling steers from the previous weaning will be in the paddock at the same time and one of these will die during the year. A total of 19 steers that are 24 months old will also start the year with 16 of these sold as the weaners enter the paddock. The remaining three older steers will be sold 12 months later. This age structure and sale pattern matches the steer herd age structure and sale pattern for the base property. For a 500 ha paddock that has been developed to stylo plus P fertiliser and has a 20% utilisation rate with steers sold in May: 48 weaner steers will enter the paddock in June and join 47 yearling steers. A total of 46, 2-3 year old steers will be sold as the weaners enter. Where steers are sold in September, 39 steers enter the paddock each year.

Table 38 shows the calculation of area required to run a steer from weaning at 6 months old until sale grazing either an unfertilised, established stylo-grass pasture or P-fertilised stylo-grass pasture with a 20% utilisation. A later sale date (mid-September) of steers grazing P-fertilised stylo-grass pastures was also examined. The greater assumed dry matter production and average diet digestibility of the P-fertilised stylo-grass pastures result in a lesser area of pasture required than unfertilised pastures.

Table 38 –Parameters used in the calculation of grazing area required for a steer from weaning until sale of the heavier cohort of steers grazing stylo-grass pastures with or without P fertiliser at 20% utilisation

Figures are the average or total for the entire grazing period

Parameter	**Stylo-grass pasture – 20% utilisation; sale in mid-May**	**Stylo-grass pasture +P fertiliser– 20% utilisation; sale in mid-May**	**Stylo-grass pasture + P fertiliser – 20% utilisation; sale in mid-September**
Days on forage (post weaning)	700	700	822
Average LWG (kg/d)	0.43	.52	.51
Average age (years)	1.5	1.5	1.6
Average liveweight (kg)	344	375	402
Average DMD of diet (%)	54	56	56
Average DMI (kg/head.day)	9.7	10.4	10.8
Total biomass consumed per head (kg DM)	6,790	7,280	8,878
% of DM consumption as grass	60	50	50
% of DM consumption as stylo	40	50	50
Total grass consumed per head (kg DM)	4,074	3,640	4,439
Total stylo consumed per head (kg DM)	2,716	3,640	4,439
Utilisation of grass biomass growth (% of DM)	20	20	20
Utilisation stylo biomass growth (% of DM)	20	20	20
Annual grass biomass production (kg DM/ha)	1,500	1,750	1,750
Annual stylo biomass production (kg DM/ha)	1,000	1,750	1,750
Annual paddock biomass production (kg DM/ha)	2,500	3,500	3,500
Total grass yield for grazing days (kg DM/ha)	2,877	3,356	3,941
Total stylo yield for grazing days (kg DM/ha)	1,918	3,356	3,941
Grass biomass available for consumption (kg DM/ha)	575	671	788
Stylo biomass available for consumption (kg DM/ha)	384	671	788
Area required to meet steer demand for 1 year (ha)	7.08	5.42	5.63
Total area required for the grazing period (area adjusted for number of days > 365), (ha)	13.58	10.40	12.68

DM, dry matter; DMD, dry matter digestibility; DMI, dry matter intake; LWG, liveweight gain.

5.2.3 Results and discussion

Investing in a strategy of fertilising established stylo pastures, growing on a P-deficient soil, with P resulted in between 21-24% return on the additional capital invested over the longer term (30 years); (Table 39). Holding steers on stylo pastures until later in the year to gain a price premium of 10 c/kg live and selling the steers at a heavier weight did not substantially improve economic performance. These positive returns from fertilising stylo pastures with P challenge the accepted paradigm based on research conducted during the 60s-90s when P fertiliser was deemed uneconomic (e.g. Miller and Hendricksen (1993), Coates (1994)). Under current costs and prices this strategy is worth re-considering as an option to improve profitability of northern beef properties.

Table 39 - Returns for implementing a strategy of fertilising a 500 ha of established stylo-grass pastures with P to run steers from weaning to sale

The comparison is the 500 ha paddock of established stylo with and without P fertiliser. All terms defined in the Glossary of terms and abbreviations

Factor	**Stylo-grass pastures – 20% utilisation, May sale**	**Stylo-grass pastures – 20% utilisation, September sale**	**Stylo-grass pastures – 20% utilisation, September sale + 10 c/kg**
Period of analysis (years)	30	30	30
Discount rate for NPV	5.00%	5.00%	5.00%
NPV	$195,000	$169,100	$198,100
Annualised NPV	$12,700	$11,000	$12,900
Peak deficit (with interest)	-$70,600	-$60,900	-$59,800
Year of peak deficit	2	2	2
Payback period (years)	6	6	5
IRR	22%	22%	25%

5.3 Age of steer turnoff and market options

5.3.1 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 weaners and older steers (Holmes *et al.* 2017; DAF 2018*a*). 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 2018*a*). The recent price premiums provided for the various categories of the live export market for steers indicated that the optimum steer sale age for the Northern Gulf region was once steers were in the target sale weight range for live export. However, prices have moderated and there are other sale age options for steers that can be considered.

5.3.2 Methods

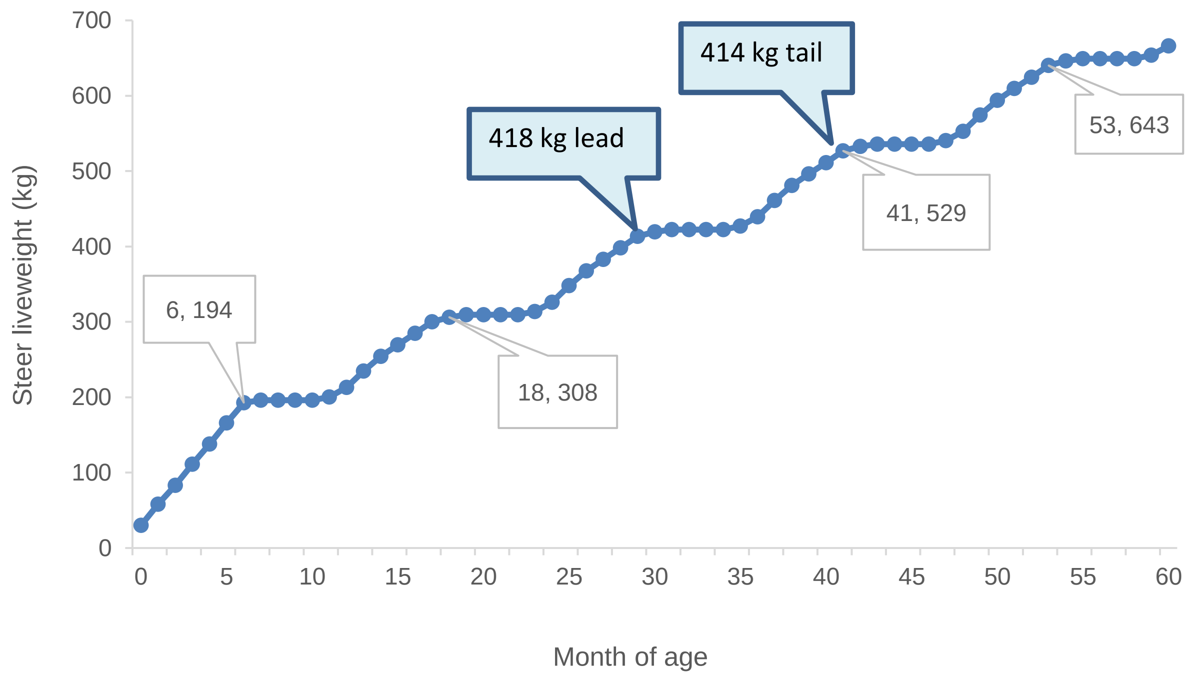
The effect of alternative steer sale ages was modelled by comparing the alternatives in a 'steady state' herd model consisting of 1,500 AE on the property and after 10 years of land condition improvement and adequate wet season P supplementation. That is, the expected herd performance at Year 10 (of the analysis incorporating land condition improvement and adequate wet season P supplementation) was used as the new base for comparison with alternative steer sale age scenarios.

Figure 18 shows the potential average liveweight of the steers at weaning and when they are 18, 41 and 53 months old, after 10 years of land condition improvement and adequate wet season P supplementation (as described in sections 4.1.2 and 4.2.2).

Steers in the base herd were sold in two groups, either at 29 months old and 418 kg (the lead) or 41 months old and 414 kg (the tail). The effect on profit of selling steers at alternative ages (and restructuring the herd to meet these new targets) was considered. The steer sale age scenarios were modelled as follows:

1. All steers were sold as weaners when 6 months old and 193 kg in the paddock. The price was $2.60/kg, 20 c/kg more than the long term price for export steers.
2. All steers were sold at 18 months of age at an average of 308 kg liveweight in the paddock. The sale price was $2.40/kg, the same as the live export yearling steer price.
3. All steers were sold at an average of 529 kg liveweight when they were 41 months old. The price was $2.40, the same as the live export steer price.
4. All steers were sold at an average of 643 kg liveweight when they were 53 months old. The price was $2.20, 20 c/kg lower than the live export yearling steer price.

Figure 18 – Northern Gulf steer weights with land condition improvement and adequate wet season P supplementation, showing alternative steer sale weights and ages



5.3.3 Results and discussion

In this strategy the effect on profit of selling steers at different ages: 6, 18, two groups at 29 and 41 months (base scenario), 41 and 53 months old, were considered. As indicated in Table 40 selecting an older age of turnoff for steers of 41 months could improve profit as well as reduce the exposure of the property to drought risk over the longer term. The results of the gross margin analysis indicated that the number of breeders mated and kept fell for each extra year that the steers were retained, potentially decreasing drought risk. 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. 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 the lesser quality country types, potentially leading to a fall in their performance. There was, until recently, a substantial premium above that used in this analysis for steers that meet the live export criteria and it may be unwise (currently) to consider a different target for age of turnoff. A further narrowing of the price per kilogram difference between younger steers and older steers would support a change to an older age of turnoff.

Table 40 - Steer age of turnoff herd gross margin comparison

Parameter	**Age of steer turnoff**				
	Weaners (6 months)	**18 months**	**Base herd (29 and 41 months)**	**Medium steers (41 months)**	**Bullocks (53 months)**
Total AE	1,500	1,500	1,500	1,500	1,500
Total cattle carried	1,539	1,671	1,739	1,721	1,661
Weaner heifers retained	288	263	233	208	181
Total breeders mated	997	912	805	721	625
Total breeders mated and kept	930	851	751	672	583
Total calves weaned	576	527	465	416	361
Weaners/total cows mated	57.76%	57.76%	57.76%	57.76%	57.76%
Weaners/cows mated and kept	61.91%	61.91%	61.91%	61.91%	61.91%
Overall breeder deaths	2.50%	2.50%	2.50%	2.50%	2.50%
Female sales/total sales %	46.52%	47.15%	47.89%	48.41%	49.05%
Total cows and heifers sold	250	229	202	181	157
Maximum cow culling age	11	11	11	11	11
Heifer joining age	2	2	2	2	2
Two year old heifer sales %	60.55%	60.55%	60.55%	60.55%	60.55%
Total steers and bullocks sold	288	257	220	193	163
Maximum bullock turnoff age	0	1	3	3	4
Average female price	$671.27	$671.27	$671.27	$671.27	$671.27
Average steer/bullock price	$410.99	$587.72	$841.87	$1,098.96	$1,240.87
Capital value of herd	$960,157	$986,659	$996,850	$1,065,545	$1,108,567
Imputed interest on herd value	$48,008	$49,333	$49,842	$53,277	$55,428
Net cattle sales	$286,444	$304,736	$321,056	$333,474	$307,934
Direct costs excluding bulls	$60,345	$64,281	$63,107	$60,435	$52,443
Bull replacement	$32,577	$29,803	$26,309	$23,546	$20,432
Herd gross margin	$193,522	$210,652	$231,640	$249,493	$235,059
Herd gross margin less interest on livestock capital	*$145,515*	*$161,319*	*$181,798*	*$196,216*	*$179,630*
Difference to base herd	-$36,283	-$20,479	$0	$14,418	-$2,167

Table 41 indicates the extra returns generated by holding the steers until they all sell at 41 months of age. The comparison was with the base herd with improved land condition and an adequate wet season P supplementation program in place and where steers were sold in two cohorts at 29 and 41 months of age. These results indicate that it is important to keep a close eye on price premiums for each age of sale for steers as it may be possible to move to an older age of sale and improve both profitability and drought resilience. However, the level of the peak deficit incurred from holding steers to an older sale age will likely prevent many Northern Gulf properties changing their age of turnoff target.

Table 41 - Returns for moving to a steer sale age of 41 months compared to the base herd where steers are sold in two cohorts at 29 and 41 months of age and which is receiving adequate P supplementation and has benefited from 10 years of land condition improvement
All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5.00%
NPV	$500,300
Annualised NPV	$32,500
Peak deficit (with interest)	-$95,500
Year of peak deficit	2
Payback period (years)	8
IRR	24%

5.4 Leucaena-grass pastures on frontage country for steers

5.4.1 Introduction

The perennial tree legume, leucaena (*Leucaena leucocephala* subsp. *glabrata*) has been grown commercially in central Queensland since the 1960s with an estimated 123,500 ha planted to leucaena over its prime growing region in central and southern Queensland (350,000 km^2 total area surveyed); (Beutel *et al.* 2018). In central Queensland, leucaena-grass pastures have been identified as the most productive and profitable of all forage options, increasing beef production per hectare by ca. 2.5 times and doubling gross margins per hectare, compared to perennial grass pastures (Bowen *et al.* 2018). In addition, scenario analyses identified leucaena-grass systems as the most profitable forage option for beef cattle production in central Queensland (Bowen and Chudleigh 2017, 2018*b*,*c*) and the most profitable of all alternative technologies or management strategies available other than wet-season P supplementation of an acutely P-deficient breeder herd (Bowen and Chudleigh 2018*b*).

Assessments of suitable soil and climatic conditions indicate that there is considerable scope to expand leucaena plantings across Queensland (Beutel *et al.* 2018) with Peck *et al.* (2011) estimating that leucaena has been sown to only 2.5% of the area to which is adapted in Queensland. However, leucaena is most productive when grown in deep, fertile soils in a frost-free environment (Dalzell *et al.* 2006; Bowen *et al.* 2015*a*). Additionally, leucaena has a high requirement for available soil P (15-25 ppm to achieve 95% of maximum yield potential) which is much higher than for stylos (8-12 ppm required to achieve 95% of maximum yield potential); (Peck *et al.* 2015). In areas of Australia with >800 mm annual rainfall, the leucaena psyllid (*Heteropsylla cubana*) has limited the range of leucaena plantings. However, the recent release of a psyllid-resistant leucaena variety (cv. Redlands) may allow commercial plantings to occur in suitable land types of high-rainfall, coastal catchments (Shelton *et al.* 2017).

In the Northern Gulf NRM region the land types of red basalt and frontage have been identified as suitable for planting to leucaena and trials are currently underway to determine and demonstrate production parameters in this environment (J. Rolfe, pers. comm.). While some areas of frontage land type have been previously cleared and are available for leucaena plantings, this is not the case for the Red basalt land type (J. Rolfe, pers. comm.). As current vegetation management laws prohibit further tree clearing on the Red basalt land type, there is anticipated to be limited scope for future industry-wide leucaena-plantings on this land type. However, a 'Producer Demonstration Site' (PDS) near Mt Garnet in the 1990s, where leucaena was sown into perennial native pastures on basalt soils, demonstrated an increased carrying capacity and double the annual liveweight gain from leucaena-grass pastures compared to native pastures alone (Kernot 1998; Buck *et al.* In press).

5.4.2 Methods

In this scenario the benefits of planting leucaena into frontage country (alluvial soil), that has previously been cleared and planted to improved grass pastures (primarily buffel grass), was considered as a strategy to increase carrying capacity and growth rates of steers from weaning until sale. The effect of investing in leucaena on frontage country was modelled by comparing the performance of a 500 ha paddock of frontage country growing buffel grass pasture to the same paddock that was planted to leucaena in the first year of the analyses. The paddock ran steers from weaning to sale in one age cohort and the steers were either sold off leucaena at the normal time (May) after 12 months in the paddock or later in the season (September) after 16 months in the paddock.

The frontage country to be sown to leucaena was assumed to have a soil P level of 10-15 ppm in the top 100 mm soil and to therefore require P fertiliser at establishment and again at 5-year intervals to maintain soil P at >20 ppm to ensure the continued productivity of the leucaena pasture. Prior to planting, a custom blend of fertiliser designed for Northern Gulf frontage country was applied at 200 kg/ha ($910/t) and consisted of a mix of granulated S and double superphosphate giving 16.3% P and 20.2% S. The fertiliser blend was applied in one pass pre-planting with a fertiliser spreader, along the rows to be planted to leucaena (i.e. to 35% of the paddock area). Starting in Year 10 of the analysis, every 5 years the same custom fertiliser blend was re-applied at the same rate as at planting.

The leucaena-grass pasture was developed on the basis of cultivating 5 m wide strips across the paddock on 10 m centres (i.e. alternating 5 m wide strips of grass and cultivation). Leucaena seed was planted in double rows in the center of the 5 m strips of cultivation. No grass seed was sown as it was assumed that the buffel grass pasture in the non-cultivated strips would readily spread into the adjacent cultivated strips. The development process for the leucaena-grass pasture is given in Table 42 and the development costs shown in Table 43. Contract rates were used for leucaena planting and these included an allowance for the labour involved in driving machines, an allowance for the capital cost invested in machines, and some allowance for profit to be made by the contractor. There was no allowance made for regular mechanical cutting of the leucaena.

Table 42 - Leucaena development process for frontage country in the Northern Gulf

Year 1	Year 2	Year 3	Year 4	Year 5
fallow year; stock to July then cutter-bar in September; plant after Christmas	year of sowing; no grazing	Light stocking for 4 months to July; remove stock until after wet season	stock weaners in June at 3/4 stocking rate; full weight gain per head	full stocking rate; full weight gain

Table 43 - Leucaena development costs on frontage country in the Northern Gulf using contract rates

Item or treatment	Rate of application	Cost/unit	Number of applications	% of area treated	Cost per hectare across whole paddock
Pre planting costs					
Cutter bar	1	$150.00/ha	1	66	$100.00
Linkage spray rig	1	$8.35	1	50	$4.18
Roundup CT	1.5 L/ha	$8.50/L	1	50	$6.38
Fertiliser blend (16.3% P, 20.2% S)	200 kg/ha	$910/t	1	35	$63.70
Fertiliser spreader	1	$6.19/ha	1	35	$2.17
Planting Costs					
Leucaena planter	1	$21.23	1	100	$21.23
Leucaena seed	2 kg/ha	$50.00/kg	1	100	$100.00
Leucaena inoculant	1	$0.24	1	100	$0.24
Linkage spray rig	1	$8.35	2	50	$8.35
Spinnaker	0.14 kg/ha	$107.50	1	50	$7.53
Roundup CT	1.5 L/ha	$8.50	1	50	$6.38
Linkage spray rig	1	$8.35	1	50	$4.18
Uptake oil	0.10 L/ha	$6.32	1	50	$0.32
Post Planting Costs					
Verdict 520	0.30 kg/ha	$48.00	1	50	$7.20
Linkage spray rig	1	$8.35	1	50	$4.18
Total					*$336*

At the assumed level of soil P on the frontage country it was estimated that the steers would not require wet season P supplementation on either the buffel grass only (base scenario) or the leucaena-grass pastures. The steers running on the frontage country were expected to have a different growth path to those grazing forest country land types applied in the stylo example.

Table 44 indicates the assumed forage and steer growth parameters for buffel grass-only pastures and for leucaena-grass pastures planted in the same paddock. Due to a lack of representative data for pasture composition, diet quality and legume composition, and animal liveweight response, assumptions were made with reference to published data from outside the region (e.g. Bowen *et al.* 2015*a*,*b*; Bowen *et al.* 2018) as well as to PDS site data (Hasker 2000; J. Rolfe, pers. comm.). It should be noted that there exists a low level of confidence around these estimates due to lack of relevant data.

A mean annual buffel grass biomass production of 3,500 kg DM/ha was assumed for the grass-only pasture with a 30% utilisation rate of annual biomass grown, which is the recommended safe utilisation rate for this land type for long-term sustainability (Whish 2011). Buffel grass biomass production and utilisation rates in the leucaena-grass pastures were assumed to be the same as that for the grass-only pastures, which is in line with measured data from commercial properties in the central Queensland region (Bowen *et al.* 2015*b*). Edible leucaena biomass production was assumed to be 1,600 kg DM/ha.annum with 85% of this utilised (consumed) by the grazing steers (adapted from Dalzell *et al.* 2006; Elledge and Thornton 2012; Bowen *et al.* 2018; and data obtained from PDF producer demonstration sites in central Queensland (S. Buck pers. comm.).

Table 44 – Assumed forage and steer growth parameters for frontage buffel grass and leucaena-grass pastures grown in the Northern Gulf, with adequate herd P supplementation and after 10 years of land condition improvement

Biological parameter	Buffel grass	Leucaena-grass	
		Leucaena	Grass
Median, annual pasture biomass production (kg DM/ha)	3,500	1,600	3,500
Utilisation of annual biomass growth (%)	30	85	30
Average, leucaena content in the diet across the year (%)	0	56	
Average, annual diet DMD of grazing cattle (%)	53	58	
Average, annual steer LWG (kg/head)	151	244	
Daily liveweight gain (kg/day); annual average	0.41	0.67	
January	0.9	1.0	
February	0.8	1.0	
March	0.7	1.0	
April	0.6	1.0	
May	0.6	0.8	
June	0.3	0.5	
July	0.2	0.5	
August	0	0.5	
September	0	0.35	
October	0	0.4	
November	0.4	0.3	
December	0.5	0.7	
Carrying capacity (ha/AE)[A]	3.4	1.3	

DM, dry matter; DMD, dry matter digestibility; LWG, liveweight gain.

[A] AE defined in terms of the forage intake of a 2.25 year old, 450 kg *Bos taurus* steer at maintenance, consuming a diet of the specified DMD and walking 7 km/day (McLean and Blakeley 2014).

At these yields and utilisation levels, the resultant average proportion of leucaena forage in the diet of grazing steers would be about 0.56, which was is similar to the measured proportion for cattle on commercial properties in central Queensland (0.50; Bowen *et al.* 2018). Once the leucaena was fully established the growth rates of steers were assumed to be 62% greater per annum than for steers consuming buffel grass-only pastures on the same frontage country: 244 cf. 151 kg/annum, respectively. This is greater than the response to leucaena estimated under central Queensland conditions (42%; Bowen and Chudleigh 2018*b*) but is based on data for leucaena grown at a PDS site on the Red basalt land type in the Northern Gulf (Kernot 1998; Buck *et al.* In press).

The carrying capacity of each pasture was calculated by multiplying the median annual pasture biomass production by the specified utilisation level and then dividing by the annual pasture consumption of a standard animal unit or AE. An AE, in this exercise, was defined in terms of the forage dry matter intake at the specified diet DMD, of a standard animal which was defined by McLean and Blakeley (2014) as a 2.25 year old, 450 kg *B. taurus* steer at maintenance, walking 7 km/day. The spreadsheet calculator, QuikIntake (McLennan and Poppi 2016), which is based on the Australian Feeding Standards (NRDR 2007) with some modifications for tropical feeding systems (McLennan 2014), was used to calculate daily cattle dry matter intakes for the specified pasture DMDs.

The stocking rate (and hence number of ha required) to run a steer from weaning until reaching sale weight, for either buffel grass pasture or leucaena-grass pasture was determined by calculating available pasture biomass for consumption per hectare (based on the specified forage utilisation rate for that scenario) and then dividing by the calculated steer intake of pasture dry matter over that period (Table 45). For leucaena-grass pastures, the respective annual biomass production and utilisation levels of the buffel grass and edible leucaena components were summed to determine total biomass available. It was assumed that cattle consumed 56% of their diet DM as leucaena biomass on average across the year, similar to data from Bowen *et al.* (2018). The pasture biomass available for consumption during a defined growth path was adjusted proportionally for days greater or less than the full annual period. As described previously for calculation of representative carrying capacity figures (AE/ha), the average DM intake by steers of each forage type within each growth path was estimated using the QuikIntake Excel spreadsheet calculator (McLennan and Poppi 2016) modified from the Australian ruminant feeding standards (NRDR 2007) to better predict intake for *B. indicus* content cattle and tropical diets (McLennan 2014). In the prediction of average DM intake, the average diet DMD of buffel grass or leucaena-grass forage for the relevant period was assigned based on data from Bowen *et al.* (2015*b*). The average liveweight of the cattle (i.e. liveweight at the mid-way point) and the assumed average daily gain over the relevant period were used as key inputs. The steers were assumed to be Brahman (>75% *B. indicus*), to have a standard reference weight (SRW) of 660 kg, to walk 7 km/day (as per McLean and Blakely 2014) and the terrain to be 'level 1'

The 500 ha frontage paddock prior to the sowing of leucaena carried 175 weaner steers for 12 months with steers sold at 345 kg paddock weight. The same paddock developed to leucaena-grass pastures, and after the establishment phase, carried 350 steers from weaning for 12 months with steers sold at 438 kg paddock weight. When the steers were carried for 17 months, the leucaena-grass paddock carried 255 steers which were sold at 492 kg paddock weight at either the same sale price or with a price advantage of +10c/kg liveweight.

The costs of developing the 500 ha frontage paddock to leucaena was $168,000. The leucaena paddock required fencing (3 km) at $4,000/km plus a water tank, poly pipe and trough costing a further $15,000. The total fencing and watering costs were $35,000. Seed and seed application costs at contract rates were rounded up to $170,000 to give a total capital cost of the development of $203,000.

To allow for the seeding and spelling of the area planted all of the steers were sold in June of the first year and not replaced. A total of 25% of the usual number of weaners entered the leucaena paddock in June of the following year and then were sold at the end of December, 6 months early. In Years 3 and 4 the paddock was again stocked for 6 months (July to December inclusive) with 50% of the usual number of weaners to allow establishment of the leucaena pasture. From Year 5 a full complement of weaner steers was placed in the paddock from weaning to sale in June the following year, achieving the target weight gains and stocking rate.

Table 45 – Example of calculation of parameters used in the calculation of the grazing area required for a steer from weaning to sale weight, for frontage buffel grass and leucaena-grass pasture

Figures are the average or total for the entire grazing period

Parameter	Buffel grass pasture	Leucaena-grass pasture	Leucaena-grass pasture (later sale)
Days on forage (post weaning)	365	365	488
Average LWG (kg/d)	0.41	0.67	0.61
Average age (years)	1.0	1.0	1.2
Average liveweight (kg)	269	316	343
Average DMD of diet (%)	53	58	58
DMI (kg/head.day)	8.2	9.4	9.7
Total biomass consumed per head (kg DM)	2,993	3,431	4,734
% of DM consumption as grass	100	44	44
% of DM consumption as leucaena	-	56	56
Total grass consumed per head (kg DM)	2,993	1,495	2,062
Total leucaena consumed per head (kg DM)	0	1,936	2,671
Utilisation of grass biomass growth (% of DM)	30	30	30
Utilisation edible leucaena biomass growth (% of DM)	-	85	85
Annual grass biomass production (kg DM/ha)	3,500	3,500	3,500
Annual edible leucaena biomass production (kg DM/ha)	-	1,600	1,600
Annual paddock biomass production (kg DM/ha)	3,500	5,100	5,100
Total grass yield for grazing days (kg DM/ha)	3,500	3,500	4,679
Total edible leucaena yield for grazing days (kg DM/ha)	-	1,600	2,139
Grass biomass available for consumption (kg DM/ha)	1,050	1,050	1,404
Edible leucaena biomass available for consumption (kg DM/ha)	-	1,360	1,818
Area required to meet steer demand for 1 year (ha)	2.85	1.42	1.47
Total area required for the grazing period (area adjusted for number of days > 365), (ha)	2.85	1.42	1.96

DM, dry matter; DMD, dry matter digestibility; DMI, dry matter intake; LWG, liveweight gain.

5.4.3 Results and discussion

Investing in a strategy of planting leucaena into frontage country that has previously been cleared and planted to improved grass pastures, to improve carrying capacity and the growth rate of steers, resulted in an improvement in profitability of the paddock over the longer term (30 years) with an annualised NPV of $50,000/year generated and a return on the money invested in the leucaena development of ca. 16% (Table 46). However, the investment in a 500 ha paddock of leucaena-grass pastures for steers resulted in a substantial peak deficit of -$460,000 and a substantial payback period of 10 years. Holding the steers for another 4 months to produce heavier cattle for sale in October did not improve profits, even if a 10c/kg liveweight premium was assumed.

The positive effect on profit from investing in perennial legumes for steers has been reported for both leucaena-grass and shrubby legumes sown in central Queensland (Bowen and Chudleigh 2017, 2018*b*,*c*) but with much greater IRR's, e.g. 34% and 26% for leucaena and desmanthus, respectively (Bowen and Chudleigh 2018*b*). The higher return to legumes sown in central Queensland (cf. the Northern Gulf) was linked to the greater expected productivity in terms of total forage biomass yield, individual animal performance and stocking rates. Additionally the establishment and maintenance costs for leucaena-grass pastures sown in Northern Gulf frontage country were higher than expected for central Queensland.

It should be noted that the returns predicted here, for investment in leucaena-grass pastures on Northern Gulf frontage country, are dependent on largely untested assumptions concerning the relative forage yields and utilisation rates, diet quality and animal performance over 30 years. Further, although leucaena shows some promise in the Northern Gulf region on suitable land types it is unlikely to be widely applicable as the available area of suitability is relatively small.

Table 46 - Returns at the paddock level for investing in leucaena-grass pastures on frontage country for steers from weaning to sale compared with steers grazed on the same frontage country but growing buffel grass pastures

The comparison was the 500 ha paddock with and without leucaena development. All terms defined in the Glossary of terms and abbreviations

Factor	Leucaena-grass pastures (June sale)	Leucaena-grass pastures (October sale same price)	Leucaena-grass pastures (October, +10 c/kg sale price)
Period of analysis (years)	30	30	30
Discount rate for NPV	5.00%	5.00%	5.00%
NPV	$839,400	$711,800	$817,900
Annualised NPV	$54,600	$46,300	$53,200
Peak deficit (with interest)	-$464,200	-$454,300	-$454,300
Year of peak deficit	5	5	5
Payback period (years)	10	10	10
IRR	16%	15%	17%

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

5.5.1 Introduction

Steer growth rates in the Northern Gulf are well below genetic potential, averaging 100 kg/head.annum for 18 extensive beef businesses in a recent survey (Rolfe *et al.* 2016*b*). Nutritional supplements to increase growth rates, when used, 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 hence 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 unsupplemented 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 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 turn-off 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.

5.5.2 Methods

In this scenario a molasses production mix was fed to a cohort of yearling steers each year to increase their sale weight. The comparison was with the base herd after 10 years of improved land condition and adequate wet season P supplementation.

The assumptions relating to the molasses mix, steer supplement intake and growth responses were informed with reference to published data (Lindsay 1996, 1998; Fordyce 2009; Hunter 2012; McLennan 2014; Hunter and Kennedy 2016) and the local experience of J. Rolfe and B. English. The composition and cost of the molasses mix is given in Table 47. The feed mix was expected to be about $363/t on property.

Table 47 – Composition and cost of the molasses production mix fed to a cohort of yearling steers annually

Ingredient	Quantity (kg)	Cost ($/t)
Molasses	1000	$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 the 17% of steers previously not sold as yearlings (i.e. the tail of the mob) will be fed the molasses production mix in the paddock for 90 days from mid-June. These steers were previously sold in January of the following year as they were too light for the live export market when the first line of steers were sold as yearlings ca. 12 months earlier. The average number of steers fed annually was 37. They commenced feeding at an average weight of 306 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 weigh 369 kg liveweight in the paddock at the end of the feeding period. The expected live export 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. 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 48 indicates the calculation of depreciation, maintenance and labour costs for the fed steers.

Table 48 - 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 & troughs	0.20	$5,000	15	$67	-
Mixer	0.20	$5,000	15	$67	-
Total		$10,000		$133	-
Depreciation costs per head fed	-	-	-	$3.60	-
Opportunity cost of capital	-	-	-	5.00%	$2.70
Depreciation and capital opportunity costs per head fed	-	-	-	-	$6.31
Repairs and maintenance	-	-	-	$500	$13.51
Cost of labour (includes unpaid labour)	-	-	-	$500	$13.51

5.5.3 Results and discussion

Table 49 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-June at 306 kg starting liveweight. As evident from the negative gross margin of -$87/head, the extra costs of feeding were greater than the extra benefits.

Note that cattle were valued going into the feeding operation at their 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 50. 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.

Table 49 – Calculation of gross margin for feeding the tail of the steer cohort a molasses production mix to achieve live export target weights earlier

Parameter	**Value**
Feeding and stock costs	
Current weight in the paddock (kg)	306
Weight loss to saleyards (%)	8.0
Steer weight at saleyards (kg)	281.52
Sale price at yards ($/kg live)	$2.40
Gross sale price ($/head)	$676
Commission and insurance on sales (%)	4.0
Transaction levy, yard dues etc. ($/head)	$15.00
Transport cost ($/head)	$29.41
Steer value on property net of selling expenses	$604.00
Selling cost ($/kg)	$0.25
Average value of fed animals (c/kg on to feed)	$1.97
Average value into feed yard ($/head)	$604.21
Total number of livestock to be fed	37
Total opening value of livestock to be fed	$22,356
Expected daily gain (kg/d)	0.70
Number of days fed	90
Expected exit liveweight (kg)	369
Weight loss to saleyards	8.0%
Steer sale weight at saleyards	339
Feed consumption (% of liveweight consumed as dry matter)	1.2
% dry matter in feed	76
Supplement intake (kg/head.day, 'as-fed')	5.33
Total feed consumption (kg/head, 'as-fed')	480
Total feed required (t)	17.75
Total cost of feed 'as fed' ($/t including mixing costs and transport to property)	$363.01
Cost of feed per head 'as fed' ($/head)	$174.10
Other costs ($/head)	
Freight out	$33.00
Labour	$13.51
Interest on livestock capital (at 5%)	$7.45
Interest on feed (at 5%)	$2.15
Commission	$32.59
Transaction levy and yard fees	$15.00
Depreciation and opportunity cost of capital	$6.31
Repairs and maintenance	$13.51
Mortality	0%
Total feed and other costs ($/head)	*$297.62*
Income from sales	
Sale price at yards ($/kg live)	$2.40
Gross sale price ($/head)	$815
Gross margin per animal fed	*-$87*
Surplus or deficit per annum	-$3,222
Breakeven sale price ($/kg liveweight)	$2.66
Breakeven purchase price ($/kg liveweight)	$1.92

Table 50 – Sensitivity analysis of the margin per animal fed ($) a molasses mix to price change

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	$1.37	-$97	-$32	$34	$99	$164	$229	$294
$2.00	$1.57	-$159	-$94	-$28	$37	$102	$167	$232
$2.20	$1.77	-$221	-$155	-$90	-$25	$40	$105	$170
$2.40	$1.97	-$283	-$217	-$152	-$87	-$22	$43	$108
$2.60	$2.17	-$345	-$279	-$214	-$149	-$84	-$19	$47
$2.80	$2.37	-$407	-$341	-$276	-$211	-$146	-$81	-$15
$3.00	$2.57	-$468	-$403	-$338	-$273	-$208	-$143	-$77

Such a feeding exercise may be useful after a below average wet season where a large proportion of steers are too light to be sold as export steers and could suffer significant price penalties if sold at the usual time at lighter weights. The spreadsheet compiled for this exercise can be used in such circumstances to judge the profitability of a short term feeding exercise. This may be a feasible scenario where the mixing and feeding out equipment has other uses but purchasing $10,000 worth of equipment and then just letting it sit idle to wait for the occasional opportunity does not seem sound. The use of production rations as a drought management strategy may also lead to unwanted pressure being placed on pasture resources and land condition.

If the feeding exercise were undertaken on a regular basis an allowance for the reduced time (6 months) the steers are retained on the property would need to be made by slightly increasing the overall size of the herd (ca. 17 extra breeders would be mated) to maintain the same grazing pressure. The funds lost in the feeding exercise will not be recouped by this minor adjustment to the herd size as indicated in Table 51 which presents the extra returns generated by feeding a molasses production mix to the steer tail cohort when the herd size is adjusted to accommodate the shorter period of time the steers are on the property. The comparison was with the new base herd (1,500 AE) which has benefited from 10 years of land condition improvement and is receiving adequate P supplementation.

Table 51 - Returns for feeding a molasses production mix to the tail of the steers compared to the base herd which is receiving adequate P supplementation and has benefited from 10 years of land condition improvement

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5.00%
NPV	-$90,500
Annualised NPV	-$5,900
Peak deficit (with interest)	-$252,500
Year of peak deficit	never
Payback period (years)	never
IRR	n/a

5.6 Silage for home bred steers

5.6.1 Introduction

Silage is fermented, high-moisture, stored fodder which can be fed to cattle. It is usually made from grass crops, including maize, sorghum or other cereals, using the entire green plant (not just the grain). Forage sorghum can be grown on higher fertility soils in the Northern Gulf region and ensiled for use as a feedlot ration when mixed with additives to provide adequate protein and P. A silage feeding strategy in the Northern Gulf could increase growth rates of steers as well as freeing up grazing area that would allow expansion of the breeder herd.

5.6.2 Methods

This strategy was considered as an alternative way to increase the sale weight of steers compared to feeding a molasses production mix, sowing stylos or leucaena. The strategy was to grow the forage sorghum crop and convert it to silage using contractors, and then feed it to steers to make them heavier at sale. This scenario was applied to the base herd after 10 years of improved land condition and adequate wet season P supplementation. All of the steers were fed from June when they are 18 months old and about 308 kg in the paddock. They were sold after 90 days on feed. They were fed in yards, rather than a paddock, and hence breeder numbers were increased as the steers were on grass for 12 months less in this scenario cf. the base scenario. The number of steers fed averaged 257 and all steers were sold with no tail held over.

The total expected consumption of silage was used to estimate the amount of forage required and, at an expected yield, the total hectares of forage that needs to be grown annually. In this scenario ca. 24 ha hectares of forage sorghum with a yield of 25 t/ha was required to produce the silage for 257 steers. Table 52 shows the expected costs calculated at contract rates and Table 53 shows the cost per tonne of harvested forage. Table 54 indicates the cost per tonne forage sorghum silage in the pit.

Table 52 - Forage sorghum planting and growing costs for 24 ha using contract rates

Item or treatment	Rate of application	Cost/unit	$/ha	Total $
Pre planting costs				
Offset discs	2	$43.13	$86.27	$2,070
Planting costs				
No till seeder	2	$14.47	$28.94	$695
Forage sorghum seed	10 kg/ha	$12.00	$120.00	$2,880
Diammonium phosphate (DAP)	200 kg/ha	$0.75	$150.00	$3,600
Urea	180 kg/ha	$0.60	$108.00	$2,592
Linkage spray rig	1	$4.00	$4.00	$96
Atrazine	2.5 L/ha	$7.00	$17.50	$420
Harvest Costs				
Silage harvest	per t/ha harvested	$9.50	$237.50	$5,700
Inoculant for silage	per t/ha harvested	$3.00	$75.00	$1,800
Total annual forage costs			*$827*	*$19,853*

Table 53 - Cost per tonne of harvested forage sorghum

Parameter	Value
Expected wet matter harvested (t/ha)	25
Total wet matter produced (t)	600
Cost of wet matter at paddock ($/t)	$33.09
Dry matter %	35%
Cost of dry matter at paddock ($/t)	*$95.54*

Table 54 - Cost per tonne of forage sorghum silage in the pit

Parameter	Value
Quantity of forage sorghum harvested (t)	500
Losses in storage	5%
Tonnes available to be fed	570
Total growing and harvest costs	$19,853
Cost of forage sorghum net of losses ($/t)	$34.83
Contract cost of transport from the paddock to pit ($/t)	$8.00
Contract cost of rolling and plastic ($/t)	$3.00
Cost of forage in the pit ($/t wet in the pit)	*$45.83*

Table 55 shows the assumed components of a silage ration mix and the cost. The final cost of the silage was $122.33/t, as fed. Table 56 indicates the expected life of the capital equipment require to feed the silage, an allowance for repairs and maintenance and the extra labour required to feed the steers for the 90-day period.

Table 55 - Silage ration cost per tonne

Ration ingredient	Ingredient cost $/tonne	Quantity in ration (kg)	$/ration mix
Silage	$45.83	736	$33.73
Molasses	$200	150	$30.00
Cottonseed	$500	110	$55.00
Urea	$600	1	$0.60
Kynophos	$1,000	1	$1.00
Salt	$400	1	$0.40
Rumensin	$8,000	0.2	$1.60
Total		*999.2*	*$122.33*

Table 56 - Capital, depreciation, maintenance and labour cost

Item	Allocation to enterprise (%)	Current value ($)	Life in years	Annual depreciation in value
Depreciation and capital expense				
Feed yards and water equipment	50	$5,000	20	$125
Feeders and troughs	50	$10,000	15	$333
Forage handling equipment	100	$20,000	10	$2,000
Sheds and other structures	50	$5,000	20	$125
Ration mixer	100	$35,000	10	$3,500
Total annual depreciation		*$75,000*		*$6,083*
Depreciation costs per head fed				$23.67
Opportunity cost of capital				5.00%
Opportunity cost of capital per head fed				$12.65
Depreciation and capital opportunity costs per head fed				*$36.32*
Estimate of repairs and maintenance for feeding system				$2,570
Repairs and maintenance costs per head fed				*$10.00*
Cost of labour (includes unpaid labour)				$6,000
Labour costs per head fed				*$23.35*

Implementing a silage feeding program for the steers was expected to free up some space for extra breeders as the steers entered the feeding yards about 12 months earlier than their usual sale date. Table 57 shows the herd structure before and after the incorporation of the silage feeding strategy. The silage feeding exercise could allow extra breeders to be run at the same grazing pressure, increasing the number of steers able to be fed silage from 227 to 257. The proportion of total land area required for growing the forage sorghum was so small (ca. 20 ha) that the small increase in area required to meet the needs of the extra 30 steers was not adjusted for in this analysis in terms of reducing breeder carrying capacity on the property.

Table 57 - Breeder herd components without the silage feeding and with the silage feeding

Breeder herd components	Without silage	With silage
Total cows and heifers mated	805	912
Calves weaned	465	527
Weaner steers	233	263
Steers 12-23 months	227	257

5.6.3 Results and discussion

The strategy of growing forage sorghum to produce sufficient silage to feed all steers for 90 days from 18 months of age, resulted in a gross margin -$102/head fed. Note that cattle were valued going into the feeding operation at their market value less selling costs. This accurately reflects the opportunity cost of the steers to the silage 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 59. About 40 c/kg liveweight more than the expected sale price would be required for the feeding exercise to be profitable.

Table 58 – Calculation of gross margin for feeding steers a home-grown forage silage ration to achieve live export target weights earlier

Parameter	**Value**
Current weight in the paddock (kg)	308
Weight loss to saleyards (%)	8.0
Steer weight at saleyards (kg)	283.36
Sale price at yards ($/kg live)	$2.40
Gross sale price ($/head)	$680
Commission and insurance % on sales	4.0
Commission and insurance ($/head)	$27.20
Transaction levy, yard dues etc. ($/head)	$15.00
Transport cost ($/head)	$29.41
Steer value on property net of selling expenses	$608
Selling cost ($/kg)	$0.25
Average value of fed animals (c/kg on to feed)	$1.98
Total value of livestock into feed yard ($)	$156,372
Expected daily gain (kg/d)	1.20
Number of days fed	90
Feed consumption (% of liveweight consumed per day as DM))	2.6
% dry matter in feed	44
Total cost of feed ‘as fed’ ($/t including mixing costs)	$122.43
Cost of feed per head ‘as fed’ ($/head)	$235.70
Average sale price of fed animals ($/kg liveweight at point of sale	$2.40
Expected exit weight (kg liveweight)	416
Weight loss to saleyards (%)	8.0
Expected sale weight at saleyards (kg)	383
Expected gross sale value ($/head)	$919
Stock losses during the feeding period (%)	0
Annual interest rate (opportunity cost of capital tied up; %)	5.00
Commission (% of sale price)	4.00
Transaction levy ($/head)	$15.00
Freight out	$37.04
Growth promotant	$1.78
Vet costs	$0
Labour	$23.35
Interest on livestock capital (at 5%)	$7.50
Interest on feed (at 5%)	$2.91
Commission	$36.74
Transaction levy and yard fees	$15.00
Depreciation and opportunity cost of capital	$36.74
Repairs and maintenance	$10.00
Cost of stock losses	$0
Total feed and other costs ($/head)	*$406.33*
Gross margin per animal fed	*-$96*
Surplus or deficit per annum	-$24,737
Breakeven sale price ($/kg liveweight)	$2.65
Breakeven purchase price ($/kg liveweight)	$1.92

Table 59 – Sensitivity analysis of the margin per animal fed a home-grown silage ration to price change

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	$1.38	-$130	-$56	$17	$91	$164	$238	$311
$2.00	$1.58	-$192	-$118	-$45	$28	$102	$175	$249
$2.20	$1.78	-$254	-$181	-$107	-$34	$40	$113	$187
$2.40	$1.98	-$317	-$243	-$170	-$96	-$23	$51	$124
$2.60	$2.18	-$379	-$306	-$232	-$159	-$85	-$12	$62
$2.80	$2.38	-$441	-$368	-$294	-$221	-$147	-$74	-$1
$3.00	$2.58	-$504	-$430	-$357	-$283	-$210	-$136	-$63

Adding silage to the equation on this property appears unlikely improve profit and could expose the system to considerable production risk. Although the additional labour required is fully costed in the budget, it must be recognised that a considerable amount of extra is time required to grow, harvest and feed the silage. This is an activity that may be better utilised on a much larger scale where the fixed costs are spread over a much larger number of steers. Table 60 indicates the extra returns generated by feeding silage to the steers. The comparison was with the herd (1,500 AE) that had benefited from 10 years of improved land condition and adequate wet season P supplements. The silage feeding investment did not improve the profit generated and appears likely to increase production risk.

Table 60 - Returns for feeding a home-grown forage sorghum silage ration to steers compared to the base herd which is receiving adequate P supplementation and has benefited from 10 years of land condition improvement

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5.00%
NPV	-$282,300
Annualised NPV	-$18,400
Peak deficit (with interest)	-$784,100
Year of peak deficit	never
Payback period (years)	never
IRR	n/a

5.7 Silage for trading cull cows

5.7.1 Introduction

Growing silage to feed to home bred steers instead of allowing them to grow on native pasture appeared unlikely to be economic (5.6.3). Feeding other classes of purchased stock that could achieve a marked increase in price due to the silage feeding may provide a better outcome.

5.7.2 Methods

This strategy was considered as an alternative way to trade purchased cull cows. It cannot be applied to the cull females produced by the base herd with improved land condition and adequate wet season P supplementation as they will reach suitable slaughter weights in the majority of years without silage feeding. In such circumstances it would be equally as uneconomic to feed silage to the usual run of cull cows produced by the property as to feed it to the growing steers.

The strategy was to grow the forage sorghum crop and convert it to silage using contractors, and then feed it to purchased cull cows to make them heavier at sale. All of the mature cull cows were fed from June when they were purchased at less than 360 kg liveweight in the paddock. They were expected to be sold after about 60 days on feed. This was a separate trading/feeding activity and no impact on the overall carrying capacity of the property was expected.

Table 61 shows the price grid steps for full mouth cows provided by JBS for Dinmore abattoir. Cull cows that shift from the 160-180 kg carcass weight range to the 180-200 kg carcass weight range increased in value, on average, by 95 c/kg carcass weight over the last 2.5 years. At a 50% dressing percentage, cull cows falling into 160+ kg price category would likely have a paddock weight of 360 kg or less (allowing for an 8% weight loss during transport to the abattoirs). For cull cows to fall into the 180+ kg carcass weight price range, they would need to be about 420-440 kg live weight in the paddock.

Table 61 - Average price steps in the grid for full mouth cows Oct 2016 to November 2018 (Source: JBS price quotes)

Parameter	**Carcass weight (kg)**						
	220+	**200+**	**180+**	**160+**	**140+**	**120+**	**<120**
Average cents per kg dressed weight*	4.71	4.66	4.61	3.66	0.30	0.20	0.10
Price step	0.05	0.05	0.05	0.95	3.36	0.10	0.10

*L/M/M9 grade, 3-12 mm fat, 8 teeth, A-D shape

The total expected consumption of silage was used to estimate the amount of forage required and, at an expected yield, the total hectares of forage that needed to be grown annually. In this scenario ca. 12 ha hectares of forage sorghum with a yield of 25 t/ha was required to produce the silage for 200 light cows. Table 62 shows the expected costs calculated at contract rates and Table 63 shows the cost per tonne of harvested forage. Table 64 indicates the cost per tonne forage sorghum silage in the pit.

Table 62 - Forage sorghum planting and growing costs for 12 ha using contract rates

Item or treatment	Rate of application	Cost/unit	$/ha	Total $
Pre planting costs				
Offset discs	2	$43.13	$86.27	$1,035
Planting costs				
No till seeder	2	$14.47	$28.94	$347
Forage sorghum seed	10 kg/ha	$12.00	$120.00	$1,440
Diammonium phosphate (DAP)	200 kg/ha	$0.75	$150.00	$1,800
Urea	180 kg/ha	$0.60	$108.00	$1,295
Linkage spray rig	1	$4.00	$4.00	$48
Atrazine	2.5 L/ha	$7.00	$17.50	$210
Harvest Costs				
Silage harvest	per t/ha harvested	$9.50	$237.50	$2,850
Inoculant for silage	per t/ha harvested	$3.00	$75.00	$900
Total annual forage costs			*$827*	*$9,926*

Table 63 - Cost per tonne of harvested forage sorghum

Parameter	Value
Expected wet matter harvested (t/ha)	25
Total wet matter produced (t)	300
Cost of wet matter at paddock ($/t)	$33.09
Dry matter %	35%
Cost of dry matter at paddock ($/t)	*$95.54*

Table 64 - Cost per tonne of forage sorghum silage in the pit

Parameter	Value
Quantity of forage sorghum harvested (t)	300
Losses in storage	5%
Tonnes available to be fed	285
Total growing and harvest costs	$9,926
Cost of forage sorghum net of losses ($/t)	$34.83
Contract cost of transport from the paddock to pit ($/t)	$8.00
Contract cost of rolling and plastic ($/t)	$3.00
Cost of forage in the pit ($/t wet in the pit)	*$45.83*

Table 65 shows the assumed components of a silage ration mix and the cost. The final cost of the silage was $122.33/t, as fed. Table 65 indicates the expected life of the capital equipment require to feed the silage, an allowance for repairs and maintenance and the extra labour required to feed the steers for the 90-day period.

Table 65 - Silage ration cost per tonne

Ration ingredient	Ingredient cost $/tonne	Quantity in ration (kg)	$/ration mix
Silage	$45.83	736	$33.73
Molasses	$200	150	$30.00
Cottonseed	$500	110	$55.00
Urea	$600	1	$0.60
Kynophos	$1,000	1	$1.00
Salt	$400	1	$0.40
Rumensin	$8,000	0.2	$1.60
Total		*999.2*	*$122.33*

The capital costs shown in Table 66 represent a property that already has the silage equipment and feeding pens largely in place. Properties considering setting up a new silage feeding system would face significantly greater capital costs whether the equipment is purchased new or second hand. Considerable costs would also be incurred meeting the requirements of regulations associated with building and registering a pen based intensive feeding system for beef cattle where more than 150 head of cattle are being fed. Intensively feeding small numbers of cattle is unlikely to be economic as a standalone activity.

Table 66 - Capital, depreciation, maintenance and labour cost

Item	Allocation to enterprise (%)	Current value ($)	Life in years	Annual depreciation in value
Depreciation and capital expense				
Feed yards and water equipment	50	$5,000	20	$125
Feeders and troughs	50	$10,000	15	$333
Forage handling equipment	100	$20,000	10	$2,000
Sheds and other structures	50	$5,000	20	$125
Ration mixer	100	$35,000	10	$3,500
Total annual depreciation		*$75,000*		*$6,083*
Depreciation costs per head fed				$30.42
Opportunity cost of capital				5.00%
Opportunity cost of capital per head fed				$16.25
Depreciation and capital opportunity costs per head fed				*$46.67*
Estimate of repairs and maintenance for feeding system				$2,500
Repairs and maintenance costs per head fed				*$12.50*
Cost of labour (includes unpaid labour)				$2,500
Labour costs per head fed				*$12.50*

5.7.3 Results and discussion

The strategy of growing forage sorghum to produce sufficient silage to feed 360 kg liveweight cull cows for 60 days, resulted in a gross margin $78/head fed (Table 67). Note that cattle were valued going into the feeding operation at their value at the abattoirs.

Table 67 – Calculation of gross margin for feeding cull cows a home-grown forage silage ration to achieve slaughter weights

Parameter	**Value**
Current weight in the paddock (kg)	360
Weight loss to saleyards (%)	0
Cow weight at saleyards (kg)	360
Sale price at yards ($/kg live)	$1.83
Gross sale price ($/head)	$659
Commission and insurance % on sales	0
Commission and insurance ($/head)	$0
Transaction levy, yard dues etc. ($/head)	$0
Transport cost ($/head)	$0
Cow value on property net of selling expenses	$659
Selling cost ($/kg)	$0
Average value of fed animals (c/kg on to feed)	$1.83
Total value of livestock into feed yard ($)	$131,760
Expected daily gain (kg/d)	1.50
Number of days fed	60
Feed consumption (% of liveweight consumed per day as DM))	2.25
% dry matter in feed	44
Total cost of feed ‘as fed’ ($/t including mixing costs)	$122.43
Cost of feed per head ‘as fed’ ($/head)	$152.13
Average sale price of fed animals ($/kg liveweight at point of sale	$2.31
Expected exit weight (kg liveweight)	450
Weight loss to saleyards (%)	0
Expected sale weight at saleyards (kg)	450
Expected gross sale value ($/head)	$1,037
Stock losses during the feeding period (%)	1
Annual interest rate (opportunity cost of capital tied up; %)	5.00
Commission (% of sale price)	0
Transaction levy ($/head)	$5.00
Freight out	$55.00
Growth promotant	$0
Vet costs	$3
Labour	$12.50
Interest on livestock capital (at 5%)	$5.41
Interest on feed (at 5%)	$1.25
Commission	$0
Transaction levy and yard fees	$5.00
Depreciation and opportunity cost of capital	$46.67
Repairs and maintenance	$12.50
Cost of stock losses	$6.59
Total feed and other costs ($/head)	*$300.05*
Gross margin per animal fed	***$78***
Surplus or deficit per annum	$15,680
Breakeven sale price ($/kg liveweight)	$2.13
Breakeven purchase price ($/kg liveweight)	$2.05

The results are sensitive to the difference between the value ($/kg) of the cow at the commencement of the feeding exercise and the sale price of the cows at the conclusion of feeding as indicated in Table 68. A positive gross margin would be available from feeding silage to lightweight cull cows if the price difference between the animal going into the feeding yards and the animal coming out of the feeding yards was at least 60 c/kg on a liveweight basis. However, a positive gross margin does not necessarily mean that the strategy will add to the profitability of the property. It is necessary to conduct a property-level economic analysis to consider the change in profit and risk generated by the alternative operating system. Such an analysis accounts for changes in unpaid labour, herd structure and capital and includes the implementation phase. Although a property-level analysis has not been presented for this cull cow trading example, it is evident that adding the costs associated with constructing a new silage feeding system on the vast majority of properties in the region would make the feeding of silage uneconomic for any purpose, including the storage of silage as a drought feeding reserve.

Table 68 – Sensitivity analysis of the margin per animal fed a home-grown silage ration to price change

Expected value of cows at saleyards prior to feeding ($/kg liveweight)	**Expected value on to feed ($/kg liveweight)**	**Expected sale price of fed cows at the saleyards ($/kg liveweight)**						
		$1.80	**$2.00**	**$2.20**	**$2.40**	**$2.60**	**$2.80**	**$3.00**
$1.23	$1.23	$26	$116	$206	$296	$386	$476	$566
$1.43	$1.43	-$46	$44	$134	$224	$314	$404	$494
$1.63	$1.63	-$119	-$29	$61	$151	$241	$331	$421
$1.83	$1.83	-$192	-$102	-$12	$78	$168	$258	$348
$2.03	$2.03	-$264	-$174	-$84	$6	$96	$186	$276
$2.23	$2.23	-$337	-$247	-$157	-$67	$23	$113	$203
$2.43	$2.43	-$409	-$319	-$229	-$139	-$49	$41	$131

5.8 Annual strategy of sending steers on agistment

5.8.1 Introduction

Agisting steers on a property with better quality land types than the representative property enables faster steer growth rates and also frees up space on the home property for expansion of the breeder herd. As for all other alternative management strategies, agistment strategies can be assessed using the appropriate framework (e.g. Breedcow and Dynama suite of programs; Holmes *et al.* 2017) to determine if the extra benefits are expected to be greater than extra costs at both the gross margin and whole herd level.

5.8.2 Methods

This scenario considered the effect of sending steers annually to agistment on Northern Downs country located to the south of the Northern Gulf region. The comparison was with the base herd after 10 years of improved land condition and adequate wet season P supplementation.

The expected growth rate of steers on this relatively higher quality land type (cf. majority of Northern Gulf land types) was ca. 150 kg/head.annum annum and the expected agistment cost was $3/head.week. Additional transport costs of 300 km one way at $2/deck were incurred in sending the yearling steers to the agistment with the final transport costs to the point of sale expected to be equivalent to the transport costs assumed for the base property in the Northern Gulf to point of sale. Additionally, costs were incurred crossing the tick line. The steers were mustered twice while on agistment at a cost of $10/head.muster. The mustering cost included an allowance for travel time, fuel and labour. The final average sale weight of the steers after twelve months on agistment was assumed to be 480 kg in the agistment paddock. The breeder herd on the home property retained extra heifers until sufficiently increased in size to fully graze the area freed up by removal of the steers as yearlings. Table 69 indicates the additional direct costs of sending the initial group of 227 yearling steers on agistment to the Northern Downs country for twelve months. It cost almost $200/head.annum in additional expenses to send the steers on agistment.

Table 69 - Extra costs incurred to implement an agistment strategy for weaner steers

Item	$/head	Total $
Trucking to agistment (34 head/deck, 300 km, $2.00/km)	$15.00	$4,006
Yard fees	$2.25	$511
Dipping at tick line	$2.00	$454
Agistment (52 weeks, $3/week)	$156.00	$35,509
Mustering and travelling	$20.00	$4,540
Total costs	*$198.33*	*$45,020*

Sending the yearling steers on agistment freed up space on the home property for the breeding herd. Table 70 shows the expansion of the breeder herd if the agistment exercise were to be continued for a number of years.

Table 70 - Breeder herd components without agistment for steers and with agistment for steers

Breeder herd components	Without agistment	With agistment
Total cows and heifers mated	805	920
Calves weaned	455	531
Weaner steers	233	266
Steers 12 to 23 months	227	259

5.8.3 Results and discussion

Table 71 indicates the extra returns generated by placing the yearling steers on agistment on Northern Downs country for 12 months post weaning at $3/head.week on an annual basis. The comparison was with the herd running steers in the Northern Gulf, with improved land condition and an adequate wet season P supplement, and sale of steers in two cohorts at 26 and 37 months of age. The breakeven price for sending the yearling steers on agistment on a long term basis was less than

$2/head.week. Most of the deficit incurred on an ongoing basis is due to the retention of females to build up the herd at home, the opportunity cost associated with moving to a yearling production system on the home property, and the relatively small change in the expected weight gain of the steers on agistment compared to their potential weight gain on the home property. This agistment scenario was a permanent strategy resulting in the build-up of the breeder herd on the Northern Gulf property as the property moved to a yearling production system. In contrast, it is recognised that short term, opportunistic agistment scenarios can be profitable but must be assessed using the costs and prices at the time of the decision.

Table 71 - Returns for sending yearling steers on agistment to Northern Downs country for 12 months compared to the base herd where steers are sold in two cohorts at 26 and 37 months of age and which is receiving adequate P supplementation and has benefited from 10 years of land condition improvement

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5.00%
NPV	-$116,500
Annualised NPV	-$7,600
Peak deficit (with interest)	-$315,300
Year of peak deficit	never
Payback period (years)	never
IRR	n/a

5.9 Better genetics for breeder fertility

5.9.1 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.

5.9.2 Methods

The benefits expected to arise from converting the base female herd, running on country benefiting from 10 years of improved land condition and receiving an adequate wet season P supplement, 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 using two methods of implementation. One approach changed over the breeding bull herd in the first year and incurred a capital cost and the second approach 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 in 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 heifers with genes resulting in 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 ca. 40% of replacement heifers were culled before mating and empty replacement heifers were all culled after their first mating. Mature cows were culled on the basis of faults (about 10% of each age cohort) and their age.

The cost of replacement herd bulls was set at the same price used in the base herd, i.e. $5,000. The net cost of the changeover of all of the herd bulls at the beginning of the investment period was $80,000 (32 x $5,000 for the new bulls less 32 x $2,500 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 parameters of herd performance 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. Table 72 shows the change in weaning rate and other factors as the genes flowed through the breeding herd. The herd modelling indicates that it is likely to take at least 12 years for the overall herd weaning rate to improve by 5.51% points if all of the bull herd is replaced in the first year. The increase in weaning rate stabilised at 5.51% points rather than 6% points due to the following factors:

- As a result of the higher conception rate, the numbers in the first calf heifer class increased as a proportion of the herd. This reduced overall herd efficiency as the improved conception rate of first calf heifers (i.e. from their second mating) at 51% is still well below that of the mature breeders not yet benefiting from any genetic improvement (e.g. 68% for 4-8 year age class).
- Due to the relatively low reproductive parameters in the Northern Gulf herd only 10% of breeders pregnancy tested ‘empty’ (PTE) at > 3 years of age were culled in any year.

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

Table 72 - Modelled steps in genetic change of weaning rate with first year bull replacement at same cost

The herd weaning rate is shaded grey

Herd Component	Base herd (Year 1)	Year 4	Year 6	Year 8	Year 10	Year 12
Total AE	1,500	1,500	1,500	1,500	1,500	1,500
Total cattle carried	1,739	1,740	1,742	1,745	1,747	1,749
Weaner heifers retained	233	233	235	237	239	242
Total breeders mated	805	796	787	779	772	763
Total breeders mated and kept	751	751	744	738	732	725
Total calves weaned	465	465	470	475	478	483
Weaners/total cows mated	57.76%	58.46%	59.80%	60.95%	61.98%	63.27%
Overall breeder deaths	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%
Female sales/total sales %	47.89%	47.89%	47.94%	47.98%	48.01%	48.05%
Total cows and heifers sold	202	202	205	207	209	211
Maximum cow culling age	11	11	11	11	11	11
Heifer joining age	2	2	2	2	2	2
Two year old heifer sales %	60.55%	58.94%	60.67%	62.00%	63.04%	64.16%
Total steers & bullocks sold	220	220	223	225	226	229
Maximum bullock turnoff age	3	3	3	3	3	3

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 replacement herd bulls as herd bulls became due for replacement. Another assumption applied in this scenario was that no additional costs would be incurred in herd management. The heifers produced by the bulls with different genes for fertility were grouped with the heifers without the genes for fertility 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. The result was that females with and without the different genes had the same chance of being culled. The bulls with the different genes 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. Whether this would be possible in an actual herd is difficult to determine but appears unlikely.

Table 73 shows the incremental change in conception rates over the first 5 mating's as the genetically different bulls replace the current bull herd. All heifers had the different genes from the sixth mating and it was year 16 before the breeder herd is converted.

Table 73 - Incremental steps in genetic change of conception rate with bulls replaced over time

Herd parameter	**First mating**	**Second mating**	**Third mating**	**Fourth mating**	**Fifth mating**
Total herd bulls	32	32	32	32	32
Bulls with different genes	6	9	19	26	32
Mature cows mated to different bulls	160	220	480	640	
Number that conceive	112	154	330	415	
Number that wean a calf	99	136	291	366	
Heifer weaners produced	49	68	145	183	
Yearling heifers	48	66	142	179	
Two year heifers pre culling	47	65	138	174	
Heifers with different genes mated	29	40	85	107	
total heifers mated	136	136	136	144	
Percentage of heifers with different genes	21.2%	29.2%	62.5%	74.3%	100%
Improvement in conception rate of mated heifers	1.3%	1.8%	3.8%	4.5%	6.0%
Improvement in conception rate of 3-4 year heifers		1.3%	1.8%	3.8%	4.5%
Improvement in conception rate of 4-5 year cows			1.3%	1.8%	3.8%
Improvement in conception rate of 5-6 year cows				1.3%	1.8%
Improvement in conception rate of 6-7 year cows					1.3%
Year of impact	Year 4	Year 5	Year 6	Year 7	Year 8

Table 74 shows the change in herd structure over the 16 years taken to fully implement the strategy.

Table 74 - Modelled steps in genetic change of weaning rate and herd structure with bulls replaced over time (Gradual bull replacement, same cost)

The herd weaning rate is shaded grey

Herd component	**Base**	**Year 4**	**Year 6**	**Year 8**	**Year 10**	**Year 14**	**Year 16**
Total AE	1500	1500	1500	1500	1500	1500	1500
Total cattle carried	1739	1739	1740	1742	1744	1748	1748
Weaner heifers retained	233	233	233	235	237	240	241
Total breeders mated	805	803	797	787	779	768	766
Total breeders mated and kept	751	751	749	745	738	729	727
Total calves weaned	465	465	466	470	474	481	482
Weaners/total cows mated	57.76%	57.92%	58.56%	59.69%	60.86%	62.64%	62.90%
Overall breeder deaths	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%	2.50%
Female sales/total sales %	47.89%	47.89%	47.90%	47.93%	47.97%	48.03%	48.04%
Total cows and heifers sold	202	202	203	205	207	210	211
Maximum cow culling age	11	11	11	11	11	11	11
Heifer joining age	2	2	2	2	2	2	2
Two year old heifer sales %	60.55%	60.26%	60.08%	60.51%	61.88%	63.63%	63.85%
Total steers & bullocks sold	220	220	221	222	224	228	228
Maximum bullock turnoff age	3	3	3	3	3	3	3

5.9.3 Results and discussion

The beef property was slightly 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 5.51%. The annualised NPV was a positive $4,100/year (Table 75). The extended period of time to the peak deficit (5 years) and payback year (Year 18) suggests that the full benefits would need to be received as described and no premium paid for genetically different bulls for the investment to remain positive. The return on extra capital is 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 in similar annualised NPV to replacement of the entire bull herd in Year 1: $6,800 (Table 75).

Table 75 - Returns for investing in genetically superior bulls to improve breeder fertility compared to the base herd which is receiving adequate P supplementation and which has benefited from 10 years of land condition improvement

All terms defined in the Glossary of terms and abbreviations

Factor	Year 1 bull change-over, same cost	Gradual bull change-over, same cost
Period of analysis (years)	30	30
Discount rate for NPV	5.00%	5.00%
NPV	$63,200	$103,900
Annualised NPV	$4,100	$6,800
Peak deficit (with interest)	-$94,400	n/a
Year of peak deficit	5	n/a
Payback period (years)	17	n/a
IRR	9%	n/a

The results for investment in genetic improvement in weaning rate in the Northern Gulf are better than results for the same genetic improvement applied in a representative beef herd in the Fitzroy NRM region (Bowen and Chudleigh 2018*b*; Chudleigh *et al.* 2019) where returns were slightly reduced or unchanged as a result of implementing these alternative strategies. The difference in results between the two regions is largely due to the effect of diminishing returns for change in weaning rate for the Fitzroy NRM region herd which had an average base weaning rate of 77% from cows mated (as per CashCow data of McGowan *et al.* (2014) for the Central Forest region) cf. 59% in the Northern Gulf. This effect of diminishing returns is illustrated by comparing the percentage change in herd gross margins resulting from implementing the genetic improvement strategy. The increase in herd gross margin for the Northern Gulf property was ca. $15,000/annum (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 Fitzroy NRM region property was ca. $3,000/annum (1.2% improvement) resulting from a 5.9% point improvement in weaning rates. This eventual additional benefit was insufficient to ever offset the changeover costs incurred at the beginning of the period and led to a negative return.

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.

5.10 Objectively selected home-bred bulls

5.10.1 Introduction

Replacement bulls are a significant 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.

5.10.2 Methods

In this strategy, the potential economic impact of selecting breeding bulls from the male weaners was tested. It was assumed that the strategy would not lead to any change in the average performance of the total herd. The comparison was with the base herd after 10 years of improved land condition and adequate wet season P supplementation.

The opening complement of herd bulls required for the breeding herd, when stabilised at 1,500 AE, was about 32 bulls (bull to cow ratio of 4%). 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 $5,000. 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 4% when the change to home-bred bulls was made. Table 76 shows the structure and replacement strategy for the breeding bull herd for the base property.

Table 76 – Bull replacement strategy and cost for the base herd using purchased bulls

Parameter	Value
Number of bulls required	32
Cost of bulls purchased annually (6 bulls costing $5,000 each)	$30,000
Value of bulls sold annually (5 bulls at $1,221 each)	$6,105
Average value per head of bulls on hand	$3,380
Net bull replacement cost (total)	$26,309
Net bull replacement cost per calf weaned	$56.57

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 live export 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 first year of the analysis and entered the bull herd in the third year.

This scenario relied upon the maintenance of accurate records for the reproduction performance of heifers over their first two mating's 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

60 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 first mating and were then pregnancy tested as 'in calf' (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 ($1,500/annum). These costs included costs of additional record keeping, bull testing and some additional labour. A total of $15,000 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 ($3,000 per annum).

5.10.3 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 annualised NPV of $16,000/annum added, on average, over the life of the investment (Table 77). The return on the extra funds invested was 58% per annum. 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 relatively large positive returns for this scenario, comparative to others examined for the Northern Gulf property, suggest 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 44% and the annualised NPV from $16,600 to $13,600/annum. Herd recording systems in the region are currently rudimentary at best on many properties. Moving to home-bred bulls would require a significant step-up for most managers in identifying, recording and selecting superior females.

Table 77 - Returns for investing in production of home-bred bulls compared to the base herd using purchased bulls and which is receiving adequate P supplementation and has benefited from 10 years of from land condition improvement

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5.00%
NPV	$255,400
Annualised NPV	$16,600
Peak deficit (with interest)	-$25,000
Year of peak deficit	2
Payback period (years)	3
IRR	59%

5.11 Supplementing first calf heifers to improve re-conception rates

5.11.1 Introduction

Energy and protein supplements for first calf heifers are often recommended as best management practice to increase re-conception rates (Dixon 1998; DAF 2018*b*). 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 Northern Territory, a similar production environment to the Northern Gulf region of Queensland. 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.

5.11.2 Methods

In this strategy, a change in the re-conception rate of first calf, lactating heifers was sought by improving their bodyweight prior to calving with an M8U supplement (molasses with 8% urea by weight). The comparison was with the base herd after 10 years of improved land condition and adequate wet season P supplementation. The base herd grazing pastures which had benefited from 10 years of land condition improvement and receiving an effective wet season P supplement only had 45% of first lactation heifers likely to conceive in the 3-4 year age group. 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 Northern Territory. The available nutrition and climate of the Northern Gulf and Kidman Springs are sufficiently similar for the Northern Territory trial results to be considered relevant.

The growth model for the Northern Gulf region base herd with P supplements identifies that first calf heifers are likely to average about 410 kg liveweight just prior to calving. Feeding the heifers with an M8U mix ($280/t landed in Georgetown) for 100 days prior to calving is expected to allow the heifers to gain an additional 15 kg of bodyweight as long as the pasture being grazed has at least 6 MJ ME/kg DM available. The additional 15 kg of bodyweight is expected to improve the conception rate by 6% in the supplemented heifer group (Schatz 2010). The new conception rate was applied to the Northern Gulf herd base model to identify the investment returns that may be gained by feeding first lactation heifers with a suitable protein supplement.

The adjustment to the first calf heifer conception rate was made and additional surplus weaner heifers created by the change in reproduction efficiency were sold as 2-3 year olds to maintain the same grazing pressure and culling strategy as the base herd. The existing conception rates for heifers and age groups older than the 3-4 year age group were maintained at the same level. The one-off feeding of the M8U supplement to one group of heifers is 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.

The overall weaning rate (from cows kept) for the herd changed from 57.76% to 59.61%. The breeder herd with the heifer feeding strategy produced about seven more weaners/annum on average and total female sales increased by four/annum due to the improved efficiency of the breeding herd (Table 78).

Table 78 - Cows mated and weaners produced with heifer feeding

Parameter	Without heifer supplementation	With heifer supplementation
Total cows and heifers mated	805	792
Calves weaned	465	472

The calculation of the expected feeding cost of the M8U supplement is shown in Table 79. One-off capital expenditure of $5,000 was required for troughs and feeding out equipment.

Table 79 – Calculation of feeding costs for pregnancy tested in calf (PTIC), 2-3 year age group heifers

Parameter	Value
Number of PTIC heifers to be fed	100
Average body weight (kg)	410
Food consumed (0.4% liveweight; kg/head.day)	1.64
Number of days to be fed	100
Total intake of supplement (kg/head.day)	164
Cost of supplement ($/t landed)	$280
Total supplement fed (t)	16
Total cost of supplement ($)	$4,592
Cost of feeding out (twice/week)	
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	*$7,449*
Cost per head fed	*$74.49*

5.11.3 Results and discussion

Table 80 shows the predicted investment returns for feeding M8U supplement to first calf, lactating heifers to achieve an improved re-conception. The investment produced a negative annualised NPV of about $3,500/annum. This strategy is likely to reduce the ongoing profitability of the property.

Table 80 - Returns for investment in M8U supplement for first calf heifers to improve re-conception rates compared to the base herd which is receiving adequate P supplementation and which has benefited from 10 years of land condition improvement

All terms defined in the Glossary of terms and abbreviations

Factor	Value
Period of analysis (years)	30
Discount rate for NPV	5.00%
NPV	-$53,500
Annualised NPV	-$3,500
Peak deficit (with interest)	-$147,100
Year of peak deficit	never
Payback period (years)	never
IRR	n/a

5.12 Investing to reduce foetal/calf loss

5.12.1 Introduction

The CashCow project (McGowan *et al.* 2014) identified median values of 16.4% foetal/calf loss in heifers, 9.5% in first lactation cows and an overall rate of 12.9% for the Northern Forest region, which is applicable to the Northern Gulf region study area. (Table 81). 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 during the same period and subsequent calf loss due to that source.

Table 81 - Median reproduction performance for Northern Forest data (McGowan et al. 2014)

Reproduction performance indicator	Heifers	First lactation cows	2nd lactation cows	Mature	Aged	Overall
P4M*		11%	6%	16%	20%	15%
Annual pregnancy**	67%	43%		68%	63%	66%
Foetal/calf loss	16.4%	9.5%		11.8%	13.7%	12.9%
Contributed a weaner^	55%	23%		57%	52%	53%
Pregnant missing#		7.7%		11.3%	11.9%	10.6%

*P4M - Lactating cows that became pregnant within four months of calving

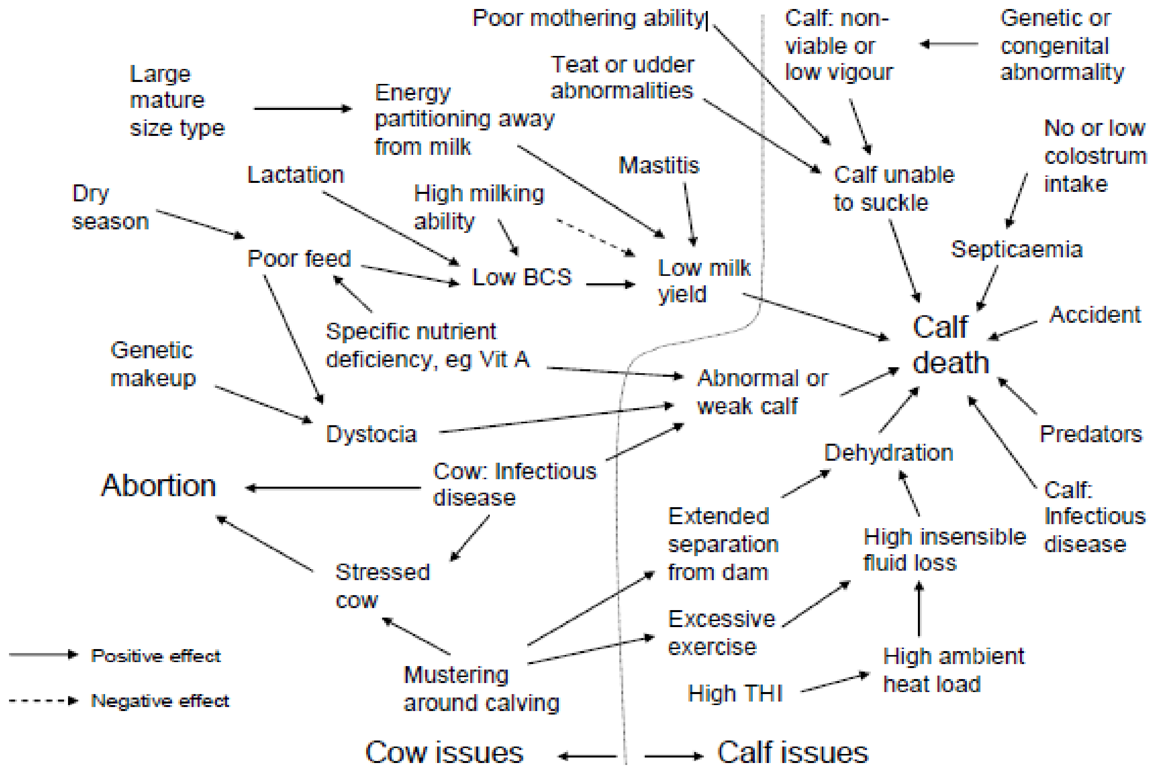
** Percentage of cows in a management group (mob) that became pregnant within a one-year period. For continuously mated herds, this included cows that became pregnant between September 1 of the previous year and August 31 of the current year

^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 19). 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 19 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 19 - Possible causal pathway for foetal and calf loss in northern Australia (McGowan et al. 2014)



5.12.2 Methods

In this strategy an investment to reduce foetal/calf loss in all breeders was investigated. The comparison was with the base herd after 10 years of improved land condition and adequate wet season P supplementation. The median values identified in the CashCow project for the Northern Forest region (McGowan *et al.* 2014 were applied in the construction of the original herd model. While the conception rates for the breeder herd had been adjusted to reflect the expected response to land condition improvement and adequate wet season P supplementation, the calf loss values identified by the CashCow project had been maintained at the same level for each class of breeder in the herd in each of the previous scenarios.

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 examples for analysis and requires us to rephrase the question. 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 half, 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 base investment herd model and the additional treatment costs inserted from the first 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 base herd model (without change) and the 'with change' herd models were compared to identify the additional returns achieved.

5.12.3 Results and discussion

Table 82 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 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.

Table 82 - Returns for investing to achieve a 50% reduction in calf loss across all breeding females compared to the base herd which is receiving adequate P supplementation and which has benefited from 10 years of land condition improvement

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	5.00%	5.00%	5.00%	5.00%	5.00%	5.00%
NPV	$80,900	$35,000	-$11,000	$125,000	$101,300	$77,500
Annualised NPV	$5,300	$2,300	-$700	$8,100	$6,600	$5,000
Peak deficit (with interest)	-$6,000	-$16,900	-$37,000	-$50,000	-$75,000	-$100,000
Year of peak deficit	1	4	n/a	1	1	1
Payback period (years)	4	8	n/a	6	9	13

6 Assessing the potential impact of drought on the herd as well as the effect of herd structure on drought risk and profitability

6.1 Introduction

Another aspect of being prepared for drought is to assess the potential impact of drought on the components of the cattle herd. The weight loss associated with drought will affect different age classes as well as the lactating (hereafter 'wet') and non-lactating (hereafter 'dry') breeders differently and hence the proportion of these groups in the herd is an important factor to consider. The proportion of the breeding herd likely to be lactating as the drought progresses is important in this region, especially, as many of the breeding herds do not remover the breeding bulls during the year. The overall herd structure will also likely have effects on the capacity of the property to respond to drought which will be related to the proportion of breeders in the herd. Assessing these aspects well prior to drought can enable adjustments to herd structure to be made that increase drought resilience.

6.2 Methods

The potential effect of the drought on the mortality and conception rates of components of the representative base herd was assessed by applying the prediction equations developed by Mayer *et al.* (2012), for breeding cattle in northern Australia, to the herd output data from the Breedcow model (Holmes *et al.* 2017). The base herd was that after 10 years of land condition improvement and adequate wet season P supplementation. While breeder liveweight, body condition score (BCS; range 0-9)) and age were key factors affecting mortality and conception rates, Mayer *et al.* (2012) identified that variation in the parameter 'body condition ratio' (BCR) could be used to model the effect of a change in BCS on mortality and conception rates in mature female cattle. BCR is defined as the ratio of current liveweight to expected body weight for age of animals in average condition ('N'). 'N', in turn, is calculated using an exponential equation describing weight from birth to maturity, given adequate nutrition and relies on use of a 'standard reference weight' (SRW) which is defined as the weight of a mature animal of average body condition. The relationship between breeder BCS and BCR derived by Mayer *et al.* (2012) was used to determine the expected liveweight at each BCS and BCR increment, for a herd with an assumed SRW of 450 kg which was considered as representative for contemporary Brahman cattle (>75% *B. indicus*) in the Northern Gulf region (Table 83). Potential effects of drought on steer mortality were assessed with reference to available literature.

The effects of changing the age of steer turnoff on herd structure and hence on the capacity of the property to respond to drought and on profitability were examined in Section 5.3. The effects of continuous mating and breeder segregation are assessed in this section of the report.

Table 83 – Equivalence of breeder body condition score (BCS) to body condition ratio (BCR) and calculated liveweight based on a breeder standard reference weight (SRW) of 450 kg liveweight; calculated using equations from Mayer et al. (2012)

All terms defined in the text and in the Glossary of terms and abbreviations

Description of animal	BCS value (scale 0-9)	Nominal BCR range	Calculated BCR	Calculated liveweight (kg)
Emaciated	0	0.5–0.6	0.50	225
Very poor	1	0.6–0.7	0.60	270
Poor	2	0.7–0.8	0.70	315
Backward store	3	0.8–0.9	0.80	360
Store	4	0.9–1.0	0.90	405
Forward store	5	1.0–1.1	1.00	450
Prime	6	1.1–1.2	1.10	495
Fat Prime	7	1.2–1.3	1.20	540
Fat	8	1.3–1.4	1.30	585
Over-fat	9	1.4–1.5	1.40	630
Over-fat	9	1.4-1.5	1.50	675

6.3 Results and discussion

6.3.1 The potential impact of drought on the herd

Figure 20 demonstrates the relationship of mortality rate to BCR and weight change in either 1 year old or 12 year old breeders, calculated by applying the equation of Mayer *et al.* (2012). It can be seen that 12 year old cows that have a low starting BCR and then lose weight will have a substantially greater rate of mortality than yearling heifers that have a similar body condition ratio and lose a similar amount of weight. Table 84 and Table 85 show the expected rate of mortality in breeders as predicted by the Mayer *et al.* (2012) mortality equation. The values were calculated for female stock that start the calendar with a BCR of either 1 or 0.9 and then lose liveweight aver varying rates over during the next 12 months.

The data indicates a serious risk of high rates of mortality if a breeding herd has a high proportion of aged cows and they begin a drought in forward store or below body condition. Having breeder BCS in less than a forward score condition (lower than score 5 on a 9 point scale) going into a drought could substantially increase the mortality risk of mature and aged cows who are considered likely to lose more than 10% of their starting liveweight.

Figure 20 – Fitted mortality surface (%/annum) for the interaction between weight change (kg/annum) and body condition ratio (BCR) for 1 year old and 12 year old females

All terms defined in the text and in the Glossary of terms and abbreviations

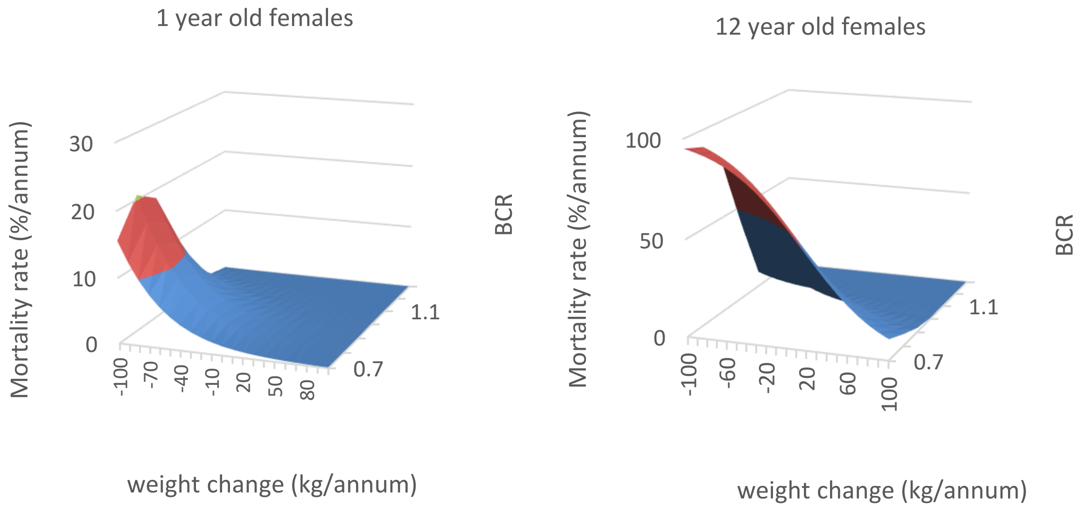


Table 84 - Rate of mortality by class of female stock starting with a body condition ratio (BCR) of 1 at the start of the calendar year and then losing various amounts of liveweight over the next 12 months

All terms described in the text and in the Glossary of terms and abbreviations

Female age class	**Liveweight loss over 12 months (kg)**				
	-20	**-40**	**-50**	**-60**	**-80**
Heifer weaners	1.58%	2.60%	3.33%	4.26%	6.89%
Heifers 1 year	1.84%	3.03%	3.88%	4.95%	7.97%
Heifers 2 years	1.84%	3.03%	3.88%	4.95%	7.97%
Cows 3 years	2.15%	3.53%	4.50%	5.74%	9.20%
Cows 4 years	2.50%	4.10%	5.23%	6.65%	10.60%
Cows 5 years	2.92%	4.77%	6.07%	7.69%	12.19%
Cows 6 years	3.40%	5.53%	7.02%	8.88%	13.97%
Cows 7 years	3.95%	6.41%	8.12%	10.24%	15.96%
Cows 8 years	4.59%	7.42%	9.37%	11.77%	18.18%
Cows 9 years	5.33%	8.57%	10.79%	13.51%	20.64%
Cows 10 years	6.18%	9.89%	12.40%	15.45%	23.33%
Cows 11 years	7.16%	11.37%	14.21%	17.61%	26.25%
Cows 12 years	8.27%	13.06%	16.23%	20.00%	29.40%
Cows 13 years	9.54%	14.94%	18.48%	22.64%	32.76%

Table 85 - Rate of mortality by class of female stock starting with a body condition ratio (BCR) of 0.9 at the start of the calendar year and then losing various amounts of liveweight over the next 12 months

All terms described in the text and in the Glossary of terms and abbreviations

Female age class	**Liveweight loss over 12 months (kg)**				
	-20	**-40**	**-50**	**-60**	**-80**
Heifer weaners	2.89%	4.72%	6.00%	7.62%	12.07%
Heifers 1 year	3.66%	5.96%	7.56%	9.54%	14.94%
Heifers 2 years	3.66%	5.96%	7.56%	9.54%	14.94%
Cows 3 years	2.15%	3.53%	4.50%	5.74%	9.20%
Cows 4 years	5.86%	9.39%	11.80%	14.72%	22.33%
Cows 5 years	7.37%	11.71%	14.61%	18.09%	26.88%
Cows 6 years	9.24%	14.50%	17.96%	22.03%	31.99%
Cows 7 years	11.53%	17.83%	21.88%	26.54%	37.57%
Cows 8 years	14.29%	21.73%	26.37%	31.61%	43.50%
Cows 9 years	17.58%	26.21%	31.43%	37.16%	49.62%
Cows 10 years	21.43%	31.24%	36.96%	43.07%	55.75%
Cows 11 years	25.87%	36.76%	42.86%	49.18%	61.71%
Cows 12 years	30.87%	42.64%	48.97%	55.32%	67.34%
Cows 13 years	36.35%	48.75%	55.10%	61.30%	72.51%

This data indicates that the age structure of the females in a breeding herd may increase (or decrease) the risk of mortality rates increasing in a drought. Table 86 indicates the age structure of the base herd receiving adequate wet season P supplementation and with land condition improvement and identifies that approximately 15% of the retained cow herd could be 9-10 years old, or older, going into a drought.

Table 86 - Age structure of the base herd in the representative beef property

Retained breeder numbers for age classes 9 years and above are shaded grey

Parameter	**Number of females in each age class (1-12)**											
Cow age start of calendar year	1	2	3	4	5	6	7	8	9	10	11	12
Cows/heifers available at start of year	230	224	101	93	88	83	78	74	69	65	61	57
Cows mated in each age group	0	133	101	93	88	83	78	74	69	65	61	0
Mated cows retained in each group	0	104	95	90	85	80	76	71	66	62	58	0
Calves weaned from each group	0	87	41	56	53	50	47	38	36	34	31	0

The base breeding herd structure and cow culling strategy for the representative herd was optimised to identify the highest herd gross margin after implementation of grazing management strategies to improve land condition and adequate wet season P supplementation. Table 87 shows the effect of including the improved herd performance in the calculation of the optimal maximum age of cow culling. It can be seen that the implementation of grazing management strategies to improve land condition and adequate wet season P supplementation changes herd performance and efficiency sufficiently that the optimum maximum age to cull cows is reduced from 11-12 years to 8-9 years. The effect of this reduced cow cull age, on overall mortality risk related to drought, would be significant. Furthermore, the herd was more $3,281/annum more profitable with this younger cull age cf. the 11-12 year target cull age.

Table 87 - Comparison of the base herd benefiting from improved land condition and adequate P supplementation with a 11-12 year old cull cow strategy and a 8-9 year old cull cow strategy

Parameter	Base herd with 1-12 year cull age	Base herd with 8-9 year old cull age
Total AE	1,500	1,500
Total cattle carried	1,739	1,743
Weaner heifers retained	233	236
Total breeders mated	805	806
Total breeders mated & kept	751	740
Total calves weaned	465	472
Weaners/total cows mated	57.76%	58.59%
Weaners/cows mated and kept	61.91%	63.85%
Overall breeder deaths	2.50%	2.50%
Female sales/total sales (%)	47.89%	47.96%
Total cows and heifers sold	202	206
Maximum cow culling age	11	8
Heifer joining age	2	2
2 year old heifer sales (%)	60.55%	39.7%
Total steers and bullocks sold	220	224
Maximum bullock turnoff age	3	3
Average female price	$671.27	$662.09
Average steer/bullock price	$841.87	$841.87
Capital value of herd	$996,850	$999,250
Imputed interest on herd value	$49,842	$49,962
Net cattle sales	$321,056	$324,673
Direct costs excluding bulls	$63,107	$63,284
Bull replacement	$26,309	$26,347
Gross margin for herd	$231,640	$235,042
Gross margin less interest on livestock capital	*$181,798*	*$185,079*
Difference		$3,281

Mayer *et al*. (2012) did not produce equations to predict the mortality rate of steers and the actual mortality rate response of steers at different ages to a fall in BCS due to drought is unknown. However, Henderson *et al.* (2013) surveyed the mortality rate in steers across a number of regions of northern Australia and found that rates of steer mortality were likely to be as high, if not higher, than that identified in females of similar age and were also likely to increase with age. One of the key insights gained from Henderson *et al*. (2013) is that rates of steer mortality in northern Australia are higher than normally anticipated by property managers. It has also been shown that any increased rate of steer mortality has a greater impact on herd profitability than a similar rate of increase in mortality in female cattle (Chudleigh *et al*. 2016).

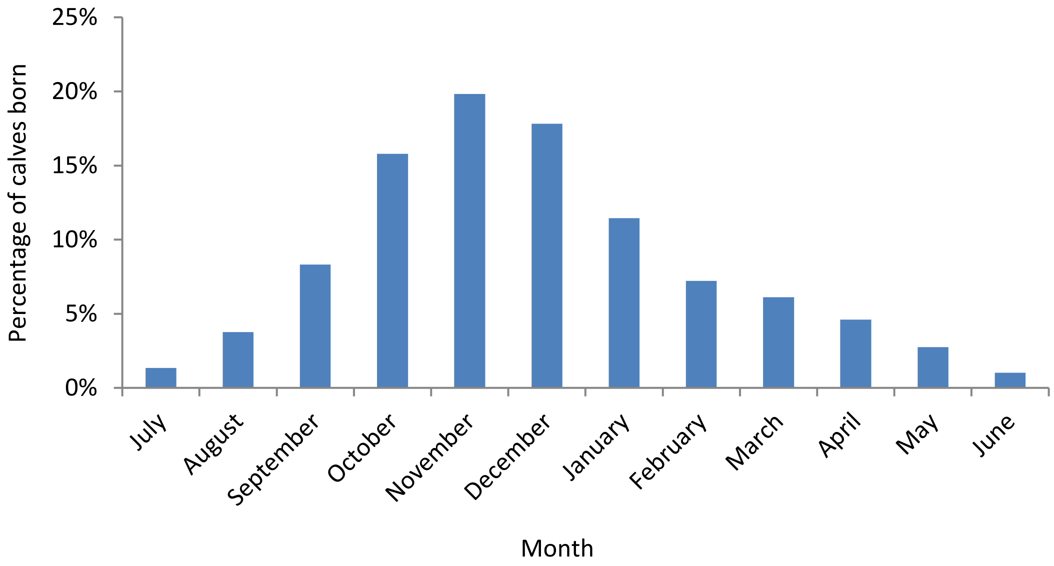
6.3.2 The effect of herd structure on drought risk and profitability

6.3.2.1 Herd performance under continuous mating

Bull control in the Northern Gulf region is often difficult due to large paddock size, multiple water points and sometimes rugged terrain. Hence, continuous mating is practiced by the large majority of properties in this region. Calving is largely dictated by rainfall, with the peak of conceptions occurring several months after the first significant rainfall (Bortolussi *et al*. 2005) although calving does occur at other times of the year.

Figure 21 shows the distribution of calving in a breeder herd with continuous mating for the period 1995-2001 at Victoria River Research Station (VRRS), (Cobiac 2006). The cattle management systems, climate and land types of the VRRS are sufficiently similar to the Northern Gulf region for a comparison to be made.

Figure 21 - Calving distribution in a continuous mated trial herd at Victoria River Research Station over 1995-2001 (Cobiac 2006)



The trial data from the VRRS identified that 85% of calf births occurred from October to March with 15% occurring from April to September (Cobiac 2006). The incidence of calving shown in Figure 21 can be organised into four calving seasons to allow consideration of the likely distribution of calves across the year.

- July - September (Late Dry)
- October – December (Early Wet)
- January – March (Late Wet)
- April – June (Early Dry)

These four calving periods fit the expected usual timing of weaning activities and, within that constraint, the periods of the year likely to generate different consequences for cows calving and calves born during those periods.

Figure 22 compares the percentage of calves born in each season for:

- Herds with continuous mating in the Northern Forest country type (CashCow database 2014; Kieren McCosker, NTDPIF pers. comm.)
- All trial genotypes in the VRRS data (Cobiac 2006)
- Only the Droughtmaster cows in the VRRS data (Cobiac 2006). These breeders were run under management conditions similar to those of the trial prior to the commencement of the VRRS trial and had settled into a regular calving pattern.

Figure 22 - Incidence of calves by calving season

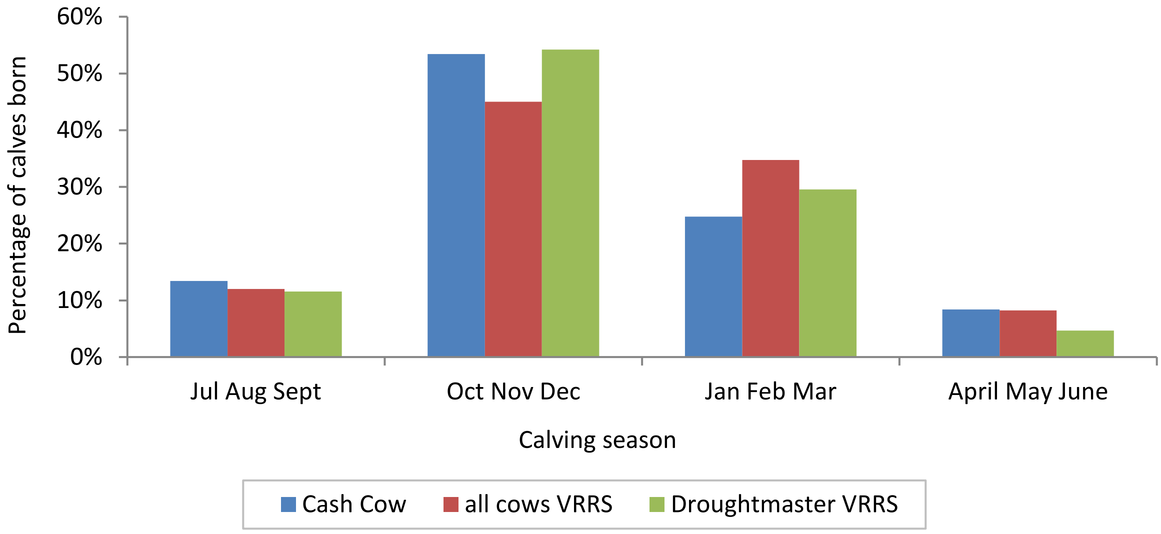


Table 88 shows the percentage of calves expected to be born in each calving season when the CashCow and the data for the VRRS Droughtmaster cows (considered more representative than all trial genotypes in the VRRS dataset) were averaged. The average number of calves born in each season is expected to be 12% in the late dry season (July-September), 54% in the early wet season (October-December), 27% in the late wet season (January-March) and 7% in the early dry season (April-June). The inter-calving period of individual breeders will cause individual cows to drift between the periods but, on average, about 80% of calves are expected to be born in the early and late wet period.

Table 88 - Percentage of calves born in each of four calving seasons

Data sets and abbreviations described in the text

Season of calving	CashCow	Droughtmaster VRRS	Average
Jul/Aug/Sept	13%	12%	12%
Oct/Nov/Dec	53%	54%	54%
Jan/Feb/Mar	25%	30%	27%
April/May/Jun	8%	5%	7%

The age of turnoff strategy chosen can have considerable impact on drought risk where continuous mating is practiced. The herd that targets weaner production appears likely to have at least 100 breeders calving in the high risk July-September period and any delay in the wet season appears likely to cause considerable mortality in this class of breeder if effective remedial action isn't taken. The herd targeting bullock production will have a substantially lower number of breeders in this at risk group.

6.3.2.2 Segregating breeders on pregnancy status prior to the drought

In the Northern Gulf herd, the status of the mature cows early in the New Year when the wet season looks short (with continuous mating) was expected to be:

- Cows that have calved in the previous July/August/September period and have a large calf on the ground. These cows are likely to be empty, are a prospect for early weaning, and could be sold as either a cow and calf unit or as a store cow after early weaning the calf. Unfortunately they are only expected to be 12% of the breeding herd and likely to be in poor body condition due to calving out of season.
- Cows that have calved in the previous October/ November/December period and have a small calf on the ground. These are considered to be difficult to wean in the short term due to the age of the calves and make up probably 50% or more of the herd.
- Cows that will calve in the current January/February/March period. These cows are high risk going into a drought due to a failed wet season as their nutritional needs will likely spike as the drought intensifies. Unfortunately about one third of the breeding cows will fall into this group and special consideration will be required if high rates of mortality are to be avoided.
- Cows that are expected to calve in the following July/August/September period. These cows are at very high risk in a drought and may need to be removed from the property if significant mortalities are to be avoided in an extended dry season in this region. They are currently dry and likely to be suitable candidates for sale or sending to agistment.

Breeding cows in the herd can only be treated as separate management groups if they have been segregated on their pregnancy status prior to the drought. Mustering the breeding herd early in the New Year and segregating on lactation status and stage of pregnancy as a response to a failed wet season is likely to lead to significant mismothering and an increased calf mortality. Therefore a critical strategy to prepare for drought in these Northern Gulf systems where continuous mating is practiced is to have an efficient herd segregation system in place well prior to drought. This will allow targeted sales and feeding programs to be completed at low cost and in an efficient time frame.

7 Responding to, and recovering from, drought

7.1 Introduction

The combination of drought and heavy utilisation of pasture by both domestic livestock and other herbivores (rabbits and macropods) has led to a series of historical degradation episodes in Australia's grazing lands manifested in the accelerated death of desirable perennial pasture species, soil surface erosion and delayed recovery from drought (McKeon *et al.* 2004). McKeon *et al.* (2004) state that the three major causes of degradation include:

1) over-utilisation of pasture by domestic and other herbivores in the pre-drought period resulting in damage to 'desirable' perennial pasture species;
2) extreme pasture utilisation in the first years of drought caused by retaining livestock (and continued presence of other herbivores) that result in loss of perennial pasture species and soil cover; and
3) continued retention of stock through a long drought period, compounding damage to the land resource and delaying pasture recovery.

Scientists and government departments have long emphasised the adoption of conservative stocking rates, and/or highly responsive stock management strategies to prevent degradation. Regardless, financial and economic influences have historically, and will continue, to result in many graziers pushing their grazing land resources to the limits to maximise returns in the short to medium term (e.g. McKeon *et al.* 2004; Rolfe *et al.* 2016*b*; Bowen and Chudleigh 2017, 2018*a*). Knowledge and tools to assess relative short and longer-term profitability of various strategies that can be applied prior to, during, and after a drought would assist managers to evaluate various destocking options for relative profitability and risk and potentially make more informed decisions.

A key component of planning for, and then responding to and recovering from, drought is to have a clear understanding of the options or strategies available, the potential interactions between them and being able to assess the relative value of each at critical points in time. These strategies are often tactical in nature and are highly dependent on the individual circumstances specific to a beef property at a given point in time. Therefore, we propose that is more efficient to provide knowledge of available strategies and their likely response functions, together with a framework within which individual managers can assess their options, rather than to provide 'answers'. The premise is that providing both a better understanding of complex interactions, as well as a framework and tools to support appropriate decision making, should improve the outcomes and timeliness of decisions made by managers of grazing properties. In this report we have provided some examples of drought response and recovery options for the representative base herd.

In responding to drought in the Northern Gulf region, the following key strategies are available to reduce grazing pressure and/or protect livestock capital:

- reducing grazing pressure and herd numbers by culling dry females and pregnancy tested 'empty' cows,
- reducing liveweight loss of breeders by early weaning,
- reducing grazing pressure and herd numbers by culling from within groups of remaining herd classes (cows, heifers and steers),
- drought feeding, or

- agistment.

In the drought recovery period, key strategies available to increase cash flow and profits include:

- the purchase of cattle to rebuild the herd,
- taking stock on agistment, or
- trading cattle.

7.2 Methods

These choices were assessed with reference to the Breedcow herd model output for the base herd and with use of the Cowtrade, Bullocks and Splitsal programs within the Breedcow and Dynama suite (Holmes *et al.* 2017), where relevant. The responding to drought analyses were for a base herd after 10 years of land condition improvement and adequate wet season P supplementation, i.e. for a property running 1,500 AE. The recovering from drought analyses were for a base herd after 30 years of land condition improvement and adequate wet season P supplementation, i.e. for a property running 1,813 AE.

7.3 Results and discussion

7.3.1 Assessing key strategies which may be applied in response to drought

7.3.1.1 Reducing grazing pressure by culling dry females and pregnancy tested 'empty' (PTE) cows

In a circumstance where it is apparent early in the New Year that the wet season may be short and normal numbers of cattle may need to be reduced, there will be a group of females in the breeding herd that were pregnancy tested in calf the previous year but have subsequently lost , or will lose, their calf. Table 89 shows the expected average herd structure and identifies the pregnancy tested in calf (PTIC) empty breeders (females that have a positive pregnancy test but then lose the calf prior to branding or weaning). About 70 cows will fall into this category in the base herd and will be identifiable as dry breeders at weaning time if the herd has been segregated on their pregnancy test status. Although these PTIC empty females have a high probability of being pregnant again after losing their calf, they are likely to be in reasonable body condition and are an obvious candidate for immediate sale. Although this action may reduce weaner numbers in 15-18 months' time, their sale will allow an early reduction in grazing pressure and may also remove sub fertile breeders from the herd. If drafting off and culling PTIC empty females is not already practiced then it may be an easy way to reduce grazing pressure early in the year and can coincide with any early weaning activities being undertaken.

Table 89 - Herd status showing pregnancy tested in calf (PTIC) empty cows (females that have lost a calf prior to branding or weaning)

Cow age of culling is 12 years old; PTIC empties shaded grey

Herd structure parameter	**Joining age group**										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Opening breeders	227	221	103	95	90	85	81	76	72	67	63
Number mated	0	136	103	95	90	85	81	76	72	67	0
Conception (%)	0%	78%	45%	70%	70%	70%	70%	65%	65%	60%	60%
Conception losses (%)	0%	16%	10%	12%	12%	12%	12%	14%	14%	14%	14%
Sale of empties (%)	0%	100%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Number able to mate	0	136	103	95	90	85	81	76	72	67	0
Number pregnant	0	106	46	67	63	60	56	49	47	40	0
Number empty	0	30	57	29	27	26	24	27	25	27	0
Number PTIC empties	0	17	4	8	7	7	7	7	6	6	0
Number remaining pregnant	0	89	42	59	56	53	50	43	40	35	0
Number empties sold	0	30	6	3	3	3	2	3	3	3	0
Total sold	0	30	6	3	3	3	2	3	3	3	0
Number retained	0	106	98	92	87	83	78	73	69	65	0
Calves weaned	0	89	42	59	56	53	50	43	40	35	0

A substantial component of the herd are mothers of weaners that can soon be pregnancy tested and their status revealed. The expected conception rates indicate that a number of PTE cows will be identified and a higher than normal culling rate can be applied at weaning to reduce grazing pressure. Table 89 above indicates that there are likely to be 271 PTE cows after mating ('Number empty' row) with approximately 217 of these cows normally retained in the herd. Segregating a herd that has continuous mating into calving groups and PTE cows allows these cows to be managed as separate groups. The PTE group of cows at weaning represent a significant opportunity to reduce cow numbers early in a drought although selling them will reduce the number of weaners produced in later years due to the biennial calving pattern of many of the mature cows in the breeding herd.

7.3.1.2 Reducing liveweight loss of breeders by early weaning

Early weaning is known to be the most effective strategy to reduce liveweight loss of breeders during the dry season and droughts, and hence reduce breeder mortality rates and improve reproductive efficiency (Dixon 1998; Tyler *et al.* 2012). As weaning a breeder is expected to improve individual liveweight by ca. 10 kg/month, the management decision to wean a breeder 3 months early results in a breeder 30+ kg heavier mid-year cf. an unweaned breeder.

Early weaning in the base herd would lead to approximately 500 weaners with an average weight of about 110-115 kg needing to be fed supplements at different times of the year. A herd segregated on pregnancy status would facilitate early weaning activities and make mustering activities more efficient. The lighter weaners, less than 100 kg liveweight, will need to be separated and fed a diet that has more than 20% crude protein and they may need to be fed for some weeks. For example, a target weight gain of 250 g/d may require feeding 1.5 kg/head.day of calf pellets for at least 30 days to shift the light weaners from 92 to 100 kg liveweight (Tyler *et al.* 2012). The heavier weaners, greater than 100 kg liveweight, will also need supplements of protein meal, hay and optionally grain, if pasture quality is too poor for the growth rate required.

The application of the program Splitsal (Holmes *et al.* 2017) to the expected weaner weights at an early weaning indicated that if the mob of weaners had a standard deviation of 15 kg liveweight, ca. 20% would be less than 100 kg and have an average weight of about 92 kg. The remaining 80% would be heavier than 100 kg and have an average weight of about 117 kg (Table 90). The Cowtrade program (Holmes *et al.* 2017) and spreadsheets can be used to determine the additional cost of supplementing the early weaners and this can be compared to the expected reduction in mortality rate and the improvement in reproduction efficiency in the breeders that had their calves weaned early. It is considered likely that early weaning would generally be the more economic option but this depends entirely upon the expected severity of the following season.

Table 90 - Splitsal analysis of expected weaning weight distribution in February

Parameter	Value
Average liveweight of total group (kg)	113
Standard deviation of weights (kg)	15
Liveweight range in total group for 95% of group, assuming a normal distribution (kg)	83-142
Cut-off weight for lighter group (kg)	100
% of total group above cut-off weight	80
Average weight of heavier group (kg)	117
Average weight of lighter group (kg)	92

7.3.1.3 Reducing grazing pressure by culling from within cow, heifer and steer groups of the remaining herd vs. drought feeding

7.3.1.3.1 Calculating the cost of drought feeding

There have been a number of detailed guides produced to inform beef producers about management of stock going into a drought and supplementary feeding stock as they progress through a drought (see https://futurebeef.com.au/knowledge-centre/drought/). As each situation has different costs and returns, no detailed examples have been added here. Spreadsheets for calculating the relative cost of feeds are available at https://publications.qld.gov.au/dataset/agbiz-tools-animals-and-grazing-beef. These tools can be used to calculate the approximate cost of drought feeding based on appropriate strategy where cattle are segregated according to their feed requirements, and provided feed which addresses the most limiting nutrient (Tyler *et al.* 2008). Once the costs of feeding stock have been calculated, they can be incorporated in such programs as Cowtrade and Bullocks to assess whether it is worth feeding or selling.

7.3.1.3.2 Considering the sale of PTIC cows and later re-purchase of cows and calves

One option is to consider the sale of PTIC cows at pregnancy testing with the expectation of repurchasing cows and calves prior to the normal weaning period in the following year. This action effectively maintains the expected output of the breeding herd over time and could substantially reduce the grazing pressure applied to the property after a failed wet season.

There are significant risks in this action but one approach to assessing the potential impact of the decision is to compare the costs of keeping the PTIC cows with the expected costs of replacing them at a later date. The next section follows a format that highlights the key data required to assess the decision to sell or retain PTIC cows.

Estimating the current sale value is necessary to identify the opportunity costs of retaining the cows. Table 91 shows the calculation of the current on farm value of the cows.

Table 91 - Calculation of on-property value of sale cattle

Parameter	**Value**
Cow weight in the paddock (kg)	450
weight loss to get to sale yards or works	5%
Cow weight at saleyards or works (kg)	428
Sale price at yards or works ($/kg live)	$2.00
Gross sale price ($/head)	$855
Commission & insurance % on sales	3.50%
Commission & insurance ($/head)	$29.93
Transaction levy, yard dues etc.	$15.00
Transport cost ($/head)	$10.53
Cow value net of selling expenses	$799.55
Selling cost ($/kg)	$0.13
Net value in the paddock ($/kg)	*$1.78*

Table 92 demonstrates the process required to identify the number and value of PTIC cows and the expected period of time until they are expected to be replaced with cows and calves. For this exercise, the benefits to the property of holding and feeding, or selling and replacing, 100 PTIC cows was examined.

Table 92 – Identification of the number and value of PTIC cows in the herd and the expected period of time until they are expected to be replaced

Parameter	**Value**
Number of PTIC cows	100
Date that PTIC cows could be sold	1 May 2018
Date that cows and calves could be replaced	1 May 2019
Days to replacement	365
Current liveweight of PTIC cows (kg)	450
Expected sale price now ($/kg liveweight)	$1.78
Current sale value ($/head) on farm	*$799.55*
Current sale value ($/mob) on farm	*$79,955*

Table 93 shows the calculation of the expected feeding costs if the cows are retained, the opportunity cost of not selling the cows (interest forgone) and the approximate cost (value) of the 90 cows and calves available at the end of the period. Allowance is made for the percentage of cows (10%) likely to lose their calves and the percentage of cows likely to die (5%). The expected cost of replacing 90 cows and 90 calves at the end of the period was also identified.

Table 93 – Expected feeding and opportunity costs for retained cows, the value of cows and calves at the end of the feeding period and the cost of replacing them

Parameter	Per head	Per mob
Treatment costs of holding PTIC cows		
Number of PTIC cows to be fed		100
Number of days to be fed		182
Supplement intake at 1% of 450 kg liveweight (4.5 kg/head.day); (kg/head, as-fed)	819	82,000
Cost of supplement (/t landed)		$300
Total supplement cost ($)		$24,570
Wages and fuel for 1 feeding out		$50
Number of times fed (supplement is fed out twice per week)		52
Total feeding out cost		$2,600
Total supplement and feeding out cost ($)	$271.70	$27,170
Health costs if held and not sold ($/head)	$5.00	
Other supplement costs if held and not sold ($/head)	$25.00	
Management costs if held and not sold ($/head)	$0.00	
Total treatment costs ($)	*$301.70*	*$30,170*
Opportunity cost of interest foregone in holding PTIC cows (5% interest rate)		
Interest cost - cattle ($)	$39.98	$3,998
Interest cost - treatment costs ($)	$7.54	$754.3
Opportunity cost of interest ($)	*$47.52*	*$4,752*
Total cost of retaining cows and calves		
Weaning rate from retained PTIC breeders		90.00%
Number of cow and calf units held at the end of the period		90
Mortality rate for retained cows		5.00%
PTIC empty cows at the end of the period		5
Adjustment for value of PTIC empty cows		-$3,998
Value or cost of cow and calf units at the end of the period	*$1,231.99*	*$110,879*
Expected cost of replacing cows and calves		
Number of cow and calf units to be purchased		90
Total travel costs (total costs of finding stock)		$300
Travel costs ($/head)	$3.33	
Transport costs to property (90 head, 200 km at $2.00/km, 24 per deck)	$16.67	$1,500
Induction cost $/unit	$10.00	$900
Expected purchase cost of cow and calf unit ($)	$1,250.00	$112,500
Total landed cost of cow and calf unit ($)	*$1,280.00*	*$115,200*
Gain (or loss) on holding and feeding		***-$4,321***

The values retained in the table suggest that the property was not worse off selling the cows now and replacing them in twelve months' time with cows and calves if they could be purchased for about $1,250 per unit. Table 93 reveals the sensitivity of the exercise to variation in the current sale price and the expected replacement cost. A positive number indicates it was better to hold the PTIC cows and feed them.

Table 94 - Sensitivity analysis for gain from holding and feeding PTIC cows ($) in relation to replacement cost for cow and calf unit and sale price for PTIC cows

Expected price of replacement cow and calf unit ($/kg liveweight)	Expected sale price of PTIC cow at the yards or works ($/kg liveweight)				
	$1.80	$1.90	$2.00	$2.10	$2.20
	$ per head on farm				
	$717.04	$758.29	$799.55	$840.80	$882.05
$950	-$14,015	-$18,347	-$22,679	-$27,010	-$31,342
$1,050	-$5,015	-$9,347	-$13,679	-$18,010	-$22,342
$1,150	$3,985	-$347	-$4,679	-$9,010	-$13,342
$1,250	$12,985	$8,653	$4,321	-$10	-$4,342
$1,350	$21,985	$17,653	$13,321	$8,990	$4,658
$1,450	$30,985	$26,653	$22,321	$17,990	$13,658
$1,550	$39,985	$35,653	$31,321	$26,990	$22,658

This exercise looks at holding and feeding or selling and replacing 100 PTIC cows and this property is likely to have four times this many on hand at the start of the drought. Making the wrong choice could be disastrous for this property. Other factors such as the expected availability of cows and calves at the end of the period and their ongoing performance compared to the PTIC cows already on the property will also be factors that can influence this decision. Classes of PTIC cows currently on the property, and likely to experience increased rates of mortality, are the potential candidates for sale.

7.3.1.3.3 Considering culling from within cow, heifer and steer groups

Early weaning and the sale of a few PTIC empties will not do much to reduce grazing pressure if the season continues to deteriorate. Early in the drought year the base herd is likely to have:

- ca. 230 early weaners sitting around the yards being fed,
- ca. 450 cows who have been weaned but whose pregnancy status is unknown,
- ca. 217 cows that were PTE last year, retained to maintain breeder numbers and have been with the bulls,
- ca. 221, 2-3 year old heifers, some that have been mated, and some to be sold in May
- up to 227 heifers that will be mated at the end of the year,
- ca. 227 steers that have another 12 months to go before their usual sale date, and
- ca. 221 steers that will be sold in May.

The lead of sale steers are an easy candidate for sale and will probably go first but once this is done the choices become more complex as selling down the numbers of each class of cattle that remain (cows, heifers, steers) will have significant ramifications for the future earning capacity of the property.

There are two age groups of heifers that can be managed separately in a circumstance where it is apparent early in the New Year that the wet season may be short and normal numbers of cattle may need to be reduced. The heifers that are about 12+ months of age are a saleable item but are required over time to maintain the breeding herd. There are more than 200 of these heifers and selling the lead may produce a cash flow and reduce grazing pressure. Culling and selling the tail will produce less cash but is likely to have a smaller impact on the future requirements of the breeding herd. The second cohort of heifers that are about 24 months of age are likely to be with the bulls or in the cull heifer paddock. It is expected about 40% will have been culled pre-mating and these are an obvious candidate to be sold with the yearling heifers selected for sale. The remaining 60% can be sorted as early as April with all heifers that are not pregnant (or not detectible) at that time viewed as candidates for sale. In a dry year the conception rate in these heifers could be lower than normal with potentially a significant portion of these heifers available for sale.

One way of considering the choices is to use the Cowtrade and Bullocks programs that are part of the Breedcow and Dynama suite of programs (Holmes *et al.* 2017). The Cowtrade program is used to calculate the prospective profitability of breeder groups (i.e. some of them will have or already have calves) while the Bullocks programs is used to calculate the prospective profitability for groups of steers and empty cows or heifers. The Cowtrade and Bullocks programs can also assist with decisions where sales are forced by drought or a variety of other circumstances.

When buying cattle to fatten or grow out, it is logical that the most profitable options (the options that provide the greatest future benefits) are the ones to choose. The profitability criterion for choosing between fattening or growing opportunities is nearly always the predicted gross margin per AE after interest. If finance is tight to the degree that the available pasture cannot be completely stocked, then the gross margin expressed as a percent of herd and expenses capital is a more satisfactory criterion. However, if selling stock to reduce grazing pressure or to relieve financial pressure, the object should be to achieve the grazing or financial objective with least damage to future income. That is, if the issue is grazing pressure, it is best to sell first those groups with the lowest gross margin per AE after interest. If the issue is financial, it is best to sell first those groups with the lowest percent return on livestock and expenses capital.

7.3.1.3.4 Assessing destocking vs. a drought feeding strategy for breeders with 'Cowtrade'

The Cowtrade and Bullocks programs that are part of the Breedcow and Dynama suite of programs (Holmes *et al.* 2017) can be used to consider wider choices that may include the options of comparing feeding PTIC cows with selling other classes of stock. Such analyses will also be specific to the seasonal and financial circumstances prevailing at the time.

In a previous example we considered the PTIC cows in isolation as we decided the choice under consideration was to feed them or sell them and purchase them back at a later time. However, there are other classes of cattle left on the property and selling some of them may provide a better outcome than either selling or retaining the PTIC cows.

In general, if selling stock to reduce grazing pressure or to relieve financial pressure, the objective should be to achieve the grazing or financial objective with least damage to future income. Each class of stock remaining on the property will contribute to the future income of the property in different ways and it is necessary to assess this impact of the sale of each alternative class of stock if an informed choice is to be made.

The Cowtrade program was first used to test the decision to feed or sell the PTIC cows and then this result was compared to selling other classes of livestock. During this process a number of key assumptions had to be made:

- The value of the breeder unit in the paddock (net of selling expenses) now. This may be a cow and calf unit that will need to be fed for a considerable period if it is retained in the herd until weaning time.
- The value of the breeder unit at the end of the period. The end of the period could be a) at the expected time of the drought breaking (end of feeding period), b) the weaner being sold off the mother, or c) the time that the cow and calf unit will be replaced.
- The cost to retain the breeder unit over the required period.

Table 95 shows an example analysis of drought feeding options for the base herd. The scenario was that the producer is running out of feed for a group of PTIC cows and can either sell them now (1st May) for $800/head net or hold them and feed them. If they are sold, the decision would be to replace the breeder units with cow and calf units in about April-May the following year. The calves would be likely to be close to weaning age at this time. The expected landed replacement cost is $1,228 ($810 + $418). The cost and length of the feeding exercise was unknown so it was tested at $150, $250 and $350/cow. Weaning costs were expected to be about the same in each scenario. The figure calculated for the gross margin per AE after interest was considered the most appropriate indicator of the success of the feeding venture as it is an accurate method of comparing the impact of selling different classes of cattle going into a drought. In this case we need the most efficient way to reduce grazing pressure (AE's on the property) and selling the class with the lowest future return per AE will remove the most AE's at the least cost to long term profit. It can be seen at a feeding cost of $350/head for the breeders, the best option would be to sell the cows and buy back in a year later. At feeding costs of $247/head, or lower, the best option would be to hold the breeders and feed them. The breakeven level for the feeding exercise was ca. $247/cow for feed inputs.

Table 95 – Example Cowtrade analysis of a drought feeding option for the representative base herd

Interest rate for 'gross margin after interest' calculation was 5%; break-even level of feeding at $247/cow shown and shaded grey

Parameter	Drought feeding option			
	$247/cow	**$150/cow**	**$250/cow**	**$350/cow**
Starting date for analysis	01/05/2018	01/05/2018	01/05/2018	01/05/2018
Calving date	15/11/2018	15/11/2018	15/11/2018	15/11/2018
Sale date for adults and progeny	01/5/2019	01/5/2019	01/5/2019	01/5/2019
Weight of breeders at start (kg)	450	450	450	450
Weight of breeders at sale (kg)	450	450	450	450
Weight of progeny at 5 months (kg)	150	150	150	150
Weight of progeny at sale 9kg)	200	200	200	200
Age of progeny at sale (days)	167	167	167	167
Starting value of group (net/head)	$800	$800	$800	$800
Sale value of breeders (net/head)	$800	$800	$800	$800
Sale value of progeny (net/head)	$418	$418	$418	$418
Weaning rate from breeders (%)	90	90	90	90
Death rate on breeders (%)	5	5	5	5
Death rate on progeny after 5 months (%)	3	3	3	3
Husbandry cost on breeders ($/head)	$247	$150	$250	$350
Husbandry cost on progeny ($/head)	$25	$25	$25	$25
Period of rating for breeder (days)	365	365	365	365
Period of rating progeny to 5 months (days)	348	348	348	348
Period of rating for progeny after 5 months (days)	17	17	17	17
AE rating of breeder	0.99	0.99	0.99	0.99
AE rating of progeny to 5 months	0.31	0.31	0.31	0.31
AE rating of progeny post 5 months	0.02	0.02	0.02	0.02
AE rating for breeder and progeny	1.32	1.32	1.32	1.32
Total gross margin per unit (breeder & progeny)	$55.41	$152.41	$52.41	-$47.59
Gross margin/AE.year	$42.00	$115.53	$39.73	-$36.07
Interest on breeders	$39.00	$39.00	$39.00	$39.00
Interest on progeny	$9.12	$9.12	$9.12	$9.12
Interest on husbandry costs	$6.74	$4.31	$6.81	$9.31
Total interest/unit on stock and expenses capital	$54.86	$52.44	$54.94	$57.44
Average capital base/AE (12 month equivalent)	$831.65	$794.89	$832.79	$870.69
Total gross margin/unit after interest	$0.55	$99.98	-$2.52	-$105.02
Gross margin/AE.year after interest	***$0.42***	***$75.78***	***-$1.91***	***-$79.60***
Return on livestock and expenses capital	*5.05%*	*14.53%*	*4.77%*	*-4.14%*

7.3.1.3.5 Assessing destocking vs. drought feeding options by combining 'Cowtrade' and 'Bullocks'

In the previous section a strategy was considered in Cowtrade that looked at either selling PTIC females or keeping them and feeding them when a drought was beginning to take effect. As there are usually are a number of classes of dry stock that could also be sold as an alternative to breeding females to reduce grazing pressure going into a drought, the Bullocks program can be used to evaluate these options.

The Bullocks program can be used to test the same options for non-breeding cattle as the Cowtrade program does for breeder groups. Although the primary focus of the Bullocks program is on selecting the most profitable turnover cattle, it may also be used to evaluate forced sales options. Furthermore, the gross margins calculated in the Bullocks program for non-breeders may be compared with the gross margin for breeders as calculated in the Cowtrade program if they are compared on a per AE after interest, or capital invested, basis. The Bullocks program, as for the Cowtrade program, requires data for purchase and sale dates, weights, prices (landed and net, respectively), expected mortalities, variable costs, interest rate and purchase and sale price increments for the sensitivity tables.

The scenario outlined in the previous section was extended by identifying that the manager also has an option of selling some steers that would normally be sold in 12 months' time. This would allow the cows to spread out over the property, reducing grazing pressure and saving on feeding costs. This option was considered by firstly adjusting the feeding costs in the Cowtrade drought feeding example and identifying the 'gross margin after interest' for the change. In this case, it was estimated that selling the steers and freeing up some pasture could reduce the cow feeding cost to $75/PTIC cow if the drought continued on to the end of the year. In this case, expenses of $25 per head for the husbandry expenses usually incurred are also included with the drought feeding cost to give a total treatment cost per cow of $100.

Table 96 shows the modified output from the Cowtrade analysis for this extended scenario. In this case, keeping the cows, selling the steers, and incurring a drought feeding cost of $75/cow retained produced a gross margin/AE after interest of $114.63.

Once the Cowtrade analysis was adjusted to look at the alternative of spreading the cows out on to the steer country, the Bullocks program was used to identify the value of holding the steers and selling the breeders. Table 97 shows the expected sale weight (381 kg) of the steers if they were sold now compared to keeping them for another 10 months. A dressing percentage of 100% was used as the steers will be sold as 'feed-on' steers if they are kept. The selling price is the expected liveweight selling price for this class of steers. In this example, keeping the steers produced a gross margin/AE after interest of $126.31 cf. $114.63 for the strategy of keeping the PTIC cows and selling the steers. Hence, in this example, selling steers and reducing the feeding costs of cows would reduce profitability by about $12 for each steer AE sold.

This comparison indicates it is probably better to keep the steers (as they will generate more profit over the next 12 months) and either sell some cows (and possibly buy them back after the drought) or embark on an intensive drought feeding or agistment program, depending upon the estimate of drought feeding costs. There are many unknowns in this form of analysis. It is very difficult to successfully predict the cost of a drought feeding program or the length of a drought. Allocating expected values based on experience, the seasonal timing of the decision, and current market circumstances will often highlight the core differences between options and what it will take to make them work.

Table 96 - Example Cowtrade analysis showing the expected gross margin if steers are sold as an alternative to fully drought feeding breeders

Interest rate for 'gross margin after interest' calculation was 5%

Parameter	**Drought feeding at $75/cow**
Starting date for analysis	01/05/2018
Calving date (max 150 days earlier than start)	15/11/2018
Sale date for adults	01/05/2019
Sale date for progeny	01/052019
Weight of breeders at start (kg)	450
Weight of breeders at sale (kg)	450
Weight of progeny at 5 months (kg)	150
Weight of progeny at sale (kg)	200
Age of progeny at sale (days)	167
Starting value of group (net/head)	$800.00
Sale value of breeders (net/head)	$800.00
Sale value of progeny (net/head)	$418.00
Weaning rate from breeders (%)	90
Death rate on breeders (%)	5
Death rate on progeny after 5 months (%)	3
Husbandry cost on breeders ($/head)	$100
Husbandry cost on progeny ($/head)	$25
Period of rating for breeder (days)	365
Period of rating progeny to 5 months (days)	348
Period of rating for progeny after 5 months (days)	17
AE rating of breeder	0.99
AE rating of progeny to 5 months	0.31
AE rating of progeny post 5 months	0.02
AE rating for breeder and progeny	1.32
Total gross margin per unit (breeder & progeny)	$202.41
Gross margin/AE.year	$153.42
Interest on breeders	$39.00
Interest on progeny	$9.12
Interest on husbandry costs	$3.06
Total interest/unit on stock & expenses capital	$51.19
Average capital base/AE (12 month equivalent)	$775.94
Total gross margin/unit after interest	$151.23
Gross margin/AE.year after interest	*$114.63*

Table 97 – Example drought sale analysis for steers using Bullocks

Parameter	Value
Start date	01/05/2018
End date	16/02/2019
Days on forage	291
Paddock purchase weight (kg)	381
Traded purchase weight (kg)	362
Paddock sale weight (kg)	495
Traded sale weight (kg)	470
Purchase price $/kg live, landed	$1.96
Sale price $/kg dressed weight net	$1.87
Dressing % @ sale	100%
AE standard weight (kg)	455
Mortality	4%
Variable cost/head	$6.20
Interest rate (per annum)	5.00%
Gross margin/beast purchased	$128.02
Gross margin/AE.year	$166.81
Gross margin/AE.year after interest	*$126.31*

7.3.1.4 Agistment

The direct cost of agistment, if it is available, is relatively straight forward to calculate. Table 98 presents an example the cost of agistment for cows until the end of February after which time the cows were expected to be returned home with 90% calves at foot. This cost was compared to the cost of keeping the cows at home and feeding them a drought supplement.

The indirect costs of agistment are more difficult to calculate. No allowance has been made in Table 98 for any additional losses above and beyond those expected if the cows were kept at home and it is difficult incorporate the risk of agistment running out halfway through the agistment period forcing the cows home or into the sale yards at an unknown price.

It is also difficult to incorporate potential damage done to land condition on the home property if the cows are kept at home and fed drought supplements. For instance, protein supplements usually cause an increase in appetite and potentially a rapid decline in the remaining paddock feed.

The effect of the agistment strategy, on future cash flow after the drought has ended, is explored in the Drought Recovery section and compared to strategies where stock have been sold.

Table 98 - Cow agistment cost

Factor	Cost/head
Freight to agistment (24 head/deck for 500 km at $2.00/km)	$41.67
Agistment cost ($4.00/week.head over 43.43 weeks from 01/05/18-01/03/19)	$173.71
Mustering and travelling	$15.00
Veterinary costs	$5.00
Freight home (20 head/deck for 500 km at $2.00/km)	$50.00
Total costs per head	*$285.38*

7.3.2 Decision making in the drought recovery phase

This section considers the potential impact, in the drought recovery phase, of destocking decisions made going into a relatively short term drought. There will be different market conditions, pasture quality and quantity as well as differing supplement costs and availability coming out of each drought so this section presents a framework for considering the possible range of options during the drought recovery phase, not a suggested course of action.

Table 5 indicated that the majority of recorded droughts in this region began in the early months of the calendar year and mostly finished with the seasonal break. On this basis, the most common timing for a drought related herd reduction is early in the calendar year after a failed or poor wet season. Table 99 shows an example for the sale of alternative groups of cattle in response to the commencement of a drought. The first column shows the expected number of cattle on the property in each class at the start of the period. This is followed by columns that show the expected level of sales in an average year, the sales if all of the PTE breeders are targeted (option A) and the sales if the young females and the steers are targeted (option B). The potential effects of the alternative sales strategies on cash flow in later years were modelled to identify any possible differences in outcomes for the property. The representative herd was that after 30 years of land condition restoration and with adequate wet season P supplementation.

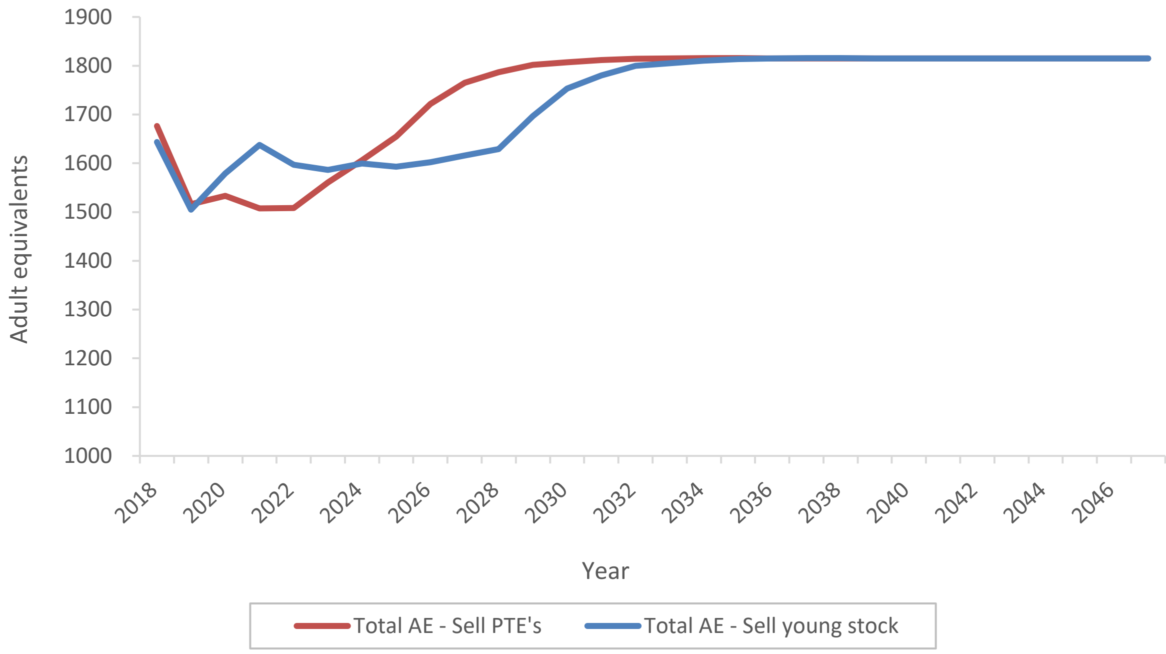
Table 99 - Expected sale pattern and herd structure for the base herd with different response to drought (1,815 AE, after 30 years of land condition improvement and with adequate wet season P)

Class of cattle	Number of cattle			
	Start of year	**Normal sales**	**Option A: sell PTE breeders**	**Option B: sell young stock**
Heifer weaners	282	1	1	282
Heifers 1 year	274	0	0	0
Heifers 2 years	267	139	139	139
Cows 3 years	125	7	69	7
Cows 4 years	115	3	35	3
Cows 5 years	109	3	33	3
Cows 6 years	103	3	31	3
Cows 7 years	98	4	29	4
Cows 8 years	92	3	32	3
Cows 9 years	87	3	30	3
Cows 10 years	82	4	33	4
Cows 11 years	76	76	76	76
Steer weaners	281	0	0	70
Steers 1 year	274	0	0	274
Steers 2 years	267	222	222	222
Bullocks 3 years	44	44	44	44
Herd bulls	37	6	14	6
Home-bred bulls 2 years	0	n/a	n/a	n/a
Total cattle	*2,163*	*518*	*787*	*1,143*
Total adults	*2,050*	*517*	*786*	*791*

Figure 23 indicates the impact of grazing pressure at the property level during the drought and subsequent years if seasons return to normal at the end of the first calendar year. Initially the two sales strategies made to reduce numbers (as described above) end up with a similar reduction in grazing pressure. That's is, selling 787 head in option A (Sell PTE's) or selling 1,143 head in option B (sell young stock) leads to the same residual grazing pressure applied to the property for the remainder of the year.

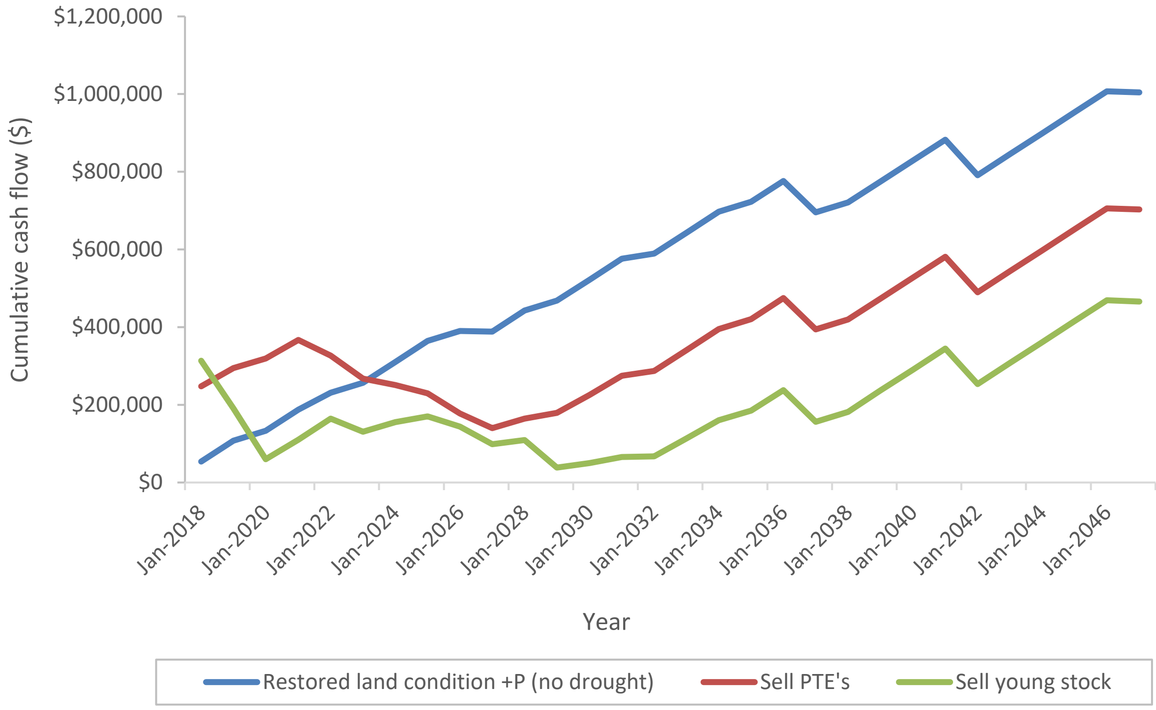
It is noticeable that it takes a considerable period of time before the property returns to its long term carrying capacity if the normal culling and selling procedures are resumed once the drought breaks and no additional cattle are purchased. The decision to sell down the young stock including the weaner heifers causes a significant lag in rebuilding stock numbers compared to the decision to sell down the PTE females.

Figure 23 - Change in adult equivalents (AE) over time with sale strategies in response to drought



Although the initial reduction in grazing pressure is similar, the choice made of how many to sell, and when, will impact the capacity of the property to service commitments as they arise. The choice to sell down the PTE breeders provides approximately the same amount of cash and grazing pressure reduction in the first year and the retention of younger females to rebuild the breeder herd associated with this strategy, allows the cash balance to be maintained for slightly longer than the alternative strategy of selling the young stock and retaining the breeder herd (Figure 24). Both drought sale strategies end up with about the same amount of deficit by Year 6 or 7 but then begin to diverge again after that period.

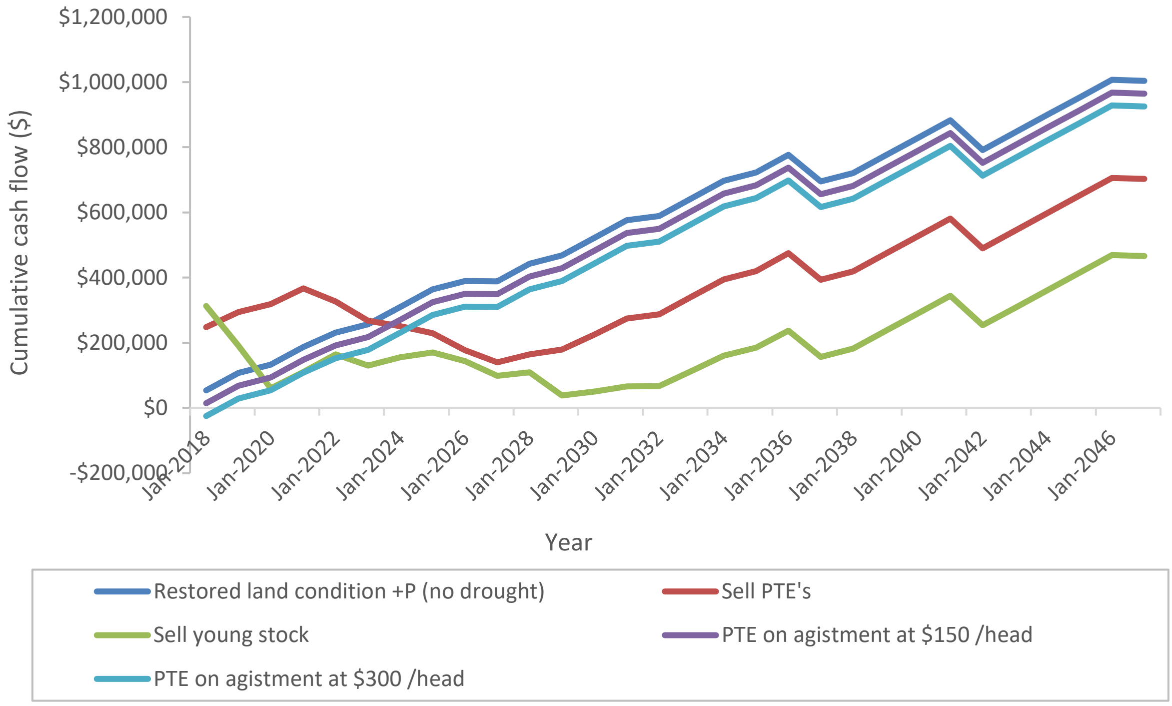
Figure 24 - Cumulative cash flow over time with different sale strategies in response to drought



It is apparent that letting the herd slowly rebuild after either drought enforced destocking strategy is likely to seriously impact the ongoing viability of the property. It appears a decision to rebuild numbers only by retaining extra breeding females will cause the property to forgo between $0.3 million and $0.45 million in cash flow over the following 20 years. It is necessary to identify strategies that will efficiently fill the gap between the actual grazing pressure applied and the total carrying capacity available each year as the herd rebuilds.

One option is to send the portion of the breeder herd that would be sold in the sell PTE breeders strategy on agistment for the period of the drought (let's say 12 months) and then return them once the season has broken. Figure 25 shows the comparable cumulative cash flow if the breeders targeted for sale were sent on agistment for 12 months at a cost of $150 per head or at $300 per head inclusive of transport and management expenses. In this scenario about 262 cows would be sent on agistment for 12 months at a cost of $52,400 or $78,600. Deficits were increased in the short term compared to the sale option but lower in the medium to longer term.

Figure 25 – Comparative cash flows for alternative herd rebuilding strategies including agistment



Successfully finding suitable agistment that allows the breeder herd to perform at a similar level to the home property may prove problematic but incurring the short term cost of expensive agistment may be a more viable option than dramatically selling down the herd and trying to eventually rebuild numbers over time. Long term agistment is a different scenario with different costs and returns.

If no agistment can be found and the sell down occurs, strategies that efficiently fill the gap between potential income and realised income while the herd is rebuilding will need to be identified. The available choices also depend upon the timing of the seasonal break and how widespread it is in nature. An early break with follow up rain prior to Christmas will allow a different recovery to a late break with little chance of effective follow up summer rainfall. Table 100 indicates the available grazing capacity if the option to sell PTE breeders is followed.

Table 100 - Available capacity (AE) with sale of breeders as a response to drought

Year	Carrying capacity (AE)		
	Sell PTE breeders (AE)	**No drought (AE)**	**Difference (AE)**
2018	1676	1815	138
2019	1516	1815	299
2020	1533	1815	282
2021	1507	1815	307
2022	1508	1815	307
2023	1561	1815	254
2024	1606	1815	209
2025	1655	1815	160
2026	1721	1815	93
2027	1765	1815	50
2028	1787	1815	28
2029	1802	1815	13
2030	1807	1815	8
2031	1812	1815	3

The base property will have up to 300 AE/annum spare grazing capacity if a significant sell down of numbers occurs. The available options for filling this gap will probably include:

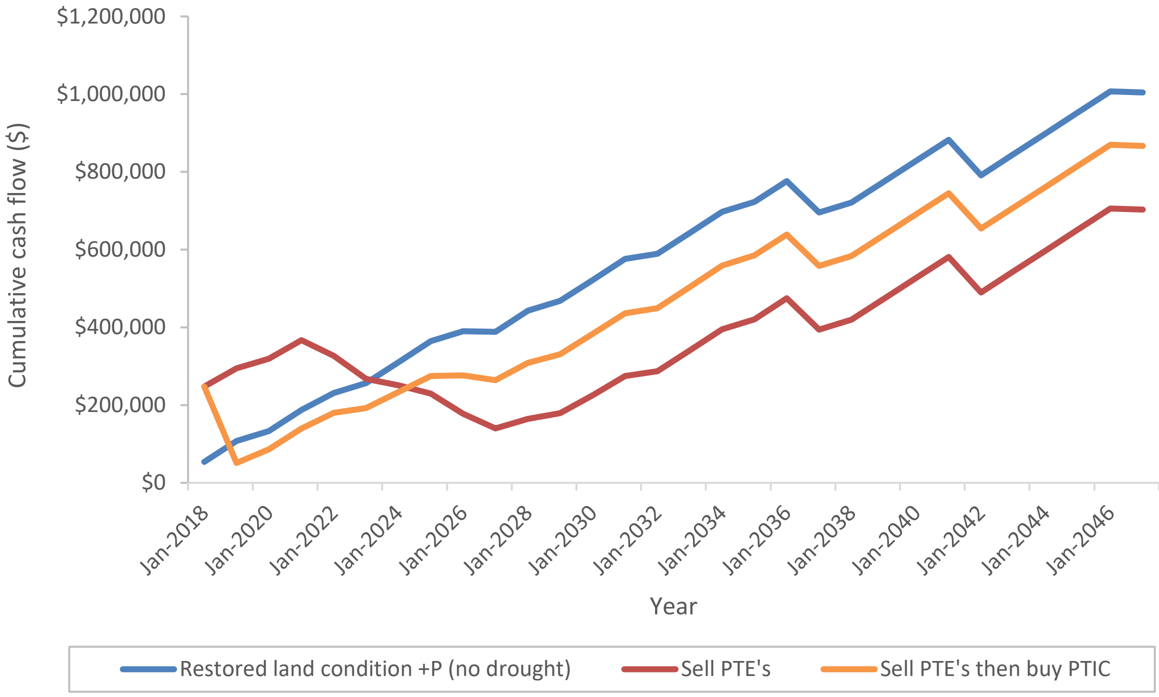
- the purchase of cows (and calves) to rebuild the herd faster
- taking cattle on agistment
- the purchase of groups of steers, heifers or cows and calves as turnover stock. That is, they are purchased specifically as a trading option to be sold once they reach a target weight or condition
- re-purchasing the components of the herd that were sold to rebuild numbers to the long term herd structure
- a combination of all of the above.

Each drought will provide different opportunities related to the availability of stock and the length of the drought but in each case the same framework can be applied to consider potential outcomes associated with each choice. This section will concentrate on cash flow aspects.

7.3.2.1 The purchase of cows to rebuild the herd

The purchase of PTIC cows in May of the year after the drought breaks will be used as an example of the framework applied to assess the relative efficiency of rebuilding the profit of the property through breeder purchases. In this example, the drought caused the sales in early 2018 with the PTIC cows purchased in May the following year. About 229 PTIC cows were purchased in 2019 to increase the number of weaners to a more normal level. Figure 26 indicates that purchasing PTIC cows to restore the breeder herd will substantially increase and extend cash flow deficits in the short term and may not provide a better outcome than just allowing the herd to return to normal numbers through foregoing sales. Some managers may be wary of a strategy taking 7 years to regain the same bank balance as that of a much lower risk strategy (rebuilding the herd).

Figure 26 - Comparative cash flows including the impact of purchasing PTIC cows



7.3.2.2 Taking stock on agistment

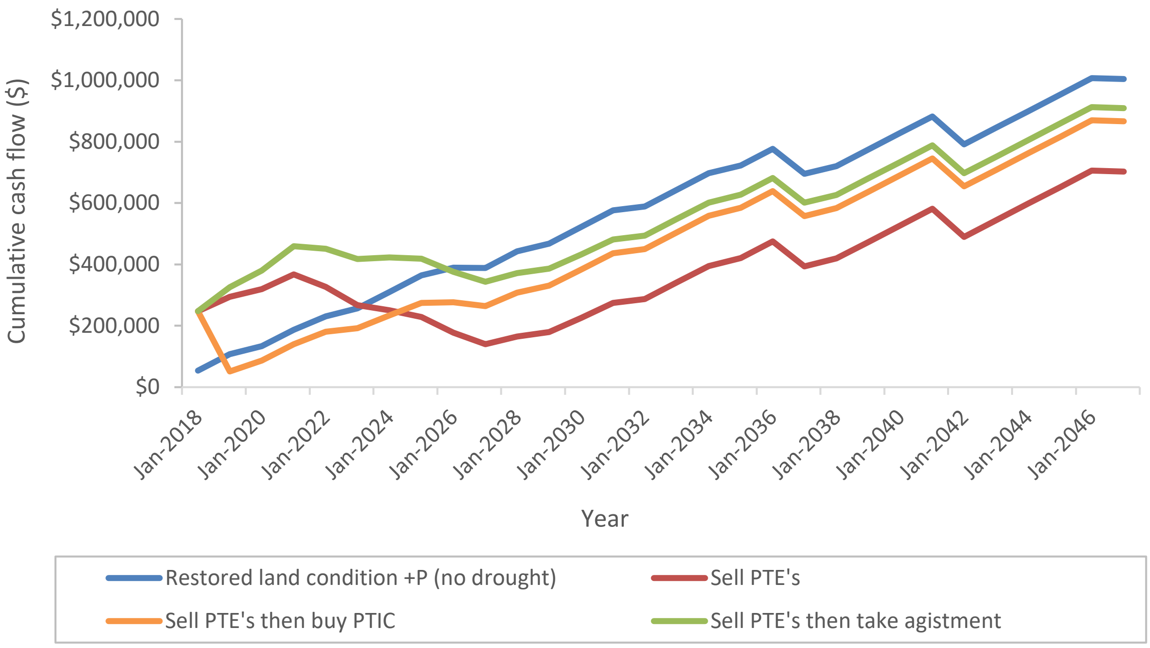
For this example we assumed that the difference in AE count between the base herd and the herd that sells down mature breeders and steers is available for agistment from 2019 onwards. Table 101 shows the additional income available from long term agistment taken while the breeder herd is rebuilt if $2 per AE per week is received. Agistment income will continue to be received until 2036 in this scenario, although only minor amounts will be received after 2026.

Table 101 - Potential extra income from agisting the spare carrying capacity of the property while the herd rebuilds

Parameter	Year									
	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Room for agistment (AE)	299	282	307	307	254	209	160	93	50	28
Agistment income	$31,069	$29,310	$31,960	$31,909	$26,436	$21,703	$16,660	$9,711	$5,204	$2,911

Figure 27 indicates the cumulative cash flow if the spare grazing capacity can be filled by stock on agistment at $2 per AE per week. Whether this is possible once the drought is broken is unknown but higher or lower rates of income from agistment are easily tested in the model. Taking cattle on agistment provides significant protection of cash balances in the early years while the herd is rebuilding and appears to be more profitable than just purchasing PTIC cows. It also appears to be the lowest risk option available in the 5-8 years after a significant short term drought.

Figure 27 - Comparative cash flows including the impact of agisting while numbers are rebuilt



7.3.2.3 Trading cattle

There are numerous scenarios for the trading of cattle as part of recovering from drought and it is recommended that a number of alternatives are assessed using current prices for each class, and expected weight gains, to confirm which alternative may be lower risk and more profitable at the time the decision is being made. The Bullocks program can be used to assess the purchase of dry stock and the Cowtrade program can be applied to assess the purchase of cows and calves or PTIC cows as a trading option. In each case the decision criteria is to select the class of cattle likely to provide the highest gross margin per AE after interest over the relevant time period. It should also be noted that where cattle are purchased to be traded the choice of which class of stock to purchase should be reassessed at least once each year.

An example for the annual trading of steers is presented here to show the process of assessment, not to identify a recommended course of action. In this scenario yearling steers were purchased in February after the drought and the exercise was repeated every 12 months until the remaining breeder herd was rebuilt. The steers were purchased at the long term selling prices for this class of steers applied in the base herd model although this will vary every 12 months in reality. The number purchased was decided by the AE rating for the steers and the spare grazing capacity available as the breeding herd returned to normal size. The steers were sold at the long term price applied to the class of steers one year older in the base herd model. The understanding was that, on average, these will be the average prices over time and represent the average margin between the purchase and sale price. The annual weight gain of the steers was set at about 10% lower than that expected in the base herd growth path for steers due to some of the purchased steers running on breeder country in this exercise. Table 102 shows data extracted from the Bullocks program. The indication was that the each steer purchased and held for twelve months was equivalent to 0.86 AE.

Table 102 - Bullocks program extract for steer trading

Start date	01-Feb-2019		
End date	31-Jan-2020		
Days on forage	364		
	Weight (kg)		
Purchase weight	254	Average daily gain (kg)	0.31
Sale weight (live)	368		
Purchase price $/kg live, landed	$2.52	Purchase price/head (landed)	$641.76
Sale price $/kg dressed weight net	$2.40	Sale price/head (gross)	$839.04
AE standard weight (kg)	455	Average weight for AE calculation	311
Mortality	1.00%	AE per head	0.68

The gross margin per AE calculated in the Bullocks program could not be multiplied by the spare grazing capacity to identify the impact of the trading exercise as the steers were purchased one year and then sold the next, thereby impacting the cash flow and interest costs of the property.

Figure 28 indicates that, in this example, the significant additional interest and other expenses incurred in trading yearling steers is likely to initially reduce the cumulative cash flow below that of the option of taking stock on agistment. The capacity of the property to fund the steer purchases may also be a relevant factor to consider. The steer trading model would also be more risky than any of the other options considered so far as we have not included any assessment of the price risk associated with trading cattle in this environment.

Figure 28 - Comparative cash flows including the impact of trading steers while numbers are rebuilt

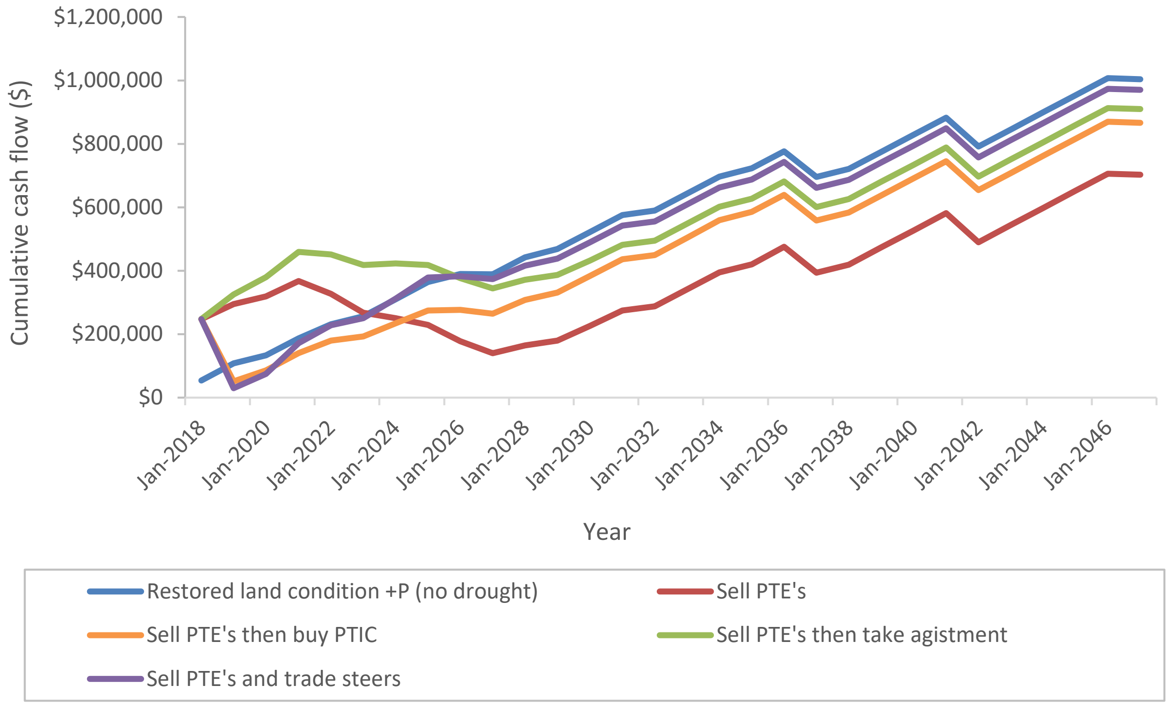


Figure 28 indicated that the economic and financial difference over time between trading steers and purchasing PTIC cows is likely to be the assumptions concerning the purchase price, pregnancy rate, and transaction costs together with the sale price of purchased stock. The best way to recover from drought in this environment is to restore cash flow as soon as possible. The relatively low reproduction efficiency of the herd identifies that waiting around for numbers to recover is not a good idea when there are bills to be paid.

It is best in such circumstances to take opportunities as they arise during the drought recovery phase. At some times trading may be an option, at others taking stock on agistment or purchasing PTIC cows may be the best way forward. The recommended strategy is thus to assess and reassess the tactical options, match the number of stock on the property to the available pasture resource and, sometimes, be prepared to take additional risk.

This assessment of opportunity needs to be conducted at each point in time that drought recovery decisions have to be considered as it is obvious that a small change in the parameters applied will change the relative ranking of the options. It is also clear that while just looking at the short term ramifications of these choices may often be sufficient, looking at the medium term impact may also help. However, beef production is very dynamic and variable and hence predicting outcomes at a time in the medium term future is very challenging.

It is obvious that once a couple of likely prospects for recovery options are identified some detailed consideration should be given to the relative riskiness of the alternatives. This is particularly so with exercises that incorporate agistment. Due diligence seems to be a key ingredient of successfully concluding an agistment agreement.

8 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, respond to, or recover from drought. In this analysis 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 Northern Gulf NRM region of Queensland. The results of these analyses can be used to support informed decision making by property managers.

The information provided here should be used, firstly, as a guide to an appropriate method to assess alternative strategies aimed at improving profitability and drought resilience in the Northern Gulf 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 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 (Broad *et al.* 2016; Johnson 2018). 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 drought.

Managers who successfully manage both the poor rainfall years and extended drought events focus on balancing cattle and grass supplies and apply annual wet season spelling across substantial areas of the property (20% spelled until perennial grass seed set). Weaner paddocks also receive a full wet season spell annually. Conservative stocking rate management on these properties, in combination with wet season spelling, builds robust pastures that are dominated by perennial, palatable and productive (3P) species capable of withstanding occasional heavy grazing during dry years.

Generally cattle numbers remain more stable on a property where a grass surplus is maintained during the good seasons. These feed reserves, in association with good land condition, act as a buffer for the extended dry and drought years. Such managers are also seasonally responsive and base their stocking rate and sale decisions on trigger points such as end of February rainfall and grass supply. Empty and cull cows, kept in a close paddock, can be easily sold at this time while other options include feedlotting, agistment or moving cattle to a second property. If rainfall and grass supplies are seriously deficient by Easter more cattle are sold or moved off the property. For these managers sell-down decisions at this time are more driven by feed supplies than cattle prices. Age of turnoff and herd structure on these extensive breeding operations also determines sale options. A beef business selling weaners and carrying a high proportion of breeders is inherently risky in dry years. In contrast, sell-down agility is enhanced when age of turnoff increases and there is a higher proportion of growing cattle in the herd. Agile managers place a high priority on retaining high ground cover and pasture stubble at the break of season to maximise pasture response to first storms and overall wet season growth.

In contrast many managers in the Northern Gulf NRM region operate higher risk grazing and production systems where stocking rates exceed safe carrying capacities in most, if not in all, years. In many cases these high stocking rates appear to be associated with set stocking practices and a mentality of 'holding on' to cattle. Consequently minor rainfall and feed deficiencies regularly undermine herd productivity (weaning, growth and death rates) and land condition which further amplifies the impact of severe drought events.

8.1 Preparing for drought

The major challenges facing beef property managers in the Northern Gulf region are the inherently low productivity of the region and poor profitability (McCosker *et al.* 2010; McLean *et al.* 2014; Rolfe *et al.* 2016*b*). Financial pressures are likely contributing to high stocking rates and land condition decline across the region (Rolfe *et al.* 2016) and this will inevitably reduce long-term productivity and profitability as well as increasing susceptibility to drought. Hence the first priority, in terms of management strategies for the Northern Gulf, was to address the decline in land condition being experienced by many property managers through a reduction in stocking rates and implementation of a wet season spelling regime. The second priority was to implement appropriate P supplementation for cattle due to the known biological and economic benefits of this strategy (Winks 1990; McCosker and Winks 1994; Dixon 1998; Jackson *et al.* 2012; Bowen and Chudleigh 2018*b*). Addressing these two issues for the representative, base beef property substantially improved relative profitability over the medium term (Table 1) but appeared unlikely to make the property sufficiently resilient to survive as a separate production system into the future. This was because profitability was insufficient to pay the total costs of the property when livestock prices were maintained at the level of the longer term average. That is, cumulative cash flow after 30 years was negative and declining. Even so, it was critical that these two issues were addressed before anything else was considered.

The remaining question was whether additional strategies could be found to make the property more viable. The results of the investigation of additional strategies for their ability to improve profitability and business resilience, and hence prepare for drought, are summarised in Table 2. These results are the difference in returns between the new representative, base beef property (after 10 years of land condition improvement and with adequate wet season P supplementation) and the same property after investing in the specified management strategy. They are a guide to possible additional strategies that may further build profit and 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. The benefits of Table 2 are additive to those identified in Table 1. That is, a property that currently has declining land condition and poor economic performance due to overstocking and inappropriate wet season P supplementation can potentially add benefits from Table 2 to those identified in Table 1.

The strategies that appear worthy of further consideration include planting stylo for steers, fertilising existing stylo pastures with P, optimising the age of turnoff for steers over the longer term and using home-bred bulls. Planting leucaena on suitable land types also shows some promise but is unlikely to be widely applicable. The advantage provided by home-bred bulls appears to arise from the high average value some managers pay for herd bulls and the difference between that cost and the costs associated with breeding your own.

The results of our study of the representative property suggest that, other than P supplementation, investments focused on improving the performance of the breeder component of the herd in isolation are unlikely to substantially improve profit and resilience, even when achieved at a low cost. These results support findings of Rolfe *et al.* (2016*b*) who concluded that the financial gain from investing to lift herd performance in Northern Gulf businesses was unlikely to exceed the additional operating costs thus resulting in reduced return on assets.

This 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. 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.

Strategies that involved improving the nutritional status of cattle by sending steers on agistment or providing expensive supplements to steers or breeders always reduced profitability and resilience of the property despite improving steer growth rates or breeder reproduction performance.

As documented by Rolfe *et al.* (2016*b*) producers running extensive beef businesses in the Northern Gulf region face a complex mix of biophysical, productivity, family and financial challenges. These authors identified that low profitability and debt servicing pressures made the investment in alternative strategies unaffordable for most Northern Gulf region businesses. Furthermore, low profitability appeared to be driving overstocking and land condition decline for many properties and constraining ability to implement grazing strategies to improve land condition. If the decline in land condition decline documented by Shaw *et al.* (2007), Gobius (2013) and Shaw *et al.* (2017) continues then long-term productivity and profitability of business in the Northern Gulf will decline even further. However, despite declining gross and net income resulting from continued land condition decline, our analyses indicated that the total value of assets of the representative property after 30 years of land condition decline would be almost double the starting value if land appreciated at 3%/annum in real terms. Hence, there may be little incentive for managers to implement higher risk strategies of changed grazing management. Hamblin (2009) argues that more effective agricultural policies are required for areas of agricultural land such as the Northern Gulf, with low inherent productivity and where environmental and social decline are endemic.

While our analysis was based on a base property entirely located within the Northern Gulf region, the survey data of Rolfe *et al.* (2016*b*) indicates that many businesses operated a breeding property located in the Northern Gulf in association with one or more finishing properties located outside the region. The additional properties located outside the Northern Gulf region may improve the overall profitability of the beef business relative to the data presented here for the Northern Gulf beef property in isolation.

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, 2019) and Bowen and Chudleigh (2017, 2018*b*,*c*). 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 financial risk play a large role in the level of adoption, and the 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.

8.2 Responding to, and recovering from drought

The capacity of the representative property to respond to drought is initially defined by the way the breeder herd is already segregated and managed. In this analysis the representative breeder herd had been segregated on pregnancy status and this provides an opportunity for the manager to take decisive action, in rapidly reducing grazing pressure, if the following season were to be below average. This capacity is part and parcel of having an efficient production system in place prior to drought and provides significantly more options than those available to the producer that does not pregnancy test and has in place an unsegregated breeder herd structure that exposes them to increased drought risk.

Drought response strategies are often seen as tactical, short-term decisions which are highly dependent on the individual circumstances prevailing at the time. This is not always correct as the options available to respond to drought are often determined by the decisions made prior to the drought and the actions taken in response to drought will often determine the medium term outcomes for the beef property once the drought breaks. Flexibility is the key when responding to drought and setting a drought response (and recovery) plan prior to drought may prevent the consideration of more viable alternatives that are revealed as the drought progresses. It is necessary to apply the right planning framework and to reassess the strategy as change occurs. The best option may only be identified after a number of strategies are compared for both their short term and medium term impact on the cash flow and profit outlook for the property as the drought progresses. Therefore a key element is the ability of a management team to maintain the capacity to assess and reassess options as a drought progresses and to apply a logical decision making framework during a time of great stress and high physical workload.

The consideration of alternative drought responses should initially be undertaken by looking at impacts on components of the herd in isolation together with the additional costs and benefits. The finding from this study was that assessing the sale of alternative classes of cattle should be done on the basis of the impact on both future profit and future cash flow and that all classes of cattle should be incorporated in the assessment.

Drought recovery strategies should be targeted at returning cash flow and profit to their long term trend as quickly as possible. However, it is known that rapid rebuilding of herd numbers following a drought can exacerbate land degradation (McKeon *et al.* 2004). Hence, appropriate monitoring of the pasture resource needs to be conducted to ensure it is capable of supporting the livestock numbers during each phase of the herd rebuilding period.

Deciding prior to drought upon the recovery action that is considered most likely to return the property to a positive cash flow, and profitable operation the quickest, will often determine the response actions which should be considered first. However, this may not be the best management mindset to take into a drought.

The tools, herd models and framework developed in this study can be used by producers and their advisors to support planning and review activities. The best drought response and recovery option will only be identified after a number of strategies are compared for both their short term and medium term impact on the cash flow and profit outlook for the property.

9 Summary of strategies and Conclusions

The results of management strategies and the conclusions reached should be considered in the context of the representative, base beef property. The starting base property was 30,000 ha of native pastures on various land types and was considered to be in ca. B- land condition on average (scale A-D) with a carrying capacity ca. 65% of the safe, long term carrying capacity of these land types when in A condition. The starting base property carried ca. 2,500 AE with estimated ratio of AE to safe carrying capacity of 1.54 given the B- land condition status. It was assumed that under this sustained stocking rate the land condition would decline at a rate of 0.5% decrease in safe carrying capacity per year over the next 30 years resulting in a decrease in herd performance. The management features of the self-replacing Brahman breeding herd included uncontrolled mating and minimal (inadequate) phosphorus (P) supplementation. The mortality rate of the base herd was 7.5% and the average weaning rate from all cows mated was 47.4%. The average, annual post-weaning weight gain for steers was ca. 86 kg/head.

The **annualised NPV**, used as one of the key criteria to assess the strategies, can be considered as an approximation of the **average annual change in profit over 30 years**, resulting from the management strategy.

9.1 Continuation of the current herd management and stocking rate

The scenario considered was a linear decline in land condition over 30 years at a rate of 0.5% decrease in carrying capacity per year (from 65% of original carrying capacity in Year 1 to 50% of original carrying capacity by Year 30) under a 12 ha/AE stocking rate regime where breeder numbers were maintained but herd performance decreased.

Herd gross margin declined by 56% over 30 years in line with declining livestock productivity. However, if the land value increased at 3%/annum above the rate of inflation (i.e. in real terms) over the 30 year period, the beef property would have almost double the value of assets in real terms held at the start of the 30-year period regardless of falling land condition and income-generating potential. This result indicates little incentive for property managers to implement higher risk strategies of changed grazing management to address declining land condition.

9.2 Key strategies to build profit and drought resilience

9.2.1 Improving land condition by managing to long-term carrying capacity and wet season spelling

Reducing grazing pressure to match pasture growth and hence the current safe carrying capacity of the property starting in ca. B- land condition, as well as implementing a wet season spelling regime with 20% of the property spelled every wet season for the whole of the growing season, was assumed to result in a linear improvement in land condition from 65% of the safe, long-term carrying capacity in A condition to 72.5% by the end of the 30 years of the analysis. In this strategy, stocking rate was reduced by 40% in the first year of the analysis, from 2,500 AE to 1,500 AE and this was maintained for the first decade. After the first decade, the stocking rate was gradually increased from 1,500 to 1,813 AE by Year 30 in line with assumed improvements in land condition and carrying capacity. Herd performance parameters affected by the improvement in land condition were assumed to increase linearly over the first 10 years of the analysis and to be maintained thereafter.

By Year 30 of the analysis, the cumulative cash flow of both the land condition improvement scenario and the land condition decline scenario was negative and declining with neither system sufficiently profitable to pay the total costs of the property. The long-term herd output associated with the improved land condition scenario was not sufficient to make the property more viable long-term. While the annualised NPV due to implementing the land condition improvement strategy was positive ($15,100 extra/annum) this was mostly due to the early release of capital resulting from the herd reduction. Focussing on improving land condition through a rapid reduction in stock numbers appeared unlikely to make the Northern Gulf property viable, indicating that additional strategies needed to be found to improve property performance.

9.2.2 Improved land condition in combination with adequate wet season phosphorus supplementation to improve herd performance

An adequate wet season P supplementation strategy was examined in combination with the previous scenario to reverse land condition decline. Improvements in biological parameters for cattle reproduction, growth rates and liveweight were implemented over 4 years as a balance between the simultaneous effects of a) linear improvements due to land condition improvement over the first 10 years of the analysis and b) the biological benefits due to additional P supply which would be expected to occur by the second season of supplementation. The level of animal performance achieved after the first 10 years was continued to Year 30 and the land condition and safe carrying capacity improved at the same rate over 30 years as outlined for the previous land condition improvement scenario.

The combination of a significant herd reduction, improvement in land condition over time, and the feeding of adequate wet season P supplements improved cumulative cash flow by more than $1.8 million over 30 years. Over 30 years the annualised NPV of the property was improved relative to the scenario where land condition was allowed to decline ($59,800 extra/annum). However, the underlying beef production system was still unlikely to be viable long-term with the management changes implemented, as indicated by the negative and declining cumulative cash flow at the end of 30 years. It is evident that further improvements to herd and property management need to be identified and investigated for their ability to improve profitability and resilience, and hence prepare for drought.

9.3 Other strategies that may build profit and drought resilience

The property with grazing management to improve land condition and adequate wet season P supplementation was used as a new base to test additional strategies for their ability to improve the long-term profitability and drought resilience. These additional strategies were considered in combination with previous two, rather than in isolation, as addressing land condition decline and P deficiency for cattle were seen as the first essential steps in improving resilience and long-term profitability.

Other than property-level stylo development, which was implemented concurrently with improvements in land condition and adequate wet season P supplementation, all other strategies were implemented after 10 years of land condition improvement and adequate wet season P supplementation. That is, a new 30-year investment model was constructed based on the 1,500 AE herd model at Year 10 of the preceding analysis. The mortality rate of the new base herd was 2.5% and the average weaning rate from all cows mated was 57.8%. The average annual post-weaning weight gain for steers was ca. 113 kg/head.

9.3.1 Stylo pastures on phosphorus deficient soils for steers

The introduction of stylo pastures for steers was initially assessed by developing a 500 ha paddock to run steers from weaning to sale in two age cohorts, similar to the overall property, with steers sold either at the normal time in May or in September. Several levels of pasture utilisation were examined. The comparison was the 500 ha paddock with and without stylo development. In addition, a property-level scenario was examined where sufficient stylo-grass pastures were established to run all weaner steers produced by the property until sale in May. This property-level strategy was implemented concurrently with land condition improvement and adequate wet season P supplementation from Year 1 of the analysis and was compared to a base herd which implemented land condition improvement and adequate wet season P supplementation but no stylo. The stylo development was targeted to forest land types typical of region with ca. 4 ppm P in the top 100 mm of soil.

Investing in developing native pastures with stylos, on 500 ha, selling the steers in May, and utilising the pasture at 20% resulted in an 11% return on the additional capital invested (IRR) over the longer term (30 years). Holding steers on stylo pastures until later in the year (September) to gain a price premium of 10 c/kg live and selling the steers at a heavier weight did not substantially improve economic performance. Increasing the utilisation rate of stylo-grass pastures from 20% to 40% substantially increased economic performance ($5,100 cf. $17,300 extra annualised NPV/annum for May sale date of steers).

When sufficient stylo-grass pastures were developed over a period of 6 years to run all steers from weaning until sale in May, and utilised at 20%, the return on additional capital invested (IRR) was 10%, similar to the paddock-scale development. This strategy resulted in a substantial peak deficit (-$270,600) and payback period (15 years). Although implementing this strategy increased risk in the short term, the cumulative cash flow of the property was positive by Year 15 of the analysis and increased thereafter. However, the total return on assets over 30 years was less than 1%/annum, as for the base property.

9.3.2 Stylo pastures and phosphorus fertiliser

This analysis extends the previous analysis of stylo pastures by adding P fertiliser to a 500 ha paddock with established stylo pastures growing on a P-deficient soil (ca. 4 ppm P in the top 100 mm). The fertiliser was reapplied every 2 years from Year 3 at a rate of 4.9 kg P/ha for the remaining 20 years of the analysis. The marginal returns were calculated for the extra capital required to buy and apply the fertiliser and the extra steers need to stock the stylo-grass paddock.

Investing in a strategy of fertilising established stylo pastures, growing on a P-deficient soil, with P fertiliser resulted in between 21-24% return on the additional capital invested (IRR) over the longer term (30 years) and improved the annualised NPV by approximately $12,682/annum. Holding steers on stylo pastures until later in the year to gain a price premium of 10 c/kg live and selling the steers at a heavier weight did not substantially improve economic performance.

9.3.3 Age of steer turnoff and market options

The effect on profit of selling steers at different ages: 6, 18, two groups at 29 and 41 months (base scenario), 41 and 53 months old, was considered.

The analyses indicated that selecting an older age of turnoff of 41 months for all steers could improve profit and reduce the exposure of the property to drought risk over the longer term. The annualised NPV from moving to a steer sale age of 41 months compared to the base herd where steers were sold in two cohorts at 29 and 41 months of age was relatively substantial compared to other strategies considered: $32,500 extra/annum. In terms of drought risk, an older age of turnoff reduces the proportion of breeders in the herd and therefore the level of risk going into drought. Sell-down options also increase, during dry spells or extended drought events, when a herd structure includes these older steer cohorts. However, the level of the peak deficit associated with this strategy (-$95,500) may prevent many Northern Gulf properties changing their age of turnoff target.

9.3.4 Leucaena-grass pastures on frontage country for steers

The benefits of planting leucaena into frontage country, that has previously been cleared and planted to improved grass pastures (primarily buffel grass), was considered as a strategy to increase carrying capacity and growth rates of steers from weaning until sale. The effect of investing in leucaena on frontage country was modelled by comparing the performance of a 500 ha paddock of frontage country growing buffel grass pasture to the same paddock that was planted to leucaena in the first year of the analyses. The paddock ran steers from weaning to sale in one age cohort and the steers were either sold off leucaena at the normal time (May) after 12 months in the paddock or later in the season (September) after 16 months in the paddock.

Investing in a strategy of planting leucaena into a 500 ha paddock of frontage country resulted in an improvement in the annualised NPV of the paddock over the longer term (30 years) of ca. $50,000/annum and a return on the capital invested in leucaena (IRR) of ca. 16%. However, the investment in a 500 ha paddock of leucaena-grass pastures for steers resulted in a substantial peak deficit for the property of -$460,000 and a substantial payback period of 10 years. Holding the steers for another 4 months to produce heavier cattle for sale in October did not improve profits, even when a 10c/kg liveweight premium was assumed. It should be noted that these predicted returns are dependent on largely untested assumptions concerning the relative forage yields and utilisation rates, diet quality and animal performance over 30 years. Further, although leucaena shows some promise in the Northern Gulf region on suitable land types it is unlikely to be widely applicable as the available area of suitability is relatively small.

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

An annual strategy of feeding the tail of the steer cohort (17% of steers) a molasses production mix for 90 days from mid-June at 306 kg starting liveweight was assessed.

This molasses-feeding strategy resulted in a gross margin of -$87/head. This strategy reduced the economic and financial performance of the property resulting in $5,900 reduction in annualised NPV/annum compared to the base scenario with no molasses feeding. The strategy also substantially increased peak deficit levels (-$252,500) and financial risk and did not generate sufficient returns to repay additional borrowings within the 30 years of the analysis.

Molasses feeding equipment and infrastructure is often under-utilised when these feeding systems are opportunistic and carried out on a relatively small scale. However we acknowledge that there are several beef producers in the Northern Gulf who have invested in storage and equipment (mixing and feeding) over 2 decades and apparently successfully use molasses production feeding strategies. We have not assessed the profitability of the production feeding strategy within these operations. Regardless, if molasses feeding is being considered we recommend that an individual economic assessment be made using appropriate methodology. Furthermore, any north Queensland molasses feeding exercises should target a specific market and ideally turn off cattle towards December when premium prices are more likely due to the shortage of slaughter and/or boat cattle. In a practical sense where molasses storage, mixing and feeding equipment has previously been purchased the profitability of a short term feeding exercise is price sensitive. The profitability of molasses feeding generally relies on a 40 c/kg liveweight price difference between the animal going on to feed and the animal coming off feed. Aside from feeding steers, molasses storage and equipment on many properties is used biannually for weaner feeding. Feeding young weaners high energy and protein rations is considered a priority by some managers in the Northern Gulf region. Molasses production mixes are more affordable than the weaner pellets, crumble or grain mixes currently available.

9.3.6 Silage for home-bred steers

The strategy of growing forage sorghum annually to produce sufficient silage to feed all steers for 90 days from 18 months of age was assessed.

This silage strategy resulted in a gross margin -$96/head. The silage feeding investment produced a negative annualised NPV (-$18,400 less/annum) and appeared likely to increase production risk. About 40 c/kg liveweight more than the expected sale price of the steers (prior to feeding) would be required for the feeding exercise to produce a positive gross margin. Adding the costs associated with constructing a new silage feeding system on the vast majority of properties in the region would make the feeding of silage uneconomic for any purpose, including the storage of silage as a drought feeding reserve.

We acknowledge that a small number of beef producers in the Northern Gulf have slowly invested in silage equipment and infrastructure or have acquired silage and feeding operations through a property purchase. These properties have areas of cleared country with suitable soils and rainfall for forage cropping, while one property uses irrigation to produce several silage crops annually. Initially, these producers fed lower cost rations (silage and whole cottonseed) to a range of cattle targeting specific markets such as feeder steers (>400 kg), lighter boat cattle and slaughter cows. Recently silage rations have improved in quality with the inclusion of grain sorghum headlage to reduce the need for costly feed concentrates. Cattle turnoff from silage feeding mostly occurs towards the end of the year when cattle supplies wane and price premiums are common. Regardless, if a silage strategy is being considered we recommend that an individual economic assessment be made using appropriate methodology.

9.3.7 Silage for trading cull cows

The strategy of growing forage sorghum to produce sufficient silage to feed 360 kg liveweight cull cows for 60 days was considered as an alternative way to trade *purchased* cull cows. This strategy cannot be applied to the cull females produced by the base herd with improved land condition and adequate wet season P supplementation as they will reach suitable slaughter weights in the majority of years without silage feeding.

This strategy resulted in a positive gross margin of $78/head fed. A positive gross margin resulted from feeding silage to lightweight cull cows if the price difference between the animal going into the feeding yards and the animal coming out of the feeding yards was at least 60 c/kg on a liveweight basis. However, a positive gross margin does not necessarily mean that the strategy will add to the profitability of the property. It is necessary to conduct a property level economic analysis to consider the change in profit and risk generated by the alternative operating system. Such an analysis accounts for changes in unpaid labour, herd structure and capital and includes the implementation phase. Although a property level analysis has not been presented for this cull cow trading example, it is evident that adding the costs associated with constructing a new silage feeding system on the vast majority of properties in the region would make the feeding of silage uneconomic for any purpose, including the storage of silage as a drought feeding reserve. It would be as equally uneconomic to feed silage to the usual run of cull cows produced by the property or to feed it to the growing steers.

9.3.8 Annual strategy of sending steers on agistment

The strategy of placing the steers on agistment on Northern Downs country for 12 months as yearlings at $3/head.week, on an annual basis, was assessed.

This strategy resulted in an annualised NPV of -$7,600/annum. The breakeven price for sending the yearling steers on agistment on a long term basis was less than $2/head.week. Most of the deficit incurred on an ongoing basis is due to the retention of females to build up the herd at home, the opportunity cost associated with moving to a yearling production system on the home property, and the relatively small change in the expected weight gain of the steers on agistment compared to their potential weight gain on the home property.

9.3.9 Better genetics for breeder fertility

The benefits expected to arise from investing in bulls with better genetics for breeder fertility, that provided a 6% point improvement in breeder weaning rates, were tested. It was assumed bulls with the superior genes could be purchased for the same price as regular bulls.

The property was slightly 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 5.51%: $4,100 annualised NPV/annum. The extended period of time to the peak deficit (8 years) and payback year (17 years) suggests that the full benefits would need to be received as described, and no premium paid for genetically different bulls, for the investment to remain viable. 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. This strategy resulted in a slightly better annualised NPV to that achieved with replacement of the entire bull herd in Year 1: $6,800 extra annualised NPV/annum. Property and herd managers should be made aware that the time taken to change the reproduction efficiency of the herd through selecting only replacement bulls with superior genetics 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.

9.3.10 Objectively selected home-bred bulls

The potential economic impact of converting to home-bred bulls selected from the male weaners, instead of using purchased bulls, was assessed. The key assumptions were that the bull to cow mating ratio was maintained and that no aspect of herd performance (reproduction or growth) would be impacted by the change.

Investment in conversion to home-bred bulls rather than purchased bulls was paid back by the end of Year 3 of the analysis, with ca. $16,000 annualised NPV/annum added to the property, on average, over the life of the investment (30 years). The return on the extra funds invested (IRR) was 59%/annum. 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 44% and the annualised NPV from $16,600/annum to $13,600/annum. The relatively large positive returns for this scenario, comparative to others examined for the Northern Gulf property, suggest a strategy of investing in producing home-bred bulls is worthy of further consideration.

9.3.11 Supplementing first calf heifers to improve re-conception rates

The strategy of feeding M8U supplement to first calf, lactating heifers to improve re-conception rates by 6% was assessed.

This strategy reduced the average annual profit of the property, resulting in -$3,500 annualised NPV/annum.

However, we acknowledge that a beef property in the Georgetown district has combined the feeding of M8U (intakes of ca. 1.5 kg/head/day) to first calf heifers with light stocking rate management, improved pastures, wet season P supplementation, bull selection based on fertility, and vaccination for reproductive diseases. These heifers are fed M8U from calving to the break of the season. This overall heifer, feedbase and genetic selection strategy, implemented over 10-15 years, has lifted first calf heifer re-conception rates from <20% to >60% for this property. Whether the addition of the M8U feeding to the management of first calf heifers adds value to the overall property returns has not been analysed in this case but appears unlikely on the basis of other analyses undertaken previously.

9.3.12 Investing to reduce foetal/calf loss

This investment analysis investigated the benefits from a 50% reduction in calf loss across all breeding females at cost levels of $5, $7.50 and $10 per female treated per annum or upfront capital expenditure of $50,000, $75,000 and $100,000.

The analysis indicated 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 on an individual property if a return on funds invested was being sought.

9.4 Assessing the potential impact of drought on the herd as well as the effect of herd structure on drought risk and profitability

As breeders age they have a greater expected mortality if they suffer liveweight loss during a drought. Having breeder BCS in better than a forward store condition (better than score 5 on a 9 point scale or

3 on a 5 point scale) going into a drought could substantially reduce the mortality rate of mature and aged cows who are considered likely to lose more than 10% of their starting liveweight. Implementing an effective wet season P supplementation program allowed the maximum age of cow culling to be reduced from 12-13 years to 8-9 years of age. This substantially reduced the number of mature and aged cows going into a drought and should consequently reduce mortality rates and improve drought resilience.

9.5 Assessing key strategies which may be applied in response to drought

Drought response strategies are often seen as tactical, short-term decisions which are highly dependent on the individual circumstances prevailing at the time. This is not always correct as the options available to respond to drought are often determined by the decisions made prior to the drought. Likewise the actions taken in response to drought will often determine the medium term outcomes for the property once the drought breaks. Good land managers will adjust cattle numbers quickly as summer rainfall deficiencies become evident. These managers often use 'trigger points' (end of March or Easter) to balance cattle numbers and grass supplies.

Alternative responses to drought should be considered by looking at impacts on components of the herd in isolation together with the additional costs and benefits. A key finding was that assessing the sale of alternative classes of cattle should be done on the basis of the impact on both future profit and future cash flow and that all classes of cattle should be incorporated in the assessment.

It is not possible or practical to create scenarios to reflect every possible combination of assumptions. Strategies need to be assessed using the relevant input figures at the time of the decision. Examples were developed to demonstrate a) key strategies which may be considered in response to drought, and b) how to assess strategies using tools available in the Breedcow and Dynama suite of programs. These strategies are summarised below.

- Sale of cows that will calve out of season in the current year. These cows should be identified and segregated at the second round muster during the previous year. They can be mustered early in the current year (February/March), will not be heavily pregnant and can be sold as PTIC cows. This group of cows present a substantial mortality risk as they will be heavily pregnant or lactating during the worst part of a drought year.
- Drafting off and culling PTIC empties (females that were pregnancy tested in calf the previous year but subsequently lost a calf prior to branding). This can be done at the weaning muster and may reduce grazing pressure by 5 to 15% depending on the class of cows. In a well-managed herd that has a lower rate of foetal/calf loss, less PTIC empties will be available for sale. While the sale of these females will not substantially reduce grazing pressure it is important to remove these sub-fertile cows from the breeding herd.
- Early weaning in February/March (rather than the usual first round of weaning in May/June) will reduce liveweight loss of breeders during poor seasonal conditions and hence reduce breeder mortality rates and improve reproduction efficiency. The weaners will need to be segregated on weight (>/< 100 kg) and fed supplements suitable for each group. The Splitsal program (within the Breedcow and Dynama package) can be used to indicate the expected weight distribution of weaners in February, allowing feeding costs to be calculated. The Cowtrade program (within the Breedcow and Dynama package) can then be used to compare

these costs to the anticipated benefits of a reduction in breeder mortality rate and improved reproduction efficiency.

- Selling PTIC cows at weaning and then re-purchasing cows and calves 12 months later is another strategy that can be considered using the Cowtrade program. This strategy is aimed at maintaining the number of weaners available to the property over time and can be compared to the expected feeding costs if the cows are retained to produce weaners as normal. A table can be produced to indicate the sensitivity of the exercise to variation in the sale price for PTIC cows, the cost of feeding, and the replacement costs of cows and calves. An estimate of the break-even costs and prices for the drought feeding strategy can be determined using the Cowtrade program.
- The sale of other classes of dry stock as an alternative to selling breeding females can be evaluated by comparing the outputs of the Bullocks and Cowtrade programs. The Bullocks program (within the Breedcow and Dynama package) can be used to test the same options for non-breeding cattle as the Cowtrade program does for breeder groups. In many cases a drought response can include 'either or' options where different classes of cattle can be sold to achieve the same level of reduction in grazing pressure. The criteria for deciding which class of cattle needs to be sold first is usually the 'gross margin per AE' calculated over the selected period of time with the class achieving the lowest gross margin sold first. The class of cattle chosen for sale could change over time due to changing market opportunities and feeding costs.
- The direct costs of agistment can be determined using spreadsheets and compared to the costs of alternative management responses.

9.6 Assessing key strategies which may be applied in the drought recovery phase

The choices available during the drought recovery phase depend partly upon the decisions previously made during the drought response phase. Each alternative strategy implemented during a drought will result in a different herd structure on the property at the end of the drought and different options available for recovery. Drought recovery strategies should be targeted at returning cash flow and profit to their long term trend as quickly as possible.

Once again, the relative value of strategies needs to be assessed using the relevant input figures at the time of the decision. A limited number of examples were developed to demonstrate a) key strategies which may be considered in the drought recovery phase, and b) how to assess strategies these using tools available in the Breedcow and Dynama suite of programs. The results of the examples developed are summarised below.

- Where a significant herd reduction has been carried out, allowing herd numbers to rebuild slowly from retained progeny, and taking no other action, is likely to seriously impact the ongoing viability of the property.
- If breeders had been sent on agistment for the period of a short term dry spell (12 months) cash flow deficits would be increased in the short term compared to the sale of breeders but cash flow and profit could be more rapidly returned to the long term trend once the drought breaks.

- Purchasing PTIC (pregnancy tested in calf) cows to rapidly restore the breeder herd at the conclusion of the drought would increase and extend cash flow deficits in the short term but potentially provide a better outcome than just allowing the herd to return to normal numbers through foregoing sales.
- If the spare grazing capacity created by selling cattle at the start of the drought could be filled by stock on agistment at a suitable price once the drought breaks this strategy would improve the cash balances in the early years while the herd is rebuilding and hence appears to be more profitable than purchasing PTIC cows.
- Cattle trading can be initially considered as part of a drought recovery strategy by using the Bullocks program to assess the purchase of dry stock and the Cowtrade program to assess the purchase of cows and calves or PTIC cows. The resulting gross margins need to be incorporated into a cash flow budget for the property over the medium term to identify the impact of interest and other costs associated with funding stock purchases. The short term trading of large numbers of stock when recovering from drought is the most risky of the options considered due to the price risk associated with trading cattle, the significant additional interest and the expenses which are likely to initially reduce cumulative cash flow and the capacity of the property to fund the steer purchases. Hence, any benefits in projected long-term cumulative cash-flow and profitability, above those available from other recovery strategies, must be carefully considered.

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11 Glossary of terms and abbreviations

AE	Adult equivalent. When calculating the grazing pressure and stocking rates on sown forages, an AE was defined in terms of the daily forage dry matter intake of a standard animal which was defined by McLean and Blakeley (2014) as a 2.25 year old, 450 kg *Bos taurus* steer at maintenance, walking 7 km/day. The spreadsheet calculator QuikIntake (McLennan and Poppi 2016) was used to calculate daily cattle dry matter intakes for the specified average dry matter digestibility of each forage type. 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.
BCR	Body condition ratio. A BCR is the ratio of liveweight to the expected liveweight for age of animals at average condition (‘N’).
BCS	Body condition score. A visual assessment of cow BCS (scale 0-9) is used to rate her body fat reserves or ‘condition’.
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.
CP	Crude protein, being total nitrogen (N) x 6.25.
Cumulative cash flow	Cumulative cash flow is the predicted final bank balance of the property at the end of the investment period due to the implementation of the strategy.
Current (nominal) dollar terms	All variables are expressed in terms of the year in which the costs or income occur. The impact of expected inflation is explicitly reflected in the cash flow projections.

DAF	Department of Agriculture and Fisheries, Queensland Government
DCF	Discounted cash flow. This technique is a way of allowing that when money is invested in one use, the chance of spending that money in another use is gone. Discounting means deducting from a project's expected earnings the amount which the investment funds could earn in its most profitable alternative use. Discounting the value of money to be received or spent in the future is a way of adjusting the future net rewards from the investment back to what they would be worth in the hand today.
Depreciation (as applied in estimating operating profit)	A form of overhead cost that allows for the use (fall in value) of assets that have a life of more than one production period. It is an allowance that is deducted from gross revenue each year so that all of the costs of producing an output in that year are set against all of the revenues produced in that year. Depreciation of assets is estimated by valuing them at either current market value or expected replacement value, identifying their salvage value in constant dollar terms and then dividing by the number of years until replacement. The formula used in this analysis is: (replacement cost – salvage value)/number of years until replacement.
Discounting	The process of adjusting expected future costs and benefits to values at a common point in time (typically the present) to account for the time preference of money. With discounting, a stream of funds occurring at different time periods in the future is reduced to a single figure by summing their present value equivalents to arrive at a 'Net Present Value' (NPV). Note that discounting is not carried out to account for inflation. Discounting would still be applicable in periods of nil inflation.
Discount rate	The interest rate used to determine the present rate of a future value by discounting.
DM	Dry matter. DM is determined by oven drying feed or faecal material in an oven until constant weight is reached (i.e. all moisture is removed).
DMD	Dry matter digestibility. DMD is the intake of DM minus the amount in the corresponding faeces, expressed as a proportion of the intake (or as a percentage).
Economic analysis	Economic analysis usually focusses on profit as the true measure of economic performance or how efficiently resources are applied. The calculation of profit includes non-cash items like opportunity costs, unpaid labour, depreciation and change in the value of livestock or crop inventory. NPV and amortised NPV are both measures of profit.
Equity capital	The value of the owner's capital. This is equal to total capital minus total liabilities.
Financial analysis	Financial analysis focusses on cash flow and the determination of whether all business and family cash costs can be met. Financial analysis can also include analysis of debt servicing capacity.

Fixed (or overhead) costs	Defined as costs which are not affected by the scale of the activities in the farm business. They must be met in the operation of the farm. Examples include: wages and employee on-costs, repairs, insurance, shire rates and land taxes, depreciation of plant and improvements, 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.
Forage utilisation	The percentage of annual forage (including high quality sown forage and perennial pasture) biomass growth that is consumed by grazing livestock.
Gross margin	The gross income received from an activity less the variable costs incurred. Gross margins are only the first step in determining the effect of a management decision on farm or business profitability. To determine the value of a potential strategy to the 'whole farm' or business, a more complete economic analysis is required in the form of a marginal analysis that considers the effect of alternative strategies at the property or business level.
IRR	Internal rate of return. This is the discount rate at which the present value of income from a project equals the present value of total expenditure (capital and annual costs) on the project, i.e. the break-even discount rate. This indicates the maximum interest that a project can pay for the resources used if the project is to recover its investment expenses and still just break even. **IRR can be expressed as either the return on the total investment or the return on the extra capital.**
Land condition	The capacity of the land to produce useful forage, arbitrarily assessed as one of four broad categories: A, B, C or D, with A being the best condition rating. Three components are assessed: 1) soil and 2) pasture condition, and 3) extent of woodland thickening/tree basal area or other weed encroachment.
Marginal	Extra or added. Principle of marginality emphasises the importance of evaluating the changes for extra effects, not the average level of performance.
N	Nitrogen
'N'	'N' indicates the expected bodyweight for age of animals in average condition. This parameter is calculated using an exponential model describing weight from birth to maturity, given adequate nutrition.
n/a	Not applicable or not able to be calculated
Net Profit	This is the reward to the farmers own capital. Net Profit equals Operating profit less the returns to outside capital. The returns to lenders of fixed

	capital (interest, rent, leases) are deducted from Operating Profit in the calculation of Net Profit. It is available to the owner of the business to pay taxes or to provide living expenses (consumption) or it can be used to reduce debt. Net profit minus income tax minus personal consumption (above operators allowance if it has already been deducted from operating profit) = change in equity
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.
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.
Opportunity cost	The benefit foregone by using a scarce resource for one purpose instead of its next best alternative use.
P	Phosphorus
3P	Palatable, productive and perennial pasture species.
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.
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).
SOI	Southern oscillation index. The SOI measures the strength of the Southern oscillation which is a see-saw of atmospheric pressure anomalies between the Indonesian region and the eastern tropical Pacific Ocean. The SOI is used in making longer-term seasonal forecasts for Australia.
SRW	Standard reference weight. The SRW is the liveweight that would be achieved by an animal of specified breed and sex when skeletal development is complete and conditions score is in the middle of the range. This is an important parameter in the prediction of the energy, fat and protein content of empty body gain in immature animals.
Variable costs	These costs change according to the size of an activity. The essential characteristic of a variable cost is that it changes proportionately to changes in business size (or to change in components of the business).
Year of peak deficit	The year in which the peak deficit is expected to occur.

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13 Appendix 1. Breedcow and Dynama software

13.1 Brief description of the Breedcow and Dynama software

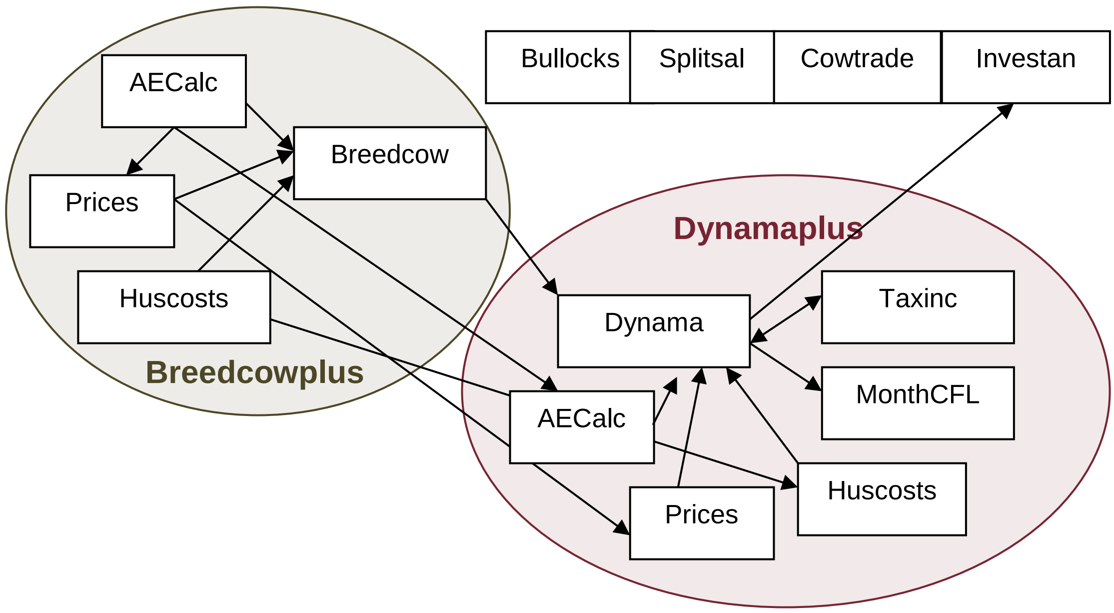
The Breedcow and Dynama package of software programs is used to assess choices for the management of beef cattle herds run under extensive conditions. **It is not an accounting package or a paddock records package and does not record individual animals**. It presents budgeting processes, adapted to the 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 29 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 29.

Figure 29 - Relationships within the Breedcow and Dynama software package



13.2 Summary of the components of the Breedcow and Dynama software

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

13.2.1 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.

13.2.2 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.

13.2.3 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.

13.2.4 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.